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Peebles

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(54) **FLUID DYNAMIC LIFT GENERATION**

(76) Inventor: **Patrick Peebles**, La Mandriola, Via Laurentina Km 14.2, Rome RM 00143 (IT)

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(52) **U.S. Cl.** **244/10**; 244/9

(58) **Field of Search** .... 244/206, 9, 10, 244/19, 21, 153 A, 39; 416/23, 24, 120, 130

(56) **References Cited**

U.S. PATENT DOCUMENTS

932,884 * 8/1909 Muckle 244/19
1,417,602 * 5/1922 Hedberg 244/9
1,487,228 * 3/1924 Garcia 244/9
1,533,713 * 4/1925 Tatay 244/9
1,535,613 * 4/1925 McFarlane 244/9
1,613,834 * 1/1927 Jordanoff 244/10
1,635,364 * 7/1927 Haussmann 244/9
1,714,608 * 5/1929 Massey 244/10
1,714,609 * 5/1929 Massey 244/10
1,759,468 * 5/1930 Smith 244/9
1,773,432 * 8/1930 Mueller 244/21
1,796,860 * 3/1931 Bowers 244/9
1,820,919 * 9/1931 Massey 244/10
1,849,547 * 3/1932 Marsan 244/9
1,850,925 * 3/1932 Evans 244/10
1,875,276 * 8/1932 Steigert 244/10
1,879,594 * 9/1932 Trey 244/10
1,927,538 * 9/1933 Zaparka 244/10
1,991,378 * 2/1935 Christiansen 244/19
2,039,676 * 5/1936 Zaparka 244/21
2,050,903 * 8/1936 Topliff 244/9
2,173,832 * 9/1939 Fahrney 244/9
2,344,515 * 3/1944 Massey 244/10
2,397,189 * 3/1946 Main 244/9
3,065,928 * 11/1962 Dornier 244/10
3,140,065 * 7/1964 Alvarez-Calderon 244/10
3,448,714 * 6/1969 Brooks 416/24
4,307,677 * 12/1981 Jastram et al. 114/167
5,100,080 * 3/1992 Servanty 244/9

FOREIGN PATENT DOCUMENTS

003837812A1 * 5/1990 (DE) 244/206
885666 * 12/1961 (GB) .
2029909 * 3/1980 (GB) 416/24
357186069A * 11/1982 (JP) 416/24

* cited by examiner

Primary Examiner—Peter M. Poon
Assistant Examiner—Son T. Nguyen
(74) *Attorney, Agent, or Firm*—Flint & Kim, P.A.

(57) **ABSTRACT**

An aircraft lifting member (wing) comprises a crossflow rotor **2** formed of a core **4** having rotor vanes **5** mounted around it, disposed in a trough **3** at the front upper part of a wing-like body **1**. Rotation of the rotor induces a downwardly and rearwardly directed airflow over the upper surface **6** of the wing-like body **1** generating both lift and thrust. The upper part of the rotor vane path projects above the upper surface **6** and the lift-generating member is open at the leading edge to expose the cross-flow rotor **2** to the incident airflow.

9 Claims, 8 Drawing Sheets

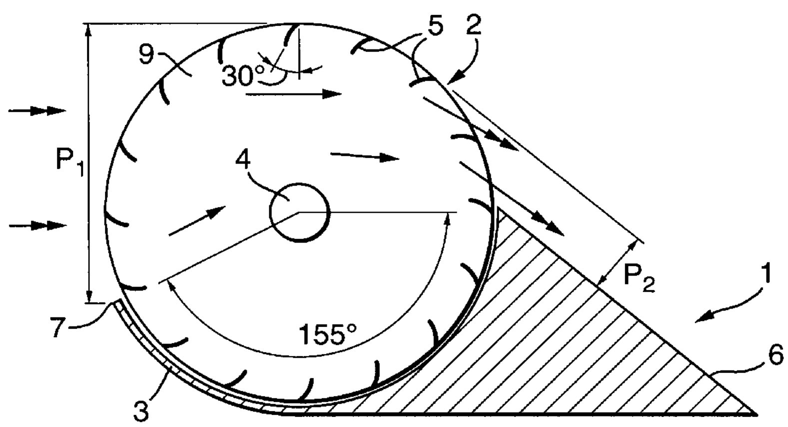


Fig.1.

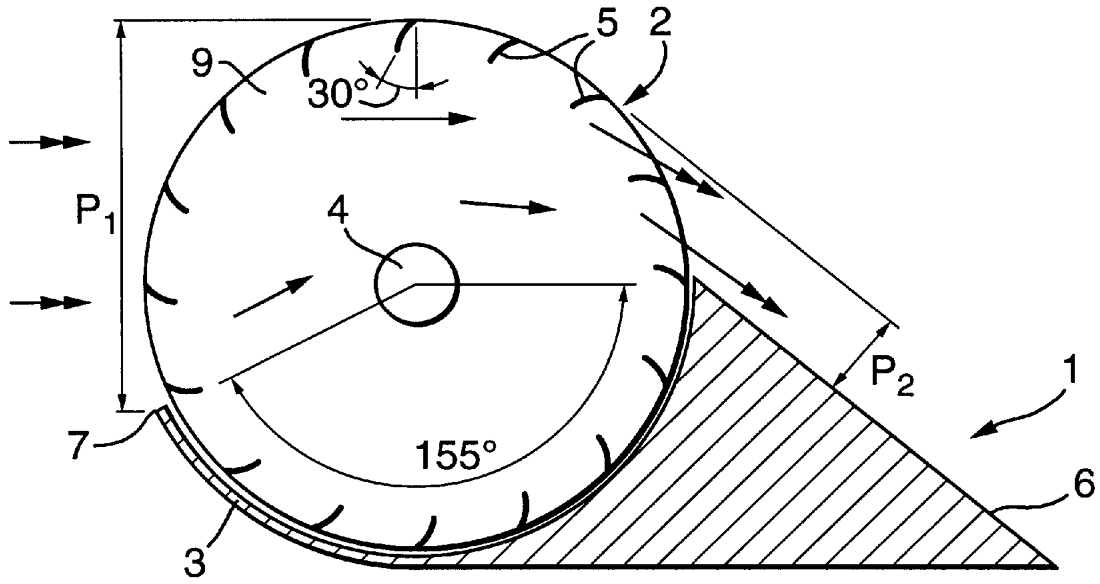


Fig.2.

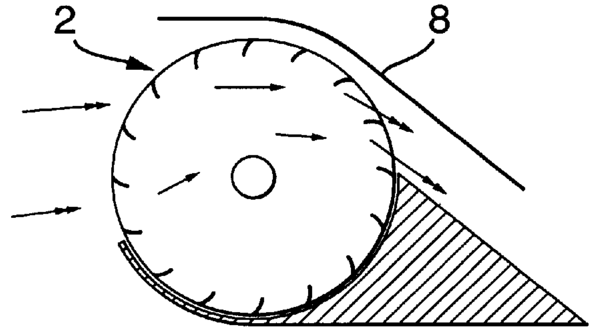


Fig.3.

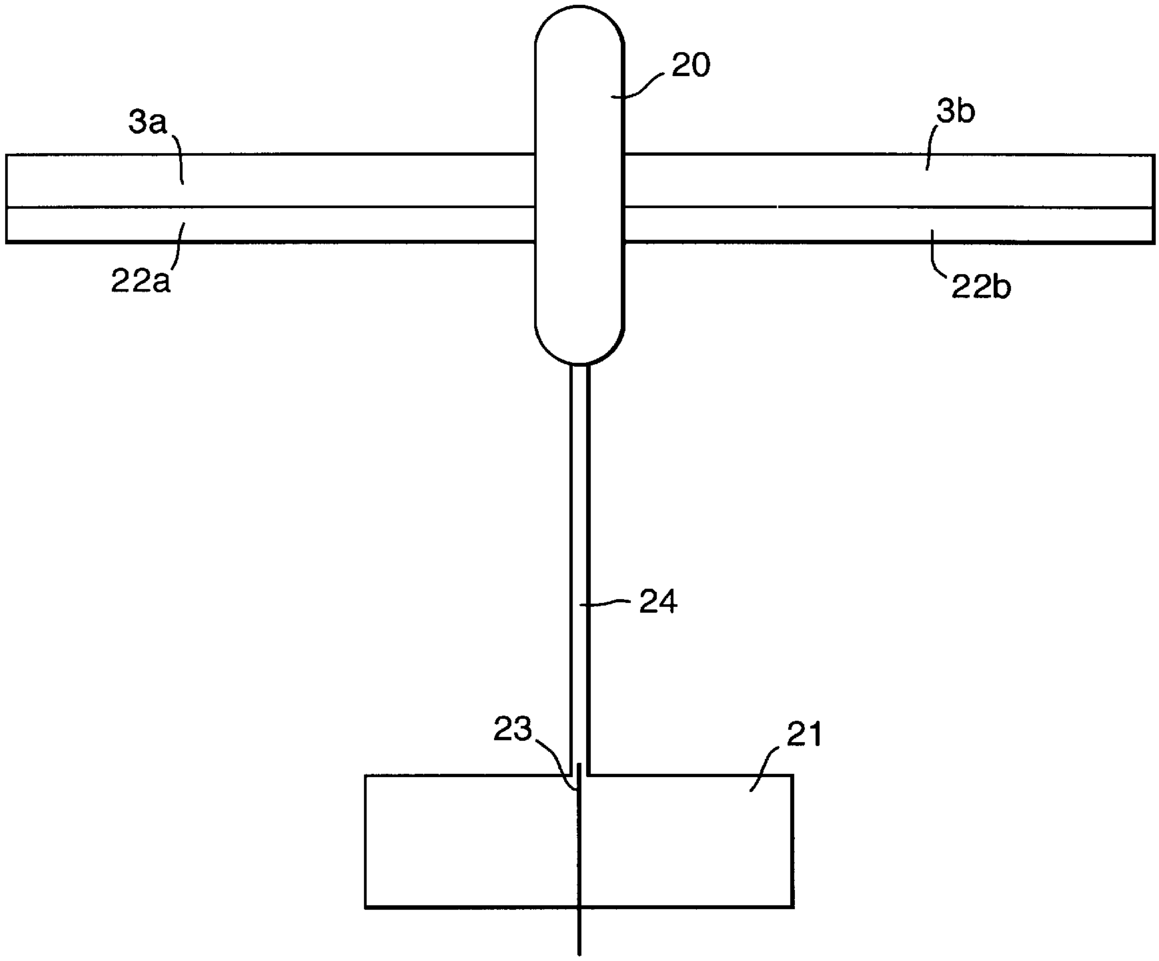
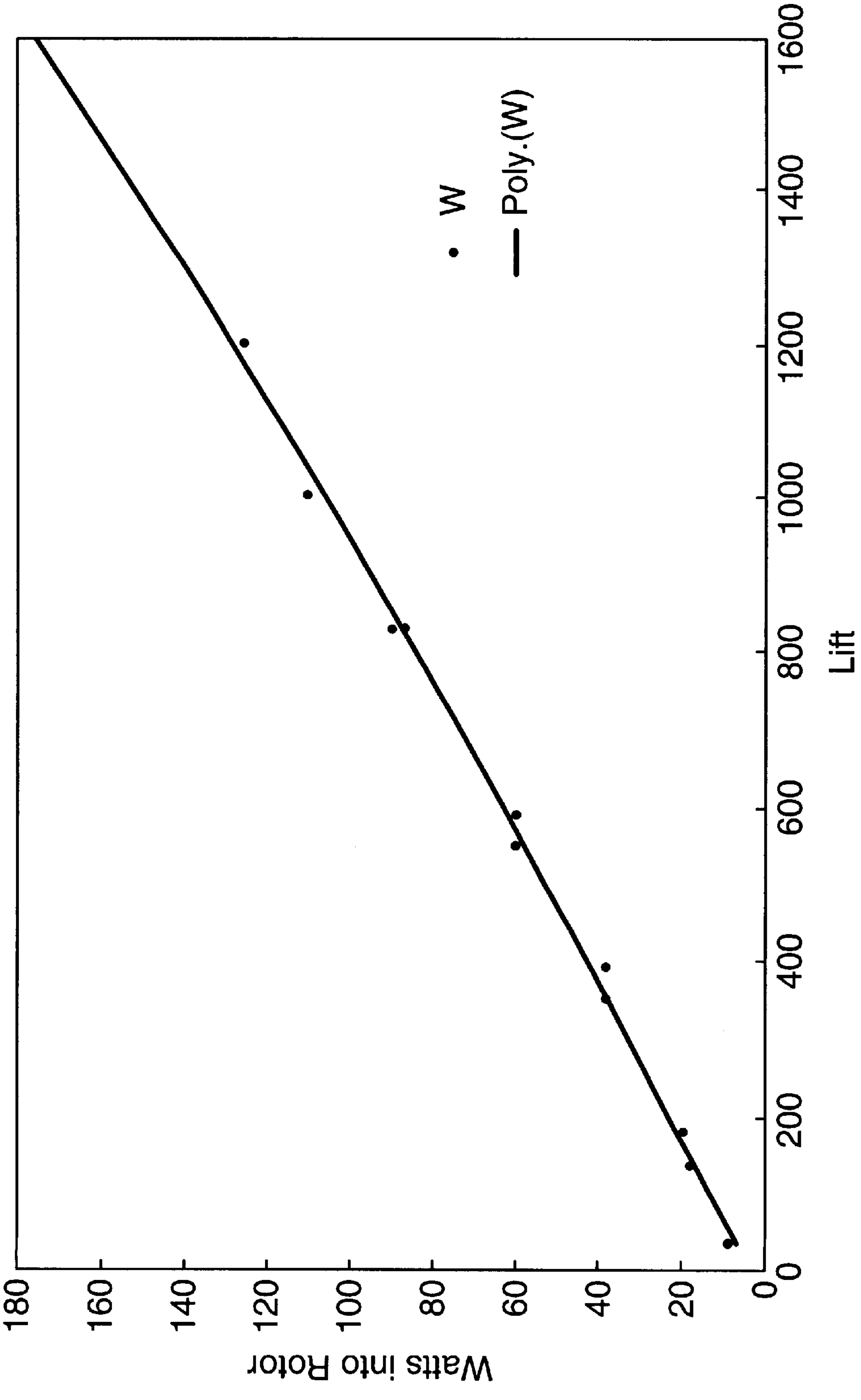


Fig.4.

16blades155

V	A	Rpm	W	Static	Sec/t	Lift	G/W	Stat/Lift	
2.2	4	1020	8.8	7	8.28	35	3.98	5.00	
3	6	1680	18	25	4.18	135	7.50	5.40	
3	6.5	1920	19.5	30	3.59	180	9.23	6.00	
4	9.5	2580	38	60	2.84	350	9.21	5.83	
4	9.5	2500	38	50	2.68	390	10.26	7.80	
5	12	3240	60	95	2.25	550	9.17	5.79	
5	12	3240	60	85	2.12	590	9.83	6.94	
6	14.5	3660	87	125	2.22	830	9.54	6.64	
6	15	3780	90	105	2	830	9.22	7.90	
6.5	17	4140	110.5	110	1.97	1000	9.05	9.09	
7	18	4200	126	170	2.03	1200	9.52	7.06	
						Average	8.77	6.68	

Fig.5.



Watts into Rotor
180
160
140
120
100
80
60
40
20
0
0
200
400
600
800
1000
1200
1400
1600
Lift
W
Poly.(W)

Fig.6.

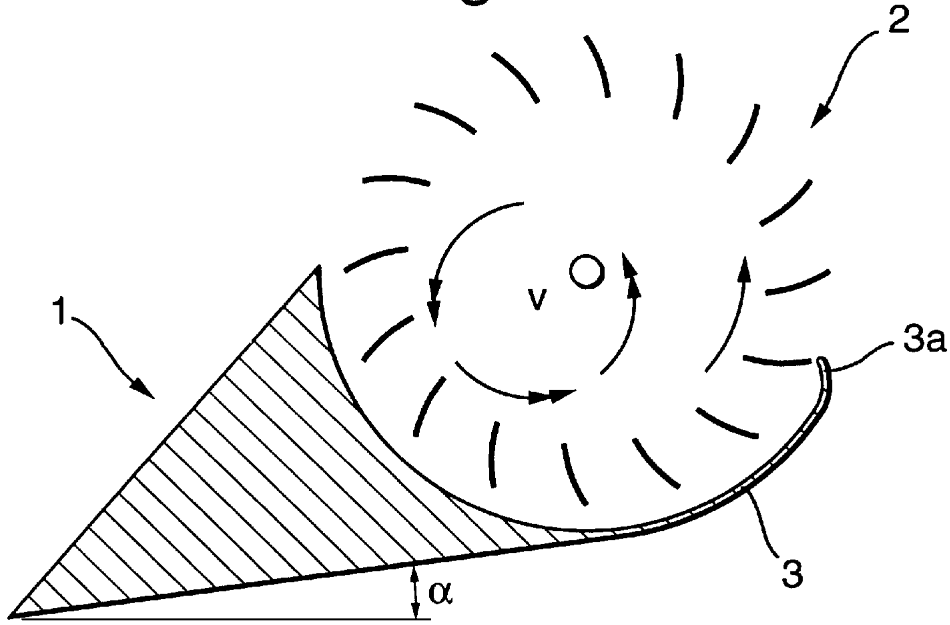


Fig.7.

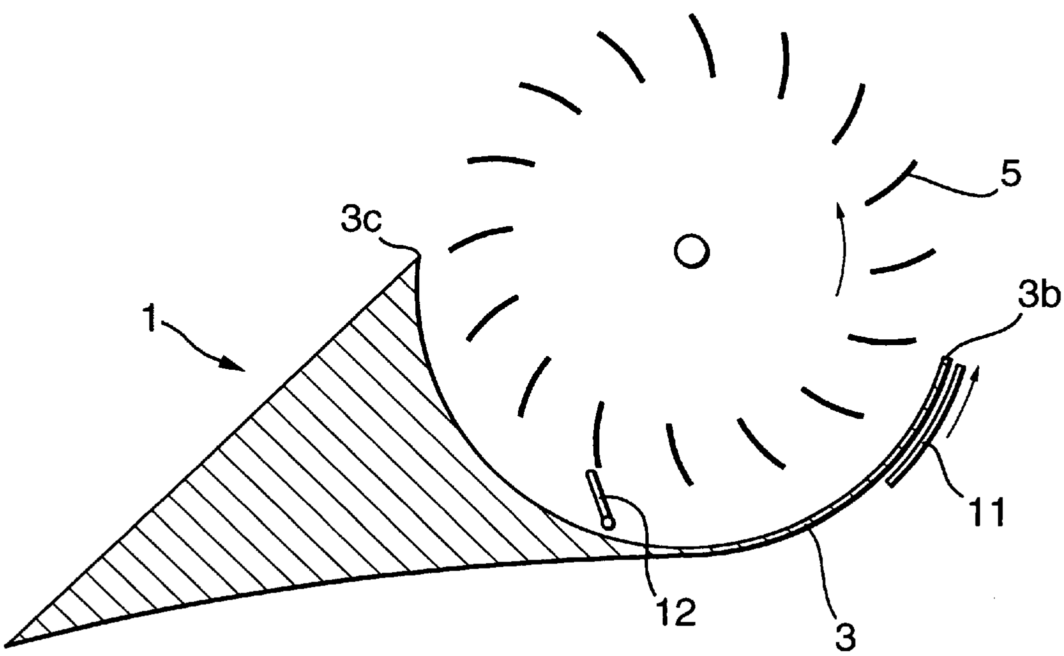


Fig.8.

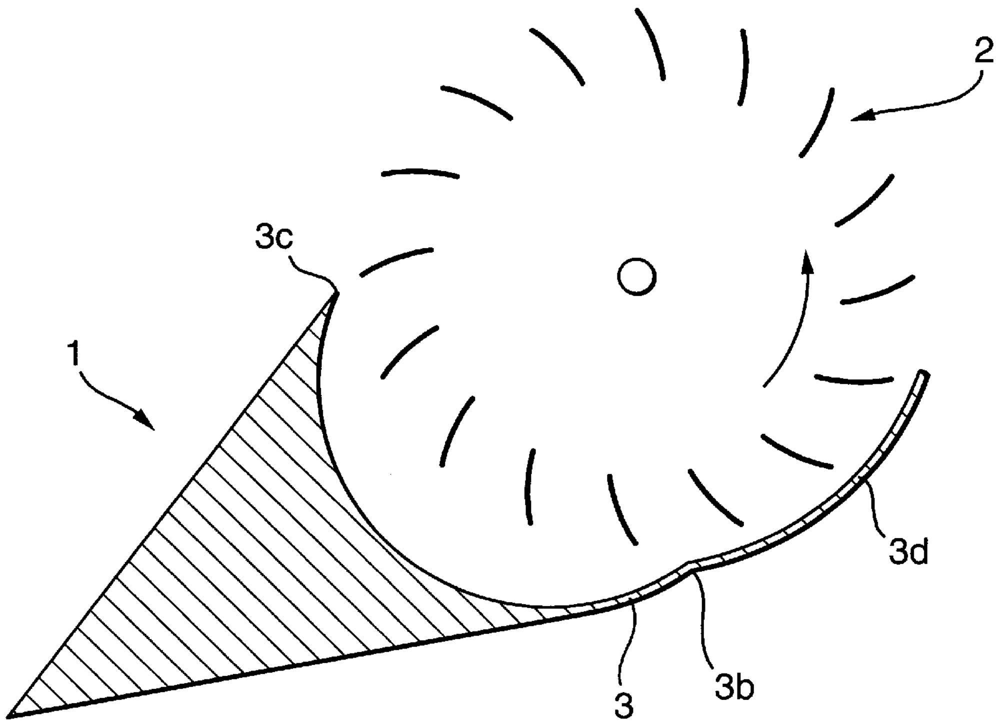


Fig.9.

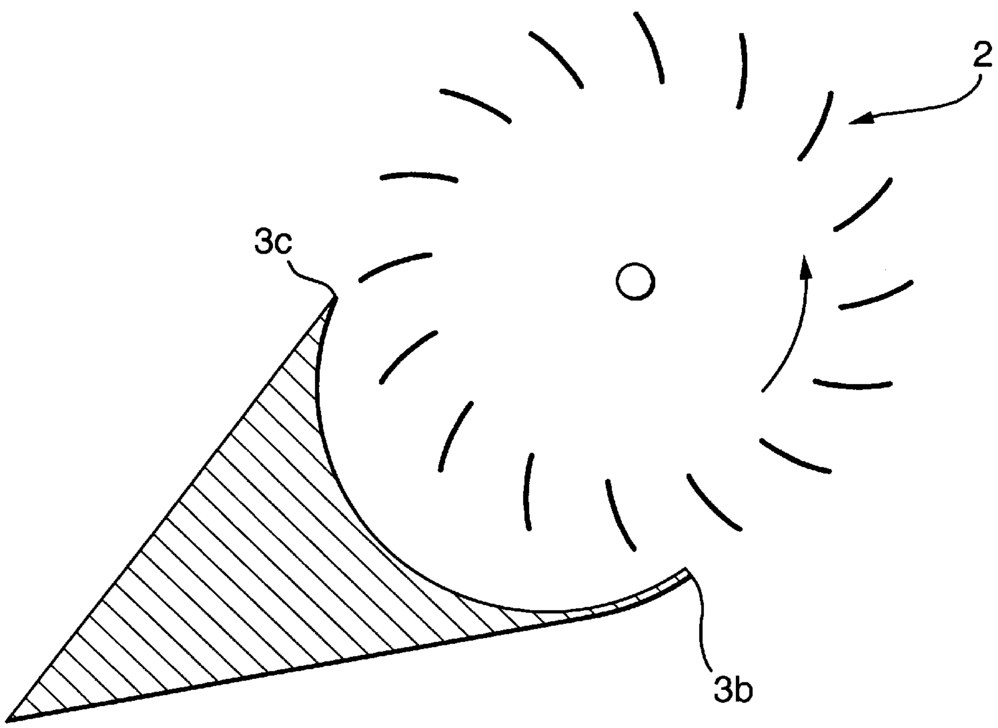


Fig.10.

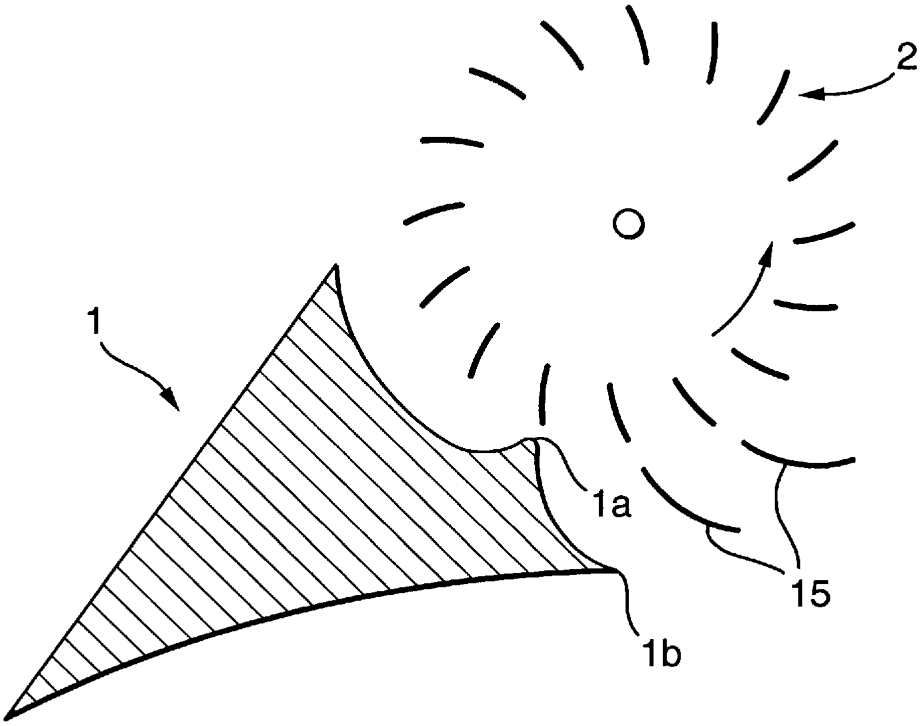


Fig.11.

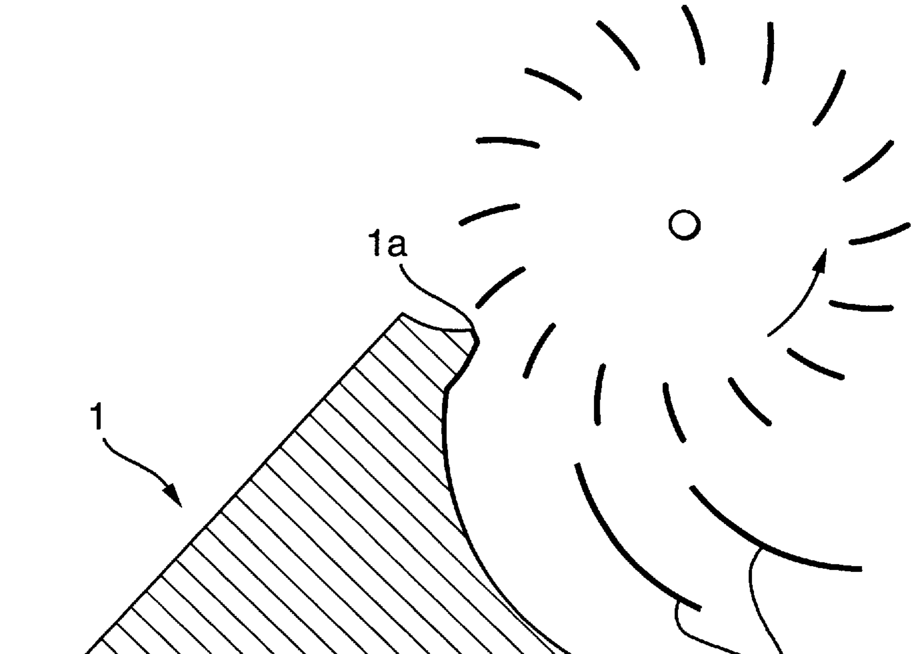


Fig.12a.

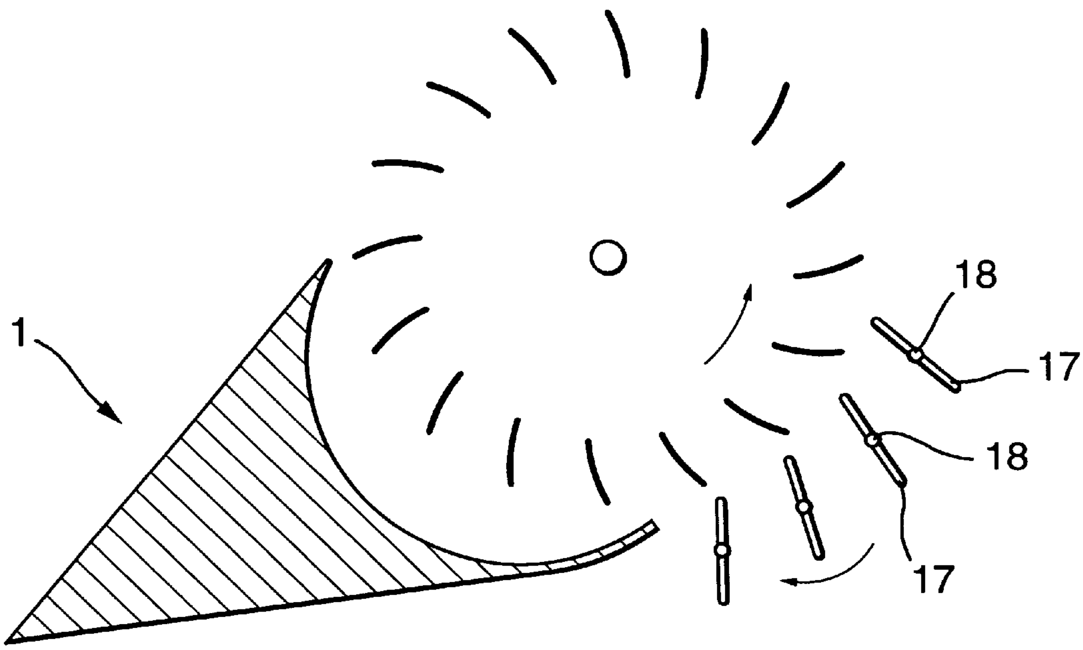
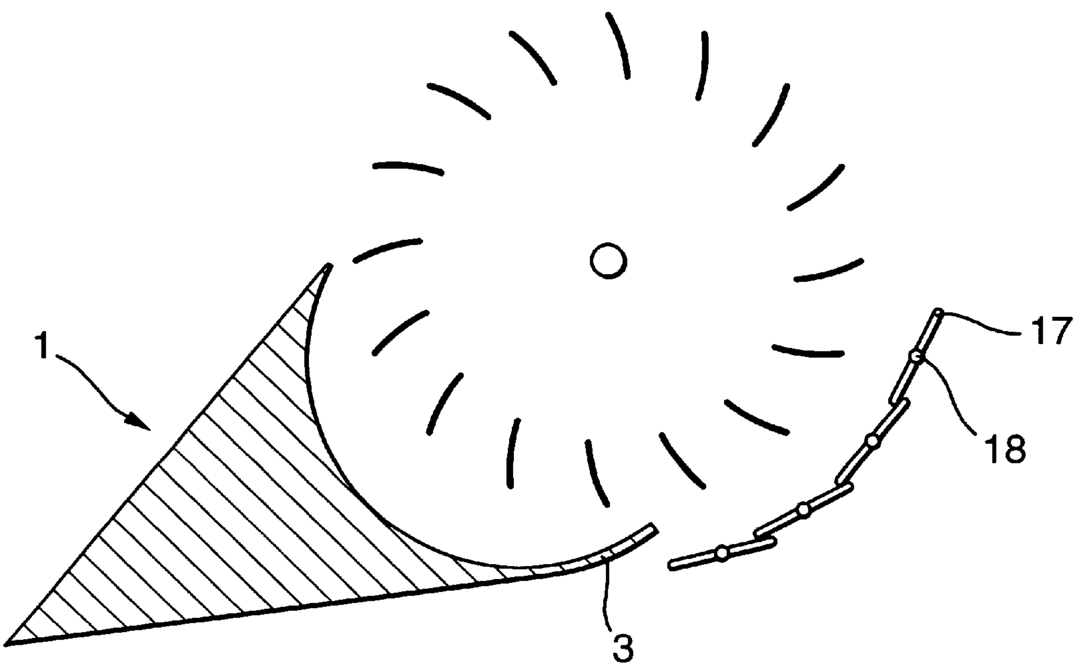


Fig.12b.



FLUID DYNAMIC LIFT GENERATION

The present invention relates to an improved form of lifting member using a fluid flow, either of an aerodynamic nature or a hydrodynamic nature. It Is particularly useful for an aircraft, and in particular as a high lift wing which will provide both high lift and thrust for a low speed aircraft, making it attractive for STOL (short takeoff and landing) purposes.

In the past STOL aircraft have depended upon either lift augmentation of an aerofoll wing, for example by blown flaps and/or the use of slats and leading edge flaps, and/or upon the use of a tilt wing construction where an engine is mounted fixed in relation to the wing so that tilting the wing to a higher angle of incidence also tilts the engine to give a measure of vectored thrust. Vectored jet thrust in the context of vertical/short take-off and landing (V/STOL) flight is also known.

The present invention aims to provide a novel way of achieving high lift at low forward speed of an aircraft.

GB-A-885888 discloses the use of a cross flow rotor at various locations in an aerofoll body, and includes in FIGS. 27 and 26 a cross-low rotor embedded in the leading edge of the aerofoll body.

In accordance with the present invention there is provided a lift-generating member comprising a wing-like body defining leading and trailing edges and opposed surfaces which converge towards said trailing edge, and a spanwise extending cross-flow rotor positioned adjacent the leading edge and one of said opposed surfaces to define an air intake region and an air discharge region along the circumferential path of the rotor vanes; wherein the rotor rotates in a direction which carries the rotor vanes in the part of their path which is adjacent said one opposed surface in a direction which extends towards the trailing edge of the wing-like body; characterised In that the surface of the rotor projects proud of the said one opposed surface over at least said air discharge region; and in that the rotor is exposed to air at the leading edge of the wing-like body to define a leading edge of the lift-generating member and to take in air at the front of said body and to discharge it over said opposed surface as a result of rotation of the rotor.

By providing for a differential in efficiency between the rotors on either side of the center line of an aircraft it is possible to control the lift differentially, to give a means of banking the aircraft.

If desired, the rotors may provide not just the lift but also all of the thrust which is required for forward propulsion of the aircraft, in which case differential power to either side of the centre line of the aircraft also provides for a measure of yaw control and for a means of controlling the aircraft in a stable banked turn.

In order that the present invention may more readily be understood the following description is given, merely by way of example, with reference to the accompanying drawings, in which:

FIG. **1** is a cross-section through a first embodiment of lifting member in accordance with the present invention;

FIG. **2** is a view similar to FIG. **1** but on a reduced scale and showing a modified form of the wing body of the lifting member;

FIG. **3** is a top plan view of an aircraft incorporating the lifting member of FIG. **1**;

FIG. **4** is a table of operating parameters measured using a tethered wing of the design shown in FIG. **1**;

FIG. **5** is a graph of rotor input power plotted against lift in grams force;

FIG. **6** is a sectional view of third embodiment of the lifting member according to the invention, shown from the opposite side from that in FIGS. **1** and **2**;

FIG. **7** is a view similar to FIG. **6** but showing a fourth embodiment of the lifting member incorporating two alternative forms of flow control (shown on the one drawing for the sake of simplicity);

FIG. **8** is a view similar to FIG. **6** but of a fifth embodiment of the lifting member;

FIG. **9** is a view similar to FIG. **6** but showing a sixth embodiment of lifting member with a more open front to the leading edge crossflow rotor;

FIG. **10** is a view similar to FIG. **6** but showing a seventh embodiment of the lining member with inlet guide vanes to assist flow into the crossflow rotor;

FIG. **11** is a view similar to FIG. **6** but of an eighth embodiment of lifting member according to the invention; and

FIGS. **12***a* and **12***b*, respectively, show a ninth embodiment of the lifting member of the present invention, with inlet guide means open in FIG. **12***a* but closed in FIG. **12***b*.

The lifting member shown in FIG. **1** uses the combination of a tapered wing-like body **1** and a spanwise extending cylindrical crossflow rotor **2** set into an upwardly open trough-like recess **3** in the front of the wing body **1** near the leading edge **7** of the wing body. As shown In FIG. **1**, the crossflow rotor **2** projects upwardly into the airflow passing over the upper surface **6** of the body **1** and it is indeed the rotation of the rotor **2**, in the clockwise direction as viewed in FIG. **1**, that induces this airflow. The rotor is open to the incident airflow at the front of the lifting member.

FIG. **1** shows that the rotor **2** is a form of crossflow rotor, also known as a tangential flow rotor, extending spanwise along the wing body. In its crudest form the rotor has a succession of discs **9** with high aspect ratio fan vanes **5** extending between the successive discs along the rotor. An optional central shaft **4** connects the various discs together and is driven by the drive means, which preferably includes a differential gearbox mechanism to vary the power distribution between such a lifting member to one side of the aircraft, and a similar such lifting member the other side. Such a rotor will of course be able to be used with any alternative wing body shape such as any of those shown in FIGS. **1**, **2** and **6** to **12**.

The crossflow rotor **2** rotates clockwise as viewed in FIG. **1** and generates an airflow, shown by the double-headed arrows, deflected upwardly over the upper surface of the rotor core **4** at an air intake region of the rotor blade path and then passing obliquely downwardly from an air discharge region of the rotor blade path to follow the upper surface of the tapering wing body **1**. At the trailing edge of the wing body **1** the airflow will detach in the form of a downwardly and rearwardly moving stream which generates a downward component of airflow giving rise to augmented lift of the lifting member, and also a rearward component which generates thrust to induce forward propulsion of the lifting member. Although not shown in FIG. **1**, when forward propulsion of the lifting member is established there will be also be an airflow passing under the wing body **1** so that the incident airstream from the left hand side of the lifting member shown in FIG. **1** will divide, with some passing over the rotor and the rest passing under the wing body, and with these two flows recombining, preferably with minimum turbulence, at the trailing edge. This, combined with an aerofoll general shape to the cross-section of the lifting member (wing body **1** and crossflow rotor **2**) may also generate aerodynamic lift in the conventional manner.

By increasing the speed of rotation of the rotor its output power can be increased and hence both the lift and the thrust on that lifting member can be increased.

As will be clear from a reading of the following description, there are various other possibilities for designing the spanwise crossflow rotor **2**. However, the concept remains the same in that there will be an airflow induced over the wing body giving rise to both lift and thrust.

An aircraft incorporating the lifting member in accordance with the present Invention may have additional thrust-generating means such as at least one engine driven propeller or at least one turbine or rocket engine, but it is envisaged that all of the thrust may be derived from the crossflow rotor **2**.

Hence variation of the speed of rotation of the rotor **2** (or its efficiency by means shown in FIGS. **7**, **12***a* and **12***b*) will not change simply the lift on that lifting members; It may also vary the thrust of that same lifting member to an extent which will allow yaw control of the aircraft having such a lifting member as a wing.

Where this differential lift facility is available it is possible for the aircraft to omit the convention lateral guidance means (such as a rudder) and/or roll control means (for example ailerons).

Although it is possible for ailerons to be omitted in their entirety, it may be helpful to have ailerons present in order to compensate for the de-stabilizing effects of a side-wind on cross-wind lending. Where ailerons are provided, it is expected that they will still produce aileron-induced yaw.

An aircraft using the lifting member of the present invention may include a variable speed drive motor driving a means (such as a differential gearbox) of varying the division of power between the spanwise rotor of the lifting member on the starboard side and the spanwise rotor of the lifting member on the port side, for the purposes of controlling yaw and/or roll.

It is also conceivable for the speed control to be linked to a conventional pitch control means such as a control column normally driving an elevator, so that increasing the motor speed will increase the power to both port and starboard side of the aircraft and hence increase the lift, giving a nose-up tendency, and vice versa. This may either augment or replace the elevator. Alternatively conventional elevator control may be employed, and the speed of the motor diving the rotor **2** may instead be controlled separately In the manner of lift augmentation means such as leading edge and/or trailing edge flaps of a conventional aircraft.

Equally it is possible for there to be a control surface attached to the wing body **1**, for example of the trailing edge, in order to vary the aerodynamic camber of that wing body for the purposes of further augmenting lift.

If desired the wing body member **1** of FIG. **1** may have the trailing edge occurring at the end of a sharper taper zone starting at a point on the upper surface of the tapering wing body. In this case the undersurface of the wing body may be a continuous planar surface as shown in FIG. **1**. However alternatively the undersurface could equally include a point of discontinuity (similar to such a point of the upper surface) at which the angle of inclination of the lower surface either increases or decreases.

Also, the trailing edge may be at the end of a downwardly curved portion of the wing body to impart aerofoll camber to the wing today, resulting from the curvature of the part of the wing body behind the trough **3** and rotor **2**. The upper surface may be convex overall (so that for the entire wing body can be of curved form with a generally aerofoll configuration) or may become convex after a point marking the termination of a forward generally planar upper surface. (It will of course be appreciated that the downwardly curved portion may be in the form of a succession of generally planar surfaces giving rise to a succession of stepped regions of different inclinations to resemble such a curved configuration).

In all of the embodiments the vanes may form a close non-interference fit with the concave part-cylindrical wall of the wing body defining the trough **3**.

In the preferred embodiment shown in FIG. **1**, the rotor discs **9** have a diameter of 80 mm. Between two successive rotor discs **9** along the span of the lifting member are 16 rotor vanes **5**, in this case each of 10 mm chord and 0.6 mm thickness. The blades are part-cylindrical curved sheets having a 30 mm radius of curvature. This is the design of prototype used for the tests whose results are shown in FIGS. **4** and **5**.

In this case the trough **3** is part-cylindrical and has the discs **9** fitting closely within it. It extends over 155° of arc of the cylinder defining the trough. Thus, as viewed in FIG. **1**, the left hand- or leading edge-side of the wing body member is cut away at **7** to expose the rotor to the incident airflow.

As shown in FIG. **1**, the rotor vanes **5** are in this case set at an angle of 30° with respect to that radius which also passes through the edge of the rotor vane **5** lying farthest from the shaft **4**. It may also be of value to control the angle of these blades while the rotor is turning. This could be in the form of collective pitch which would change the angle of all the blades at the same time or in the form of cyclic pitch control which would control the angle of the blades depending on their position relative to the wing body.

FIG. **2** shows a variant, generally similar to the embodiment of FIG. **1**, but with a slat or cover **8** over the rotor to define a slot to control the airflow over the upper surface of the lifting member.

A model incorporating the design shown in FIG. **1** has been run using direct drive to the rotors to each side of the fuselage centre line of the model. Such a model is shown in plan view in FIG. **3** as comprising a fuselage **20** having a fixed tail plane **21** and a port wing body **22***a* and a starboard wing body **22***b*. In this case a fin or vertical stabilizer **23** has also been mounted on a tail **24** of the model. The rotor has been omitted from FIG. **3** but the trough **3***a* and **3***b* of the respective wing member **22***a* and **22***b* is illustrated. It is thus possible to visualise the way in which the lifting body cross-section of FIG. **1** has been adapted to the model aircraft.

The model has an all up weight of 3.4 Kg which includes a 1 horse power motor of 5 cc displacement. The wing span of the model is 206 cm, and this comprises two active wing bodies **22***a* and **22***b* each of 93 cm span.

The model was flown in radio-controlled free flight. The airspeeds and power values (see FIGS. **4** and **5**) were extrapolated using the test results of a 90 cm span tethered wing prototype of the wing body of FIG. **1**.

For take-off the motor was running at one-third of its maximum power. Stable flight speed was measured as approximately 5.5 metres per second.

A similar tethered test was carried out using a single lifting member, of the type shown in FIG. **1** with its rotor **2** driven by an electric motor, mounted on a mast and counterbalanced by a mass arm. With such an apparatus the various parameters shown in FIG. **4** were determined. They are as follows:

V represents the voltage applied to the motor.

A represents the motor current in amps.

The third column shows the rotor speed in r.p.m..

W represents the rotor input power in watts.

The fifth column represents the forward (propulsive) thrust measured when the lifting member was held stationary, i.e. not allowed to orbit the mast.

The sixth column shows the average time to complete one revolution about the mast, when in the steady state.

The seventh column tabulates the lift force in grams.

The eighth column is the quotient of lift (gm) divided by rotor input power (watts) (i.e. the value in the seventh column divided by the value in the fourth column).

The ninth column illustrates the ratio of static thrust:lift (static thrust as shown in the fifth column, and lift as measured while the wing was in motion) for each value of the rotor speed and power quoted in the third and fourth columns.

FIG. **5** illustrates a plot of the input power of the rotor measured in watts, as the ordinate, and the lift in grams measured as the abscissa. The points correspond to the measured values tabulated in FIG. **4**, and the straight line illustrates the theoretical (compromise) plot and can be seen to be a nearly straight line.

In other words, the efficiency of the lifting member shown in FIG. **1** appears to be constant over the range of rotor speeds tested, and over the orbiting speeds encountered.

There are of course various alternative possibilities for the geometry of the rotor used with the device of FIG. **1**. For example, the thickness and chord values of the rotor vanes **5** may be varied. The angle of incidence (30° in FIG. **1**) of the rotor vanes may be changed. Also, the angle of are subtended by the trough **3** may be varied.

With the device shown in FIG. **1** it has been discovered that, for a given rotor speed, the lift tends to increase as the speed increases. Bearing in mind that the vertical projection P_1 of the part of the rotor on which the incident air impinges is much greater than the projection P_2 on to a line normal to the upper surface **6** of the wing body, it is possible that there is some form of compressibility effect generated through the ram effect of the incident air arriving at the rotor area exposed at the front of the lifting member.

The included angle of taper of the wing body **1** of FIG. **1** is approximately 45°. However, this can be varied. The air discharged tangentially from the rotor thus follows a direction approximately 45° to the vertical, giving substantial lift and thrust components.

Various alternative forms of the lifting member **1** are shown in FIGS. **6** to **12** as follows:

In these various drawings the direction of the airflow relative to the lifting wing is from right to left whereas in FIGS. **1** and **2** it was from left to right. In each view the direction of rotation of the crossflow rotor is illustrated by a single headed arrow and in FIG. **6** a vortex airflow within the rotor is illustrated by doubled headed arrows, with the centre of the vortex being designated v, but in practice the position of the vortex will be located by experiment if the position of the centre needs to be known.

It is known that the efficiency of the crossflow rotor increases with the establishment of a vortex within and eccentric to the path of the rotor vanes, and rotating at an angular velocity much higher than that of the rotor and in the same direction of rotation. The establishment of such a vortex is enhanced by various means shown in FIGS. **6** to **12**.

In FIG. **6** the shroud **3** has its front end turned inward at **3***a*, and the result of this is the formation of a vortex centred within the rotor and having the direction of rotation indicated by the double headed arrows. FIG. **6** also illustrates the angle of incidence a of the wing body **1** measured in terms of the inclination of the underside of the wing body.

FIG. **7** shows a departure from FIG. **6** in that the underside of the wing body **1** is concave to impart a degree of camber to the wing body, but furthermore the wing body of FIG. **7** has additional control features. At the front end of the shroud **3** is a movable baffle **11** which can be retracted to the position shown in FIG. **7** to allow maximum airflow into the rotor or can be extended upwardly and rightwardly so as to mask the inlet of the rotor to some extent, and thus to control the efficiency of that particular lifting body.

Also shown in FIG. **7** is a movable spoiler **12** which is illustrated in FIG. **7** as being extended so as to attenuate or to destroy the vortex. This again provides a measure of control of the efficiency of the lifting body.

It is envisaged that the baffle **11** and the spoiler **12** would be able to be used independently of one another, or together in the same embodiment, and for the sake of simplicity they have been shown in FIG. **7** as both being present. In FIG. **7** the shroud **3** is no longer concentric with the rotor **2** but has its end points **3***b* and **3***c* closer to the path of the vanes **5** of the rotor than is the shroud at a point between them (for example where the spoiler **12** is mounted), and this helps to generate the vortex provided either there is no spoiler **12** present or that spoiler has been moved anticlockwise from the FIG. **7** position to lie flush with the shroud **3**.

FIG. **8** again has the shroud **3** non-concentric between the points **3***b* and **3***c*, in order to establish the vortex, but in this case there is a forward extension **3***d* of the shroud from the point **3***b* and substantially concentric with the rotor vane path.

On the other hand, FIG. **9** lacks this forward extension **3***d* and provides a more open construction which, for a given speed of rotation of the crossflow rotor **2**, is able to admit and discharge a greater volume flow rate of air than with the FIG. **8** embodiment.

FIG. **10** provides for a larger air inlet area and relies on a bulge **1***a* of the lifting body **1** to define the necessary non-concentric portion, even though in this case there is no shroud as such. The formation of the vortex results from the cut away configuration of the part of the lifting body **1** facing the crossflow rotor **2**. Towards the lower leading part **1***b* of the lifting body **1** is a concave section which, together with guide vanes **15**, defines an inlet path or nozzle to guide incident air into the rotor blade path and hence to establish better the vortex and the flow through the crossflow rotor.

FIG. **11** again uses a bulge **1***a*, but this time positioned much higher on the lifting body **1** so that the air inlet "nozzles" defined by the convex surface of the lifting body **1** between bulge **1***a* and front **1***b*; also the two guide vanes **15** are much longer than in the FIG. **10** embodiment. This appears to give the most open configuration of the rotor, allowing the best possible flow conditions through the rotor.

FIGS. **12***a* and **12***b* illustrate an alternative form of the lifting body **1** in which the inlet configuration can be altered in flight to control the efficiency of the lifting body. FIG. **12***a* shows a set of four straight inlet guide vanes **17**, pivotable about their respective shafts **18**, between the open position shown in FIG. **12***a* and a closed position shown in FIG. **12***b*. The lifting body **1** does have a vestige of the shroud **3**, and it is possible to liken the inlet guide vanes **17** in their FIG. **12***a* position to the inlet guide vanes **15** of FIGS. **10** and **11**, and in their closed (**12***b*) position to the shroud extension **3***d* of FIG. **8** or the shrouds **3** of FIGS. **6** and **7**.

Although only FIGS. **7** and **10** illustrate camber of the lifting wing body by means of a concave underside, it would of course be appreciated that any of the embodiments shown may have such a concave underside and/or a convex upper surface (**6** in FIG. **1**) to impart camber to the body.

Although the above description is based on a lifting member for an aircraft, there are various other possibilities. It may be that the device may have hydrodynamic applications, for example in propelling boats using such a member as an immersed keel or a hydrofoil wing.

In the aerodynamic field, the device may also be used for propelling and controlling boats using the aerodynamic effect rather than the hydrodynamic thrust of an immersed screw.

When used as the lifting wing for an aircraft, as mentioned above it is possible for other thrust means to be omitted and for the airflow generated by the rotor to provide all of both thrust and lift. With reference to the (model) aircraft depicted in FIG. **3**, the drive motor for the rotors may operate such that pushing the control column to the left (port) will cause the rotor(s) of the starboard side lift-generating member to rotate faster than the rotor(s) on the port side, giving controllable roll and yaw to allow a balanced banked turn to be executed. There may still be a rudder to provide for the yaw, in which case this will be connected to the pilot's foot pedals. There may equally be some interconnection between the foot pedals and the speed differential mechanism, so that at high rotor powers there will be less rudder deflection needed for a given degree of yaw.

The elevator may be dispensed with but is more likely to be present and controlled by a trim lever rather than by rearward movement of the control column.

An aircraft incorporating such a lifting member will provide adequate degrees of lift at low speeds and will therefore have good STOL characteristics. The noise generated will be much lower than that of a conventional jet or propeller-driven machine. Because a large quantity of air is moving at a very low speed through the rotor the rotor blades themselves move slower than a conventional driving propeller so the blade noise can be much lower than that of a propeller.

In order to reduce noise levels still further it may be advantageous to shape the rotor vanes **5** so as to follow the path of a very coarse pitch helix about the axis of rotation of the shaft **4** so that they are nearly, but not quite, straight. This may avoid any tendency for a sudden noise to be created as each blade enters the trough at the trailing edge of the trough because whereas a straight blade parallel to that trough trailing edge will pass the trough edge at a single instant, a slightly helical blade will not but will instead have a point of approach which travels along the span of the wing body **1** (rather like the shearing action of the rotary blades of a cylinder mower passing a stationary straight blade).

An aeroplane incorporating such a lifting member will, for example, be applicable to sport and tourism in that an open-cockpit aircraft can be constructed to fly slowly and quietly using such a system. Equally, it can be useful for carrying loads over short distances (in view of its low flying speed). Furthermore, it can be useful for crop-dusting.

For passenger transport it may be particularly convenient to use this as a shuttle craft between nearby airports.

In the event of engine failure the spanwise rotors may be driven in autorotation by the airflow, so that recovery from a loss of lift would require simply an increase in forward speed, in a dive, and then, on nearing the ground, flattening out the flight path to exploit the kinetic energy of the rotor somewhat like the case of engine-off autorotation of a helicopter.

I claim:

1. A lift-generating member comprising a wing defining a front end and a trailing edge, opposed first and second wing surfaces which converge towards said trailing edge, and a spanwise extending tangential-flow rotor having vanes and positioned adjacent the front end and said first wing surface to define an air intake region and an air discharge region along the circumferential path of the rotor vanes; wherein the rotor rotates in a direction which carries the rotor vanes in the part of their path which is adjacent said first wing surface in a direction which extends towards the trailing edge of the wing; characterised in that the rotor projects radially proud of the said first wing surface over at least said air discharge region; and in that the rotor is exposed to air at the front end of the wing to define a leading end of the lift-generating member and to take in air at the front end of said wing and to discharge it over said first wing surface as a result of rotation of the rotor.

2. A lift-generating member comprising a wing defining a front end and a trailing edge, opposed first and second wing surfaces which converge towards said trailing edge, and a spanwise extending tangential-flow rotor having vanes and positioned adjacent the front end and said first wing surface to define an air intake region and an air discharge region along the circumferential path of the rotor vanes; wherein the rotor rotates in a direction which carries the rotor vanes in the part of their path which is adjacent said first wing surface in a direction which extends towards the trailing edge of the wing; characterised in that the wing defines a trough extending spanwise of the wing; in that said trough has parallel leading and trailing edges of which the leading edge of the trough defines said front end of the wing and the trailing edge of the trough is flush with said first wing surface; in that the rotor is positioned in said trough; in that the rotor projects radially proud of the said first wing surface over at least said air discharge region; and in that the rotor is exposed to air at the front end of the wing to define a leading end of the lift-generating member and to take in air at the front end of said wing and to discharge it over said first wing surface as a result of rotation of the rotor.

3. A lift-generating member according to claim **2**, wherein said rotor includes a plurality of discs extending perpendicular to the span of said wing, said rotor vanes being mounted between the discs to extend in a direction parallel to the axis of rotation of said rotor body between adjacent said discs, and being secured to the discs with an angle of inclination relative to the radius of the disc to which the vane is attached.

4. A lift-generating member according to claim **2**, wherein said wing has an effective camber between its front end and its trailing edge by virtue of the geometry of the part of the wing located behind the rotor.

5. A lift-generating member according to claim **2**, wherein each said rotor vane extends along a helix centered on the axis of rotation of the rotor.

6. A lift-generating member according to claim **2**, wherein the front end of the wing includes a shroud around a part of the circumference of the rotor and having one part which is closer to the rotor circumference than is the remainder of the shroud.

7. An aircraft incorporating port and starboard lift-generating members in accordance with claim **2**, and drive means for driving the spanwise rotors of said lift generating members, and including means to vary the distribution of power between the port and starboard lift generating member rotors.

8. An aircraft according to claim **7**, wherein said power distribution varying means are controlled by a pilot's control column of the aircraft whereby displacement of the control column to port generates a condition in which the power distribution to the rotors provides for a higher speed of the starboard rotor as compared with that of the port rotor.

9. An aircraft according to claim **7**, wherein said rotors provide the sole means of generating propulsive thrust for the aircraft.

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(54) **CYCLOIDAL HYBRID ADVANCED SURFACE EFFECTS VEHICLE**

(76) Inventors: **James H. Boschma JR.**, Huntsville, AL (US); **Michael McNabb**, Huntsville, AL (US)

Correspondence Address:
Neil K. Nydegger, Esq.
NYDEGGER & ASSOCIATES
348 Olive Street
San Diego, CA 92103 (US)

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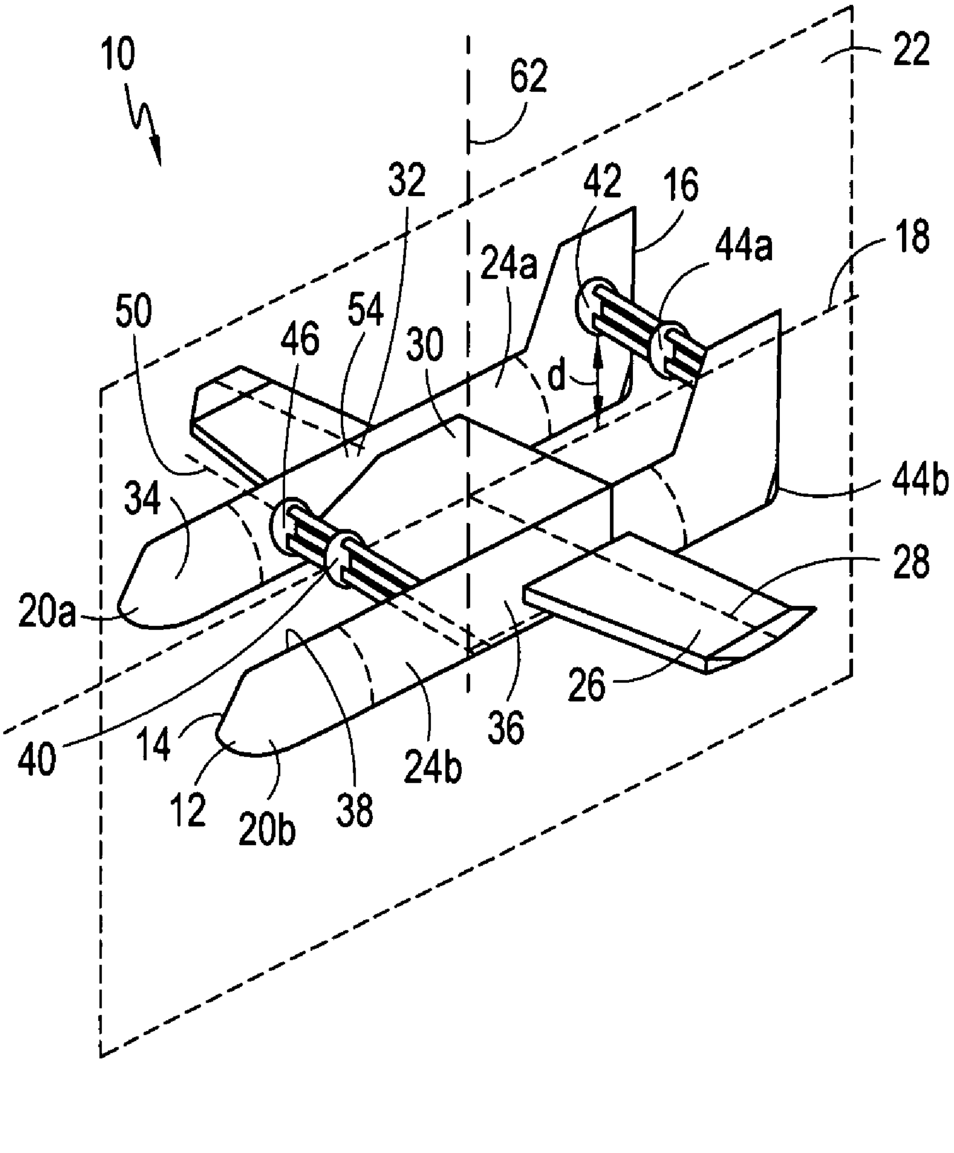
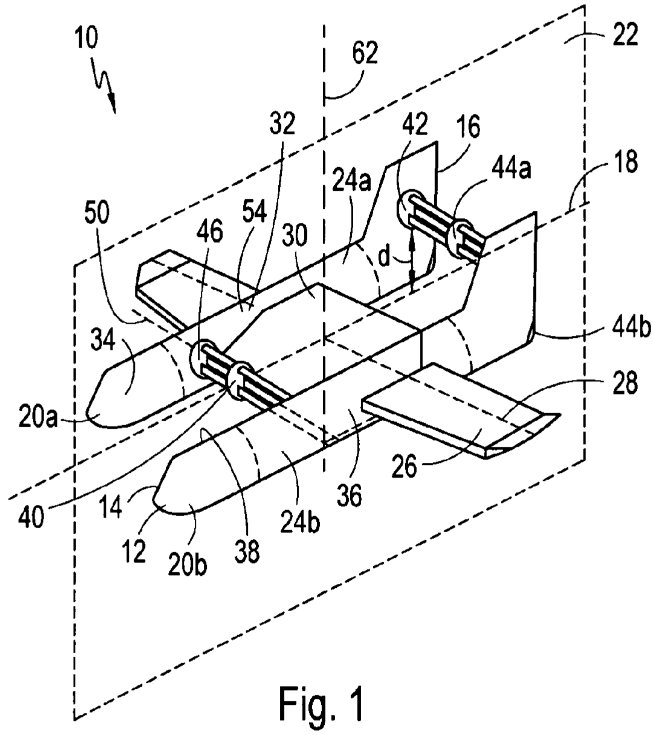
(57) **ABSTRACT**

A "wing in ground effect" aerial vehicle includes a wing mounted on a fuselage, and two cycloidal propulsion units for providing lift, thrust and longitudinal control. Additional lift is provided by a lighter-than-air gas such as helium contained in the fuselage. Operationally, the two cycloidal propulsion units and the volume of lighter-than-air gas are concertedly regulated to achieve "wing in ground effect" flight. Importantly, the two cycloidal propulsion units may operate in one of several modes, to include a curtate mode, a prolate mode, and a fixed-wing mode. Additionally, the vehicle may hover. Also, a thruster unit is mounted on the fuselage for providing forward thrust in combination with, or in lieu of, the two cycloidal propulsion units.




10
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32
42
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44a
18
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24a
d
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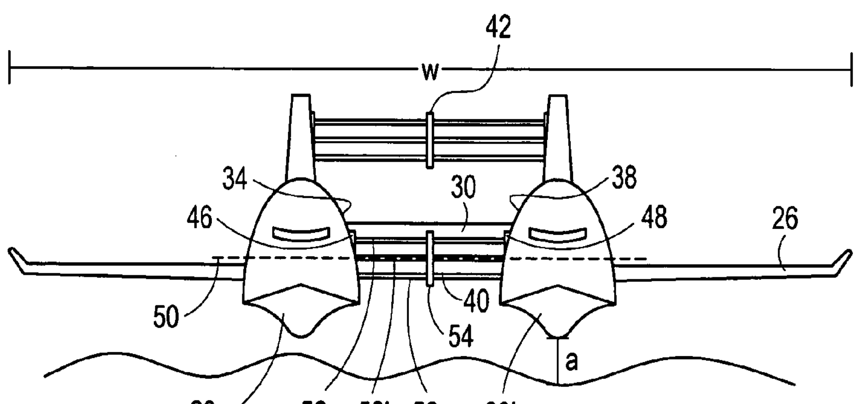
26
40
14
36
24b
12
38
20b
Fig. 1


42
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34
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54
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20a
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Fig. 2

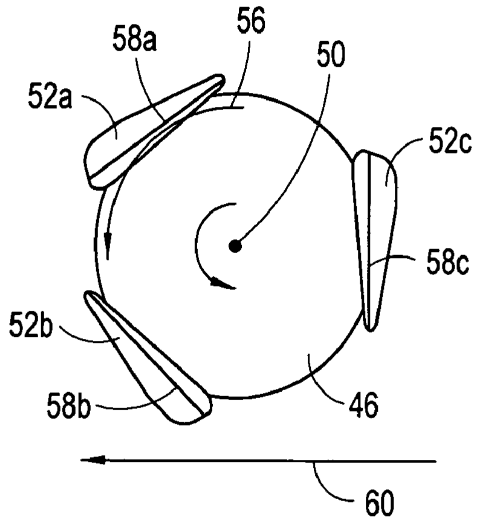

Fig. 3A

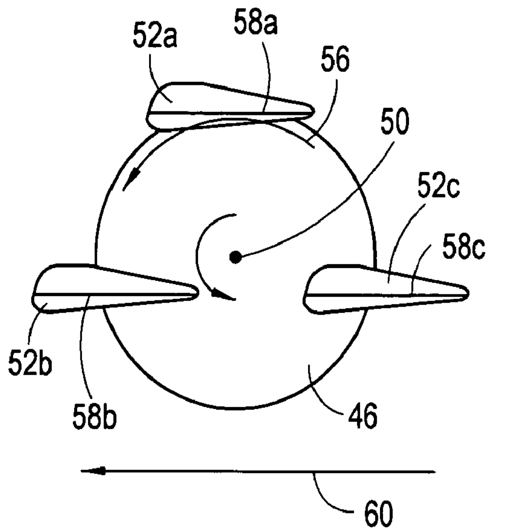

Fig. 3B

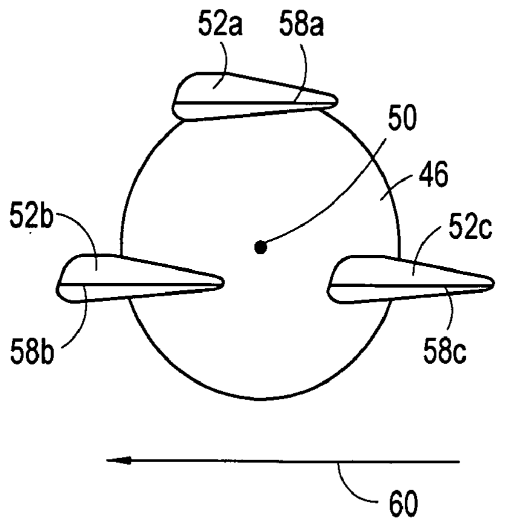

Fig. 3C

CYCLOIDAL HYBRID ADVANCED SURFACE EFFECTS VEHICLE

FIELD OF THE INVENTION

[0001] The present invention pertains generally to aerial vehicles. More particularly, the present invention pertains to "wing in ground effect" aerial vehicles. The present invention is particularly, but not exclusively, useful as a "wing in ground effect" aerial vehicle having a plurality of cycloidal propulsion units for providing thrust, lift and longitudinal stability.

BACKGROUND OF THE INVENTION

[0002] Traditionally, the long-range transport of civilian and military cargo has been accomplished by either sea lift assets or large cargo-carrying aircraft. In the case of ocean-going vessels, large port facilities are required. Also, the time required to transport cargo by sea for long distances can be significant. In the case of large cargo-carrying aircraft, the size of the payload is limited. With this as a limitation, the costs to operate such aircraft (e.g. maintenance and fuel costs) can be prohibitive. The air transport of cargo, however, is relatively fast. Airframe designers, therefore, continue to look for ways to maximize the cargo carrying capability of aircraft, while maintaining or improving on the fuel efficiency and transport range of these aircraft. Typically, the engineering options that are considered include designing lighter aircraft, designing aircraft with more efficient engines, and designing aircraft with greater fuel carrying capability. Yet another option has been to develop aircraft that take advantage of certain natural phenomena associated with winged flight, specifically surface effects or "wing-in-ground" (WIG) effects.

[0003] To better understand the operational advantages and limitations of WIG vehicles or aircraft, it is important to first understand the underlying aerodynamics of the "wing in ground" effect. In general, when a fixed-wing aircraft flies near the earth's surface, an air cushion is created between the underside of the wing and the ground. In this flight environment, the air cushion imparts lift to the aircraft, while at the same time reducing drag on the aircraft. In actuality, the air cushion effect results from two physical phenomena often respectively referred to as "chord-dominated ground effect" and "span-dominated ground effect". In particular, chord-dominated ground effect acts to increase the lift of the aircraft, while span-dominated ground effect acts to reduce the induced drag on the aircraft. The combined effect of the two phenomena is to increase the lift to drag, or L/D ratio, thereby allowing for more efficient flight on the "cushion of air".

[0004] As can be appreciated by the skilled artisan, the span-dominated ground effect is most apparent in aircraft with a high aspect ratio wing. Specifically, the higher the aspect ratio, which is the wingspan divided by the average chord length of the wing, the lower the induced drag will be. Notably, as the wing gets closer to the earth's surface and the wing vortices are constrained and weakened at the wing tips, the "effective" aspect ratio of the wing increases beyond the geometric aspect ratio. As a result of the increase in this "effective" aspect ratio, the induced drag is reduced. Also, a reduction in drag is most pronounced when the ratio of the aircraft operational altitude to the length of the wingspan is on the order of 1:10. It can be mathematically shown that the net result of an increased "effective" aspect ratio, and a decreased aircraft altitude-to-wingspan ratio, can be a reduction in induced drag by as much as 50%.

[0005] Chord-dominated ground effect relies primarily on the fact that pressure under the wing increases as the aircraft flies nearer to the ground. Therefore, as the aircraft-to-ground distance decreases, the lift imparted to the aircraft from higher pressures under the wing significantly increases. Due to these combined effects (i.e. span dominated and chord dominated ground effects), WIG vehicles are able to transport heavier loads further, using less power and less fuel than would be possible for flight out of ground effect. Not surprisingly, WIG vehicles normally operate over water, where it is possible to fly close to the surface of the earth for extended distances without encountering obstructions.

[0006] A critical design concern for WIG vehicles is longitudinal stability and control as the aircraft transitions from WIG dominated flight to "free flight" at higher altitudes. In the transition between WIG flight and "free" flight, WIG vehicles have a tendency to dramatically "pitch up." Traditional WIG designs have compensated for this "pitch moment" by employing various techniques for aerodynamic pitch control well known in the aircraft industry, to include: using very large vertical tail planes; optimizing the vehicle center of gravity; and modifying the wing design. Although many of these solutions are effective at controlling "pitch up," many also increase the vehicle weight which adversely impacts both fuel efficiency and power.

[0007] In light of the above, it is an object of the present invention to provide an aerial vehicle that takes advantage of the "wing-in-ground effect" to optimize lift capability, vehicle speed, fuel efficiency and operating range. Another object of the present invention is to provide an aerial vehicle that integrates "lighter-than-air" lift and cycloidal propulsion subsystems into a WIG vehicle. Still another object of the present invention is to provide an aerial vehicle with improved longitudinal stability and control. Yet another object of the present invention is to provide an aerial vehicle that is simple to operate, relatively easy to manufacture, and comparatively cost effective.

SUMMARY OF THE INVENTION

[0008] The aerial vehicle of the present invention includes a fuselage which defines a longitudinal axis. Preferably, the fuselage is comprised of two pods, wherein the first pod is juxtaposed with and is parallel to the second pod. Further, the two pods are positioned an equal distance, in opposite directions, from a plane of symmetry containing the longitudinal axis. Also, each pod of the fuselage is formed with an interior chamber for receiving and containing a lighter-than-air gas such as helium.

[0009] In addition to the two pods, the vehicle includes a wing that is fixedly mounted on the fuselage and is substantially symmetrical relative to the plane of symmetry. Also mounted on the fuselage are two cylindrical-shaped cycloidal propulsion units that are positioned between the two pods. More specifically, each unit is oriented with its longitudinal axis substantially perpendicular to the plane of symmetry. Further, one propulsion unit is positioned forward from the center of the fuselage, while the other propulsion unit is positioned aft of the center of the fuselage.

[0010] In addition to the two cycloidal propulsion units, the vehicle also includes a pair of thruster units that are mounted at the aft end of the fuselage. In the preferred embodiment of the present invention, a respective thruster unit is mounted on the aft end of each of the two pods. Although the thruster units are positioned to provide forward thrust for the vehicle, they are also able to provide some turning and directional control for the vehicle.

[0011] In addition to the propulsion units disclosed above, a cargo container is also mounted on the vehicle between the pods of the fuselage. In particular, the cargo container is a generally airfoil-shaped container mounted between the two pods and positioned aft of the forward cycloidal propulsion unit.

[0012] With specific regard to the two cycloidal propulsion units, the primary and secondary hub assemblies of each unit are selectively controlled to rotate about a hub axis of rotation that is perpendicular to the plane of symmetry. In each unit, a plurality of airfoil shaped blades extend between, and are attached to, the two hub assemblies for rotation therewith. Additionally, each blade is supported by a center guide that allows each blade to individually rotate about its own blade axis. Within this configuration, the two cycloidal propulsion units can be set to operate in one of three modes of operation. As more fully disclosed in co-pending U.S. patent application Ser. No. 10/690,284 which issued to Tierney and is assigned to the same assignee as the present invention, these three modes of operation are a curtate mode, a prolate mode, and a fixed-wing mode. In the curtate and the prolate modes of operation, the two hub assemblies of each cycloidal propulsion unit rotate about their respective axis of rotation. Also, in addition to their rotation with the hub assemblies, the blades are individually rotated in a predetermined manner about their own blade axis. Consequently, in these two modes, the rotation of the hub assemblies and the independent rotation of the blades provide the aerial vehicle with thrust, lift, and longitudinal stability. In the fixed-wing mode of operation, however, the hub assemblies of the cycloidal propulsion units are not rotated. Instead, in the fixed-wing mode, the substantially stationary blades are controlled only to provide vertical lift and longitudinal stability. Accordingly, the thrust necessary to propel the vehicle forward, in the fixed-wing mode of operation, is provided by the thruster units.

[0013] As indicated above, in addition to providing forward thrust in the fixed-wing mode of operation, the thruster unit may be used to assist in turning the vehicle, and to maintain directional control during flight. Further, the thruster unit may be used to turn the vehicle as it hovers. For the special flight condition for the hover mode, lift is provided by the combined effects of both lighter-than-air gas in the pod chambers and operation of the propulsion units in the curtate mode.

[0014] Once in flight, the vehicle flies within a specified flight envelope, close to the earth's surface. More particularly, the flight envelope is specifically selected to take maximum advantage of the wing-in-ground-effect, i.e. minimize drag and maximize vehicle lift. In all instances, the incorporation of a lighter-than-air gas in the interior chambers of the fuselage adds to the lift capability of the aerial vehicle of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The novel features of this invention, as well as the invention itself, both as to its structure and its operation, will be best understood from the accompanying drawings, taken in conjunction with the accompanying description, in which similar reference characters refer to similar parts, and in which:

[0016] **FIG. 1** is a perspective view of the aerial vehicle of the present invention;

[0017] **FIG. 2** is a front elevation view of the aerial vehicle of the present invention;

[0018] **FIG. 3A** is a schematic view of three airfoil shaped blades and a hub in a curtate mode of operation;

[0019] **FIG. 3B** is a schematic view of three airfoil shaped blades and a hub in a prolate mode of operation; and

[0020] **FIG. 3C** is a schematic view of three airfoil shaped blades and a hub in a fixed-wing mode of operation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] Referring initially to **FIG. 1**, an aerial vehicle in accordance with the present invention is shown and is generally designated **10**. As shown, the vehicle **10** includes a fuselage **12** having a forward end **14** and an aft end **16**. Further, the fuselage **12** defines a longitudinal axis **18**. Preferably, the fuselage **12** is comprised of two elongated pods, of which pods **20***a* and **20***b* are exemplary. As shown, pod **20***a* is juxtaposed with and parallel to pod **20***b*. Also, the two pods **20***a* and **20***b* are substantially parallel to a plane of symmetry **22** containing the longitudinal axis **18**. As contemplated by the present invention, pod **20***a* and pod **20***b* are positioned on either side of the plane of symmetry **22**, and they are spaced an equal distance from the plane of symmetry **22**. As shown in phantom in **FIG. 1**, pod **20***a* and pod **20***b* are each formed with an interior chamber, chambers **24***a* and **24***b* respectively, for receiving and containing a lighter-than-air gas such as helium.

[0022] Still referring to **FIG. 1**, the vehicle **10** includes a wing **26** that is fixedly mounted on the fuselage **12**. As shown, the wing **26** defines a wing axis **28** that is perpendicular to the longitudinal axis **18** of the fuselage **12**. Also, as mounted on the fuselage **12**, the wing **26** is substantially symmetrical relative to the plane of symmetry **22**. In addition to the wing **26**, the vehicle includes a cargo container **30** for storing cargo to be transported by the vehicle **10**. As shown in **FIG. 1**, the cargo container **30** is positioned generally in the center of the fuselage **12** and is mounted between pod **20***a* and pod **20***b*. More specifically, the right side **32** of the cargo container **30** is mounted on the left side **34** of pod **20***a*, and the left side **36** of the container **30** is mounted on the right side **38** of pod **20***b*.

[0023] Cross-referencing **FIG. 1** with **FIG. 2**, it can be seen that the aerial vehicle **10** includes a cylindrical-shaped cycloidal propulsion unit **40** that is mounted on the fuselage **12**. As shown, the cycloidal propulsion unit **40** is mounted forward of the wing **26** and between pod **20***a* and pod **20***b*. More specifically, the propulsion unit **40** is mounted on the left side **34** of pod **20***a* and on the right side **38** of pod **20***b*. Further, the cycloidal propulsion unit **40** is oriented substantially perpendicular to the plane of symmetry **22**. In addition to the cycloidal propulsion unit **40**, the aerial vehicle **10** includes a cycloidal propulsion unit **42**. As can be seen in **FIG. 1**, the cycloidal propulsion unit **42** is mounted aft of the wing **26** and between pod **20***a* and pod **20***b*. Similar to the propulsion unit **40**, the propulsion unit **42** is mounted on the left side **34** of pod **20***a* and on the right side **38** of pod **20***b*. Additionally, the cycloidal propulsion unit **42** is oriented substantially perpendicular to the plane of symmetry **22**, and it is vertically displaced from the longitudinal axis **18** by a distance "d".

[0024] Referring still to **FIG. 1**, the vehicle **10** of the present invention also includes a pair of thruster units **44***a* and **44***b*. Preferably, the thruster unit **44***a* is mounted on pod **20***a*, and it is positioned generally at the aft end **16** of the fuselage **12**. Additionally, the thruster unit **44***b* is mounted on pod **20***b*, also at the aft end **16** of the fuselage **12**.

[0025] Considering now the cycloidal propulsion unit **40** in greater detail, it can be seen by cross-referencing **FIG. 1** and **FIG. 2** that the cycloidal propulsion unit **40** includes a primary hub assembly **46** that is mounted on the left side **34** of pod **20***a*. Further, a secondary hub assembly **48** is mounted on the right side **38** of pod **20***b*. Each of the two hub assemblies, **46** and **48**, rotate about a same axis of rotation **50** that is substantially perpendicular to the plane of symmetry **22**. As can be seen, a plurality of airfoil shaped blades, of which blades **52***a*, **52***b*, and **52***c* are exemplary, extend between the two hub assemblies **46** and **48** (see **FIG. 2**). As shown, the blades **52***a*, **52***b* and **52***c* are oriented substantially parallel to the axis of rotation **50**. The blades **52***a-c* are attached to the hub assemblies **46** and **48** for rotation therewith. Further, a center guide **54** is positioned to support the blades **52***a-c*. As contemplated by the present invention, the center guide **54** is oriented substantially parallel to the two hub assemblies **46** and **48**. Additionally, the center guide **54** is positioned equidistant from each of the hub assemblies **46** and **48**, which is to say generally in the center of the length of the blades **52***a-c*. As shown in **FIGS. 1 and 2**, the blades **52***a-c* pass through, and are attached to, the center guide **54**. In this configuration, the center guide **54** helps to maintain the separation and the orientation of the blades **52***a-c* as the guide **54**, and the blades **52***a-c*, rotate about the axis of rotation **50**.

[0026] As disclosed above, the vehicle **10** includes a cycloidal propulsion unit **42**. As envisioned by the present invention, and as can be appreciated by referring to **FIGS. 1 and 2**, the cycloidal propulsion unit **42** is substantially the same as the cycloidal propulsion unit **40**. Stated differently, the structure and functionality of the two cycloidal propulsion units, **40** and **42**, are substantially the same.

[0027] In the operation of the present invention, the interior chambers **24***a* and **24***b*, of pod **20***a* and pod **20***b* respectively, are filled with a lighter-than-air gas such as helium prior to flight operations. An important aspect of the present invention is that the propulsion units **40** and **42** may be directed by a flight control system (not shown) to operate in one of several different modes, i.e. a curtate mode (**FIG. 3A**), a prolate mode (**FIG. 3B**), or a fixed-wing mode (**FIG. 3C**).

[0028] Referring now to **FIG. 3A**, operation of the cycloidal propulsion unit **40** in the curtate mode is shown. In this mode, the blades **52***a-c* rotate with the primary hub assembly **46** about the axis of rotation and travel along a circular path **56**. Importantly, in the curtate mode, the blade chord lines **58***a*, **58***b* and **58***c* remain generally tangent to the circular path **56** as the blades **52***a-c* rotate about the axis **50**.

[0029] Considering now the prolate mode of operation, as shown in **FIG. 3B**, the primary hub assembly **46** and the blades **52***a-c* still rotate about the axis of rotation **50**. In the prolate mode, however, the blade chord lines **58***a-c* remain generally parallel to the direction of flight of the vehicle **10** (indicated by arrow **60**). An important aspect of the present invention is that in both the curtate mode of operation (**FIG. 3A**), and the prolate mode of operation (**FIG. 3B**), the rotation of the hub assembly **46** and the blades **52***a-c* provides the vehicle **10** with lift, thrust, and longitudinal stability. Further, the thruster units **44***a* and **44***b* (see **FIG. 1**) may also be used to provide forward thrust during the curtate and prolate modes of operation, in combination with the cycloidal propulsion units **40** and **42** (see **FIG. 1**).

[0030] In the fixed-wing mode of operation, as shown in **FIG. 3C**, neither the primary hub assembly **46** nor the blades **52***a-c* rotate about the axis of rotation **50**. Instead, the hub assembly **46** and the blades **52***a-c* are held substantially stationary. Additionally, the blade chord lines **58***a-c* are maintained generally parallel to the direction of flight **60**. In the fixed-wing mode of operation, the thruster units **44***a* and **44***b* may be used to assist in turning the vehicle **10**, as well as providing auxiliary pitch and yaw control for maintaining directional control of the vehicle **10**.

[0031] In addition to forward flight using one of the three operational modes disclosed above (i.e. curtate, prolate or fixed-wing), the vehicle **10** may also hover. While hovering, the cycloidal propulsion units **40** and **42** can be used in the curtate mode to help suspend the vehicle **10** in the air. In the hover mode, the thruster units **44***a* and **44***b* can be used to turn the vehicle **10**. More particularly, the thruster units **44***a* and **44***b* are used to rotate the vehicle **10** about a vertical axis **62** (**FIG. 1**) which lies in the plane of symmetry **22**, and which is substantially perpendicular to the longitudinal axis **18**.

[0032] As envisioned by the present invention, the preferred operating altitude for the vehicle **10** is one that optimizes lift, and minimizes drag, by relying on the "wing in ground" effect. Thus, the preferred operational altitude for the vehicle **10** is one in which the altitude-to-wingspan ratio (a/w) is approximately 1:10. Referring once again to **FIG. 2**, the preferred wingspan "w" for the vehicle **10** is about 840 feet. In order to derive the maximum benefit from the "wing-in-ground" effect, therefore, the preferred operating altitude "a" for the aerial vehicle **10** is about 80-100 feet above the earth's surface.

[0033] While the particular Cycloidal Hybrid Advanced Surface Effects Vehicle as herein shown and disclosed in detail is fully capable of obtaining the objects and providing the advantages herein before stated, it is to be understood that it is merely illustrative of the presently preferred embodiments of the invention and that no limitations are intended to the details of construction or design herein shown other than as described in the appended claims.

What is claimed is:

1. An aerial vehicle which comprises:

a fuselage formed with at least one chamber, said fuselage defining a longitudinal axis;

a wing fixedly mounted on said fuselage, said wing being substantially symmetrical relative to a plane containing the axis;

a first cycloidal propulsion unit mounted on said fuselage for generating a first thrust vector substantially in the plane of symmetry;

a second cycloidal propulsion unit mounted on said fuselage for generating a second thrust vector substantially in the plane of symmetry, wherein said second cycloidal propulsion unit is axially distanced from said first cycloidal propulsion unit;

a means for selectively filling said chamber with a volume of lighter-than-air gas to provide lift for said vehicle; and

a means for concerted control of said first cycloidal propulsion unit, said second cycloidal propulsion unit, and said volume of lighter-than-air gas.

2. A vehicle as recited in claim 1 further comprising a thruster unit mounted on said fuselage for turning and providing auxiliary pitch and yaw control for said vehicle.

3. A vehicle as recited in claim 2 wherein said fuselage further comprises:

a first pod formed with a first chamber, said first pod being substantially cylindrical shaped to define an axis extending substantially parallel to the longitudinal axis of said fuselage; and

a second pod formed with a second chamber, said second pod being substantially cylindrical shaped to define an axis juxtaposed with and parallel to the axis of the first pod, with said first cycloidal propulsion unit and said second cycloidal propulsion unit respectively mounted on said fuselage between said first pod and said second pod.

4. A vehicle as recited in claim 3 further comprising a cargo container mounted on said fuselage between said first pod and said second pod.

5. A vehicle as recited in claim 3 wherein said first cycloidal propulsion unit comprises:

a primary hub assembly mounted on said first pod for rotation of said primary hub assembly about an axis of rotation, wherein the axis of rotation is substantially perpendicular to the longitudinal axis of the fuselage;

a secondary hub assembly mounted on said second pod for rotation of said secondary hub assembly about the axis of rotation; and

a plurality of airfoil shaped blades, wherein each said blade defines a blade axis and is attached to said primary hub assembly and to said secondary hub assembly for rotation therewith and for establishing an angle of attack for each said blade, and further wherein said blade axes are oriented substantially parallel to the axis of rotation.

6. A vehicle as recited in claim 5 wherein said second cycloidal propulsion unit comprises:

a primary hub assembly mounted on said first pod for rotation of said primary hub assembly about an axis of rotation, wherein the axis of rotation is substantially perpendicular to the longitudinal axis of the fuselage;

a secondary hub assembly mounted on said second pod for rotation of said secondary hub assembly about the axis of rotation; and

a plurality of airfoil shaped blades, wherein each blade defines a blade axis and is attached to said primary hub assembly and to said secondary hub assembly for rotation therewith and for establishing an angle of attack for each said blade, and further wherein said blade axes are oriented substantially parallel to the axis of rotation.

7. A vehicle as recited in claim 6 wherein said first cycloidal propulsion unit is operated in a mode of operation selected from the group consisting of a curtate mode, a prolate mode and a fixed-wing mode.

8. A vehicle as recited in claim 7 wherein said second cycloidal propulsion unit is operated in a mode of operation selected from the group consisting of a curtate mode, a prolate mode and a fixed-wing mode.

9. A vehicle as recited in claim 8 wherein said first cycloidal propulsion unit and said second cycloidal propulsion unit are concertedly operated in the fixed-wing mode, and further wherein said thruster unit propels said vehicle.

10. A vehicle as recited in claim 8 wherein said first cycloidal propulsion unit and said second cycloidal propulsion unit are concertedly operated in the curtate mode, to hover said vehicle, and further wherein said thruster unit is used to turn said vehicle during hover.

11. A vehicle for aerial flight which comprises:

a fuselage defining a longitudinal axis, said fuselage having a first pod formed with a first chamber and a second pod formed with a second chamber, wherein said first pod and said second pod define respective axes, with the pod axes juxtaposed and parallel to each other;

a wing fixedly mounted on said fuselage, said wing being substantially symmetrical relative to a plane containing the fuselage axis;

a first propulsion means for generating a first thrust vector substantially in the plane of symmetry, wherein said first propulsion means is mounted on said fuselage between said first pod and said second pod, and further wherein said first propulsion means is positioned on said fuselage forward of said wing;

a second propulsion means for generating a second thrust vector substantially in the plane of symmetry, wherein said second propulsion means is mounted on said fuselage between said first pod and said second pod, and further wherein said second propulsion means is positioned on said fuselage aft of said wing;

a means for filling said first chamber and said second chamber with a lighter-than-air gas to provide lift for said vehicle; and

a means for concertedly controlling said first and said second propulsion means.

12. A vehicle as recited in claim 11 wherein said first propulsion means and said second propulsion means are each a cycloidal propulsion unit.

13. A vehicle as recited in claim 12 wherein said first cycloidal propulsion unit is operated in a mode of operation selected from the group consisting of a curtate mode, a prolate mode and a fixed-wing mode.

14. A vehicle as recited in claim 13 wherein said second cycloidal propulsion unit is operated in a mode of operation selected from the group consisting of a curtate mode, a prolate mode and a fixed-wing mode.

15. A vehicle as recited in claim 14 which further comprises a thruster unit mounted on said fuselage, wherein said thruster unit provides auxiliary pitch and yaw control for said vehicle when said first and said second cycloidal propulsion units are operated in a fixed-wing mode.

16. A vehicle as recited in claim 15 wherein said thruster unit turns said vehicle when said vehicle hovers and said first and said second cycloidal propulsion units are both operated in a curtate mode.

17. A method for operating an aerial vehicle which comprises the steps of:

filling a chamber in a fuselage of said vehicle with a volume of lighter-than-air gas to provide lift for said vehicle;

operating at least one cycloidal propulsion unit mounted on said fuselage to propel said vehicle; and

concertedly regulating said cycloidal propulsion unit and the volume of lighter-than-air gas to maintain a predetermined flight altitude for wing-in-ground effect flight.

18. A method as recited in claim 17 further comprising the step of operating said cycloidal propulsion unit in a mode of operation selected from the group consisting of a curtate mode, a prolate mode, and a fixed-wing mode.

19. A method as recited in claim 18 further comprising the step of activating a thruster unit mounted on said fuselage to propel said vehicle forward when said cycloidal propulsion unit is operated in a fixed-wing mode.

20. A method as recited in claim 19 wherein said thruster unit turns said vehicle when said vehicle hovers and said cycloidal propulsion unit is operated in a curtate mode.

21. A vehicle for wing-in-ground effect flight which comprises:

a fuselage formed with at least one chamber, said fuselage defining a longitudinal axis;

a wing having a wing span and a chord length and fixedly mounted on said fuselage, wherein said wing is substantially symmetrical relative to a plane containing the axis, and further wherein an aspect ratio of the wing span to the chord length is greater than ten to one (10:1);

at least one cycloidal propulsion unit for generating a thrust vector substantially in the plane of symmetry;

a volume of a lighter-than-air gas contained within said chamber for providing lift for said vehicle; and

a flight control system for concertedly regulating said cycloidal propulsion unit and the volume of lighter-than-air gas to maintain a predetermined altitude for wing-in-ground effect flight, wherein a ratio of the altitude to the wing span is about 1 to ten (1:10).

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(71) Applicant: **AIRBUS HELICOPTERS DEUTSCHLAND GmbH**
86609 Donauwörth (DE)

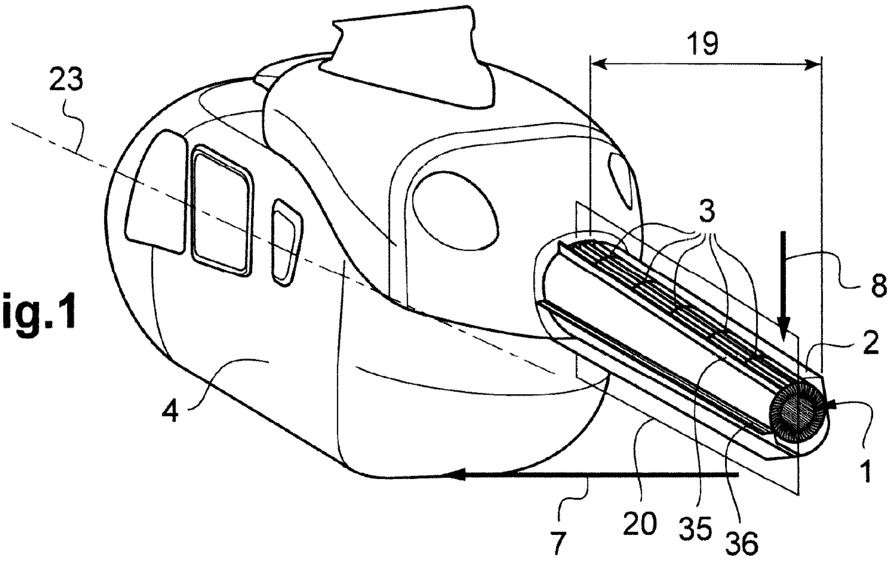
(72) Inventors:
- **Mores, Sebastian**
  D 81479 München (DE)
- **D'Alascio, Alessandro**
  D 85540 Haar (DE)
- **Bebesel, Marius**
  D 81927 München (DE)

(74) Representative: **GPI & Associés**
EuroParc de Pichaury
Bâtiment B2 - 1er Etage
1330, rue Guillibert de la Lauzière
13856 Aix-en-Provence Cedex 3 (FR)

(54) **Helicopter with cross flow fan**

(57) The invention relates to a helicopter with a fuselage (4), at least one engine, a roll axis, at least one main rotor, and at least one housing (2) mounted to said fuselage (4). An air inlet (8) and an air outlet (7) are provided along at least a part of a circumference of the at least one housing (2), said air inlet (8) and said air outlet (7) being formed by angularly offset and separate gaps between an inside segment (33) and an outside segment (34) essentially extending respectively longitudinally in direction of said roll axis. At least one rotatable compressor (1) with a plurality of airfoil blades (6) is provided radial inside said at least one housing (2) between said air inlet (8) and said air outlet (7), said at least one rotatable compressor (1) being drivable by said at least one engine about a fan axis (5) and each chord of said airfoil blades (6) is essentially radial oriented with regard to said fan axis (5).

Fig.1



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Description

[0001] The invention relates to helicopters and particularly to helicopters with an anti-torque device according to the preamble of claim 1.

[0002] A configuration of a current rotary wing flying machine, e.g. a helicopter, comprises a main rotor, which in operation transmits a torque around a yaw axis of the helicopter. In operation this torque is countered by an empennage with typically an anti-torque device, such as a tail rotor, a shrouded tail rotor, i.e. a so called Fenestron, and a vertical fin. Exception made for the fin, all other anti-torque devices need power in order to provide this anti-torque needed for a helicopter operating properly.

[0003] Additionally a typical helicopter configuration needs a horizontal stabilizer for pitch stability by generating negative lift in order to keep the helicopter fuselage in a proper, horizontal position during a typical forward flight. In additional flight conditions, such as push-over, pull-out, etc., the horizontal stabilizer provides sufficient static and dynamic stability. The typical horizontal stabilizer has a fixed incidence angle, hence the force provided by the horizontal stabilizer cannot be changed by the pilot during flight. Therefore, the minimum drag fuselage attitude might not be fully achieved.

[0004] Gathering the information of the anti-torque designs of the state of the art, the following problems occur:

Fixed vertical and horizontal stabilizing surfaces only provide forces in said fixed directions,

Fixed vertical and horizontal stabilizing surfaces do not provide any additional propulsive force,

Open tail-rotors are a potential danger for humans and can be damaged by foreign objects,

[0005] The rotating devices cannot be easily changed in diameter without having major changes and re-designs of the entire helicopter.

[0006] Cross-Flow Fans with blades arranged to a torus-like configuration are known from the heating, ventilating and air conditioning field, providing an airflow passing the blades crosswise. Cross-Flow Fans are characterized by one dominant dimension, namely small in diameter and as long as needed.

[0007] The document GB 9617440 A describes a cross-flow fan integrated in a lifting member, e. g. a wing, in order to create lift for an aircraft's airfoil.

[0008] The document GB 9902653 A describes a cross-flow fan integrated into a lifting member with additionally a movable lip in the ingestion area.

[0009] The document GB 200320870 A describes a cross-flow fan which is integrated into the rear section of an airfoil in order to control the flow around the airfoil. Additionally the document GB 200320870 A describes an enclosed housing which can be closed for cruise flight and opened for high-lift conditions as needed during take-off.

[0010] The document US 2012/0160955 A1 describes a hybrid rotor system for an aircraft which produces lift and thrust in order to propel an aircraft. This hybrid rotor system comprises a magnus rotor, a transverse flow rotor, i. e. a so called cross-flow fan, and a guide mechanism. In general US 2012/0160955 A1 relates only to aircrafts without an additional rotor system, so called cyclogyros, that pulls maximal airflow through both of propulsion and lifting surfaces. A cylindrical radial turbine is embedded in the wing with its axis parallel to the wing and leaving about 2/3 of the diameter exposed above the top side of the wing's length just after the leading edge. This increases the velocity of the airflow across the wing's upper surface beyond that of the forward motion of the aircraft. Consequently the wing of US 2012/0160955 A1 has lift at slow speeds where another wing would stall.

[0011] It is an object of the invention to provide an improved helicopter and particularly it is an object of the invention to provide a helicopter with an improved anti-torque device, to counter-act the main rotor's torque resulting on the fuselage.

[0012] The solution is provided with an improved helicopter and particularly with a helicopter with an improved anti-torque device with the features of claim 1 of the invention.

[0013] According to the invention a helicopter comprises a fuselage, at least one engine, a roll axis and at least one main rotor mounted to said fuselage and drivable connected to said at least one engine about a yaw axis essentially perpendicular to said roll axis. At least one housing of a cross flow fan is mounted to said fuselage, said at least one housing extending longitudinally essentially in direction of said roll axis with an offset relative to said yaw axis. Said at least one housing is at least partly pivotable about its longitudinal axis. Said at least one housing is provided with an air inlet and an air outlet along at least a part of the at least one housing's circumference respectively in direction of said roll axis. Said air inlet and said air outlet form angularly offset and separate gaps in the housing. At least one compressor of the cross flow fan is provided radial inside said pivotable housing between said air inlet and said air outlet, said at least one compressor being drivable by said at least one engine about a fan axis essentially parallel with said roll axis. Each of said at least one compressor comprises a plurality of airfoil blades, i.e. designed by means of aerodynamically optimized airfoils, arranged on a ring around said fan axis and each chord of said airfoil blades is essentially radial oriented with regard to said fan axis. According to an advantage of the invention the cross-flow fan provides first of all anti-torque for the helicopter as a consequence of the angular offset of the separate gaps in the housing for said air inlet and for said air outlet. Said angular offset preferably varies from 10° to 90° for an angle measured between a side from the fan axis to a lateral inlet delimitation of the inlet and a side to a lateral outlet delimitation of the outlet next to said lateral inlet delimitation of the inlet. Said cross-flow fan is characterized by one dominant dimension, namely relative to the overall dimensions of the helicopter small in diameter, while as long as needed. Any fluid, e. g. air, entering the cross-flow fan at the inlet passes crosswise to the fan axis along the radial oriented airfoil blades towards the outlet, providing two consecutive compressions, one after the fluid having entered and another one after having left the ring. The inventive cross-flow fan comprises the compressor, rotating around its fan axis and the special housing built in close contact around the radial outer tips of the airfoil blades of the compressor. The housing in close contact with the radial outer tips of the airfoil blades of the compressor prevents the fluid from trespassing radially the airfoil blades not in line with either the inlet or the outlet. The compressor comprises the given number of small aerodynamically shaped airfoil blades, spaced relative to each other in the azimuth direction from the yaw axis. Contrary to classical tail rotors of helicopters creating anti-torque for compensation of the fuselage and the main rotor torque by creating an essentially lateral force, the inventive helicopter with a cross-flow fan allows provision of anti-torque without tail rotor. Further contrary to classical tail rotors of helicopters needing horizontal stabilizers creating forces in the direction of the yaw axis, e. g. negative lift, to balance the fuselage pitch and a vertical fin creating lateral forces perpendicular to a plane of said roll axis and said yaw axis without any further support of helicopter flight performance generally, the inventive helicopter with a cross-flow fan provides support of helicopter flight performance in general. The provision and the arrangement of the cross-flow fan of the inventive helicopter improve performance in several ways, namely by providing:

- An anti-torque device (lateral thrust direction)
- A lift device (vertical thrust direction)
- A combination of said anti-torque and said lift device, i. e. both lateral and vertical thrust direction,
    - o Additional thrust due to the so called "Coanda effect" resulting outside the housing and/or
    - o additional thrust due to a diffusor type air outlet of the housing,
    - o additional lift due to air inlet substantially directed towards the main rotor plane.

[0014] Anti-torque and lift is provided to the inventive helicopter by means of the cross-flow fan without a tail rotor, without a fin and without horizontal stabilizers.

[0015] According to a preferred embodiment of the invention by remotely controlling the angular position of the gaps in the housing by means of at least partly rotating the housing around the fan axis the direction of the compressed airflow, directed normally to the fan rotation-axis, can be rotated around this fan axis providing thrust components additional to the thrust providing anti-torque. Hence the thrust vector is freely rotatable around the fan rotation-axis. An advantage of the cross-flow fan is that the direction of any fluid entering the cross-flow fan housing is not important, since the cross-flow fan "sucks" the fluid into the housing as necessary.

[0016] According to a further preferred embodiment of the invention the outlet of the housing is designed as a diffusor in order to recover pressure out of kinetic energy, transmitted to the air flow by the cross-flow fan. Generally the cross-flow fan's compressor creates high output velocities, yet, due to the diffusor, this velocity is converted into increased static pressure.

[0017] According to a further preferred embodiment of the invention the compressor of the cross-flow fan is driven by an output shaft from a main gear box driven by the at least one engine or the compressor of the cross-flow fan is driven electrically. Driving the compressor electrically would increase performance since the driving speed can be adjusted individually thus controlling the thrust provided by the cross-flow fan. Combining the controlled thrust from the compressor with the adjustable thrust vectoring by means of the pivoting housing leads to a powerful force and anti-torque device.

[0018] According to a further preferred embodiment of the invention the cross-flow fan system can be used to drive further auxiliary forward propelling devices, e.g. propeller, etc. with a rotation axis coaxial with the fan axis. With the compressor of the cross-flow fan used to drive a pusher propeller/ducted fan/radial compressor, the inventive helicopter becomes a compound helicopter.

[0019] According to a further preferred embodiment of the invention the housing of the cross-flow fan is split into a front section, an aft section and/or a mid section, the front section being closest to the yaw axis, the aft section being distal to the yaw axis and the mid section being between the front section and the aft section, said front section, the aft section and/or the mid section being separately and independently from each other pivotable about the fan axis.

[0020] According to a further preferred embodiment of the invention two cross-flow fans are provided, each with a compressor and a housing. The two cross-flow fans are mounted on the fuselage parallel to each other and preferably symmetric to a midplane defined by said plane of said roll axis and said yaw axis.

[0021] According to a further preferred embodiment of the invention the width of the inlet is greater than the width of the outlet for a better efficiency of the compressor.

[0022] According to a further preferred embodiment of the invention the angular offset varies from 10° to 90° for an angle measured between a side from the fan axis to a lateral inlet delimitation of the air inlet and a side to a lateral outlet delimitation of the air outlet next to said lateral inlet delimitation of the inlet for further adjustable thrust vectoring.

[0023] According to a further preferred embodiment of the invention the angles from the fan axis of the compressor to the lateral inlet delimitations of the air inlet in the azimuth direction relative to the yaw axis vary for the lateral inlet delimitation between 350° +/- 50° and between 10° +/- 50° to the opposed lateral inlet delimitation with the yaw axis directed to the main rotor corresponding to 0° and the degrees positive in clockwise direction.

[0024] According to a further preferred embodiment of the invention the angles from the fan axis of the compressor to the lateral outlet delimitations of the air outlet in the azimuth direction relative to the yaw axis vary on the lateral outlet delimitation between 215° +/- 50° and between 255° +/- 50° to the opposed lateral outlet delimitation.

[0025] Preferred embodiments of the invention are outlined by way of example with the following description with reference to the attached drawings.

Figure 1 shows an overall view of a part of a helicopter with a cross flow fan according to the invention;

Figure 2 shows a schematic cross sectional view through the cross flow fan of Fig. 1;

Figure 3 shows an overall view of the cross flow fan of Fig. 1 in an operating mode,

Figure 4 shows an overall view of the cross flow fan of Fig. 1 in another operating mode,

Figure 5 shows an overall view of a part of a further helicopter with cross flow fans according to the invention;

Figure 6 shows a lateral view of a part of the helicopter with a modified cross flow fan according to the invention;

Figure 7 shows a lateral view of a part of the helicopter with a further modified cross flow fan according to the invention; and

Figure 8 shows a lateral view of a part of the helicopter with an alternative cross flow fan according to the invention.

[0026] According to Fig. 1 a helicopter comprises a fuselage 4 with at least one driving unit, e.g. an integrated engine (not shown). The at least one integrated engine drives a main rotor (not shown) via a main gear box (not shown) mounted on top of the fuselage 4 of the helicopter. A rotation axis of the main rotor corresponds to a yaw axis 13 (see Fig. 3) of the helicopter.

[0027] A housing 2 of a cross flow fan is mounted to an aft region of said fuselage 4 with a roll axis 23 perpendicular to said yaw axis 13. Said housing 2 extends with angular variations of up to +/-15° relative to said yaw axis 13 essentially in direction of a roll axis 23 of the helicopter with an offset defined by a longitudinal extension 19 of the compressor 1 and housing 2 in direction of said roll axis 23 relative to said yaw axis 13.

[0028] A helicopter width is defined as the maximum distance between respective left hand and right hand surfaces of the fuselage 4 measured orthogonally to a helicopter mid-plane 20 defined by said roll axis 23 and said yaw axis 13. The present helicopter width is between 1 m - 4 m.

[0029] An air inlet 8 and an air outlet 7 are provided along a circumference of the housing 4. Said air inlet 8 and said air outlet 7 form angularly offset and separate gaps in the housing's circumference and essentially extend respectively longitudinally in direction of said roll axis. Said angular offset is about 45° of a range of possible 10° to 90° for an angle measured between a side from a fan axis 5 of the compressor 1 to a lateral inlet delimitation 35 of the air inlet 8 and a side from said fan axis 5 to a lateral outlet delimitation 36 of the air outlet 7 next to said lateral inlet delimitation of the inlet 8.

[0030] A compressor 1 of the cross flow fan with a plurality of airfoil blades 6 is provided radial inside said housing 2 between said air inlet 8 and said air outlet 7.

[0031] According to Fig. 2 corresponding features are referred to with the references of Fig. 1. The compressor 1 of the cross-flow fan is mounted radially inside the housing 2 for rotation about the fan axis 5. The compressor 1 is drivable by electrical or mechanical means, e. g. the main gear box, about the fan axis 5.

[0032] Said airfoil blades 6 provide to the compressor 1 a torus shape with a diameter 18 of around 50% (±45%) of the helicopter width. Said compressor 1 of the cross flow fan is drivable by said integrated engine to rotate about the fan axis 5 essentially coaxial with said roll axis 23. Chords of said airfoil blades 6 are essentially radial oriented with regard to said fan axis 5. A plurality of support rings 3 are provided in the circumference of the compressor 1 along the fan axis 5 of the compressor 1 corresponding to said longitudinal extension 19 of the compressor 1 and housing 2.

[0033] The radially arranged airfoil blades 6 radially inside the inlet region 11 point with their respective radial outer tips towards the inlet region 11, providing in between the airfoil blades 6 maximized passages for air 9 coming into the cross-flow fan. The radially arranged airfoil blades 6 radially in line with the outlet region 12 point with their respective radial outer tips towards the outlet region 12, providing in between the airfoil blades 6 maximized passages for outgoing air 10.

[0034] The longitudinal extension 19 of the compressor 1 and housing 2 is estimated to be between 10% and 600% of the helicopter width. An inlet opening width h1 is defined by h1=1 (+0,2, -0,95) x compressor diameter 18. The outlet opening width h2 is defined by h2=0.8 (±0,7) x compressor diameter 18 of the cross-flow fan. The inlet opening width h1 is greater than the outlet opening width h2.

[0035] The housing 2 is adapted along the fan axis 5 to segments of the torus shape of the compressor 1. The housing 2 is open to form the air inlet 8 in an inlet region 11 pointing with a perpendicular of a geometrical midplane of the air inlet 8 substantially towards the main rotor plane. The housing 2 is open to form the air outlet 7 in a lateral, outlet region 12 pointing with a further perpendicular of its geometrical midplane against the direction of movement of the main rotor in the aft region. An inside segment 33 and an outside segment 34 of the housing 2 cover the compressor 1 on opposed sides between the air inlet 8 and the air outlet 7 of the cross-flow fan to impose a defined flow direction of the air sucked through the compressor 1 for anti-torque.

[0036] The angles from the fan axis 5 of the compressor 1 to the lateral inlet delimitations 21, 35 of the air inlet 8 in the azimuth direction relative to the yaw axis 13 vary on one side between 350° +/- 50° and between 10° +/- 50° to the opposed side with the yaw axis 13 directed to the main rotor corresponding to 0° and the degrees positive in clockwise direction. The angles from the fan axis 5 of the compressor 1 to the lateral outlet delimitations 36, 21 of the outlet 7 in the azimuth direction relative to the yaw axis 13 vary on one side between 215° +/- 50° and between 255° +/- 50° to the opposed side. If the compressor 1 is driven to rotation, air 9 entering through the air inlet 8 first passes along the airfoil blades 6 in the inlet region 11, for a first compression of the air 9. The incoming air 9 produces lift 30 towards the main rotor plane due to ingestion into the compressor 1. The airfoil blades 6 of the rotating compressor 1 force further compressed air 10 exiting through the air outlet 7 providing substantial lateral thrust 22 for anti-torque. The air outlet 7 is shaped as a diffusor for increase of thrust 22 from the cross-flow fan.

[0037] Flaps and/or hatches 21 for enhanced thrust vectoring of the cross-flow fan are provided at the air inlet 8 and at the air outlet 7 of the inside segment 33 and/or the outside segment 34 of the housing 2. The flaps and/or hatches 21 are pivoted by means of joints (not shown) relative to the inside segment 33 and/or the outside segment 34 to modify respectively the effective cross sections of the air inlet 8 and of the air outlet 7 for adjustment of the thrust vector needed.

[0038] A FOD (Foreign Object Damage) grid 29 is applied to cover the air inlet 8 and/or the air outlet 7 in order to protect the compressor 1 of the cross-flow fan from foreign objects, e.g. birds, stones, etc. and protect humans from the rotating compressor 1.

[0039] Due to the asymmetric transport of air through the rotating compressor 1 air is conveyed around the cross-flow fan housing 2 with a side-effect applied to said air and consequently to the cross-flow fan housing 2. Said side-effect is typical for the cross-flow fan system. Air 28 outside the cross-flow fan's housing 2 flows around the housing 2 creating an additional side force 17 due to the Coanda effect, describing the tendency of a fluid jet to be attracted to any surface the fluid jet is passing along. The Coanda effect can be thought of as an extension of the principle of aerodynamic lift. When a fluid flows past one side of a surface, the fluid pressure is reduced and a force results acting perpendicular to the surface as "lift". The additional side force 17 due to the Coanda effect is supplemental to the lateral thrust 22 for anti-torque from the cross-flow fan.

[0040] For additional stiffness of the compressor 1 the fan axis 5 is conceived as an integrated shaft 32 rotating about the rotational axis 5 of the cross-flow fan. The integrated shaft 32 creates additional thrust due to the Magnus effect supporting the previously described cross-flow fan forces 22, 17 and 30.

[0041] According to Fig. 3 corresponding features are referred to with the references of Fig. 1, 2. The cross-flow fan anti-torque system produces thrust along the entire longitudinal length of the cross-flow fan in order to provide lift and anti-torque for the helicopter. To increase the lever for an increased yawing moment 31 at a constant cross-flow fan sideward thrust 22 the housing 2 of the cross-flow fan is split into a front section 14, an aft section 15 and/or a mid section 16, the front section 14 being closest to the yaw axis 13, the aft section 15 being distal to the yaw axis 13 and the mid section 16 being between the front section 14 and the aft section 15.

[0042] In order to allow adjustment of the respective directions of lift 30 and lateral thrust 22, generated by the entering air 9 and the exiting air 10, the front section 14, the aft section 15 and/or the mid section 16 of the inside segments 33 and the outside segments 34 of the cross-flow fan housing 2 are separately and independently from each other pivotable about the fan axis 5 for full thrust vectoring capability against yawing moments about the yawing axis 13.

[0043] The respective longitudinal extensions of the front section 14, the aft section 15 and the mid section 16 of the inside segments 33 and the outside segments 34 of the cross-flow fan housing 2 correspond to the distances between two support rings 3 of the compressor 1.

[0044] The front section 14 is angularly positioned to provide the air inlet 8 with an angle with respect to its geometrical midplane of approximately 315° and the air outlet 7 with an angle to its geometrical midplane of approximately 225° relative to the yaw axis 13, while the aft section 15 and/or the mid section 16 of the inside segments 33 and the outside segments 34 of the cross-flow fan housing 2 provide an air inlet 8 with a geometrical midplane essentially parallel to the yaw axis 13 and an air outlet 7 with its geometrical midplane with an angle of approximately 90° relative to the yaw axis 13.

[0045] According to Fig. 4 corresponding features are referred to with the references of Fig. 1-3. The front section 14 and the mid section 16 of the inside segments 33 and the outside segments 34 of the cross-flow fan housing 2 are angularly positioned for variable thrust vectoring. The air inlet 8 is directed with respect to a geometrical midplane with an angle of approximately 90° relative to the yaw axis 13 and the air outlet 7 essentially parallel to the yaw axis 13, while the aft section 15 of the inside segments 33 and the outside segments 34 of the cross-flow fan housing 2 provide an air inlet 8 essentially parallel to the yaw axis 13 and an air outlet 7 with an angle of approximately 90° relative to the yaw axis 13.

[0046] According to Fig. 5 corresponding features are referred to with the references of Fig. 1-4. Two cross-flow fans 24, each with a compressor 1 and a housing 2, are mounted parallel to each other and symmetric to the midplane 20 on the fuselage 4.

[0047] According to Fig. 6 corresponding features are referred to with the references of Fig. 1-5. A radial compressor 25 is provided at the compressor 1, distal to the fuselage 4. Said radial compressor 25 is driven by the rotating compressor 1 for the generation of forward propelling force thus providing a compound helicopter.

[0048] According to Fig. 7 corresponding features are referred to with the references of Fig. 1-5. An impeller/ducted fan 26 is provided at the compressor 1, distal to the fuselage 4. Said impeller/ducted fan 26 is driven by the rotating compressor 1 for the generation of forward propelling force thus providing a compound helicopter.

[0049] According to Fig. 8 corresponding features are referred to with the references of Fig. 1-5. A propeller 27 is provided at the compressor 1, distal to the fuselage 4. Said propeller 27 is driven by the rotating compressor 1 for the generation of forward propelling force thus providing a compound helicopter.

Reference List

[0050]

1 compressor

2 housing

3 radial support rings

4 fuselage

5 fan axis

6 airfoil blades

7 outlet

8 inlet

9 Incoming fluid

10 Exiting fluid

11 Inlet region

12 Outlet region

13 yaw axis

14 Front section

15 Aft section

16 Mid-section

17 Side force vector due to the Coanda effect

18 Compressor diameter

19 Longitudinal extension

20 mid plane

21 flaps/hatches

22 Thrust vector

23 Roll axis

24 Multiple cross flow fans

25 Radial compressor

26 Axial compressor/impeller/ducted fan

27 Propeller

28 outside Flow

29 Foreign Object Damage (FOD) grid

30 Thrust vector

31 Yawing moment about the helicopter vertical axis (yawing axis)

32 Shaft

33 inside segment

34 outside segment

35 lateral inlet delimitation

36 lateral outlet delimitation

Claims

1. A helicopter comprising
a fuselage (4), at least one driving unit, a roll axis (23), at least one main rotor mounted to said fuselage (4) and drivable by said at least one engine about a yaw axis (13) perpendicular to said roll axis (23), and
at least one housing (2) mounted to said fuselage

(4), said at least one housing (2) extending essentially in direction of said roll axis (23) with an offset relative to said yaw axis (13),
characterized in that

- an air inlet (8) and an air outlet (7) are provided along at least a part of a circumference of the at least one housing (2), said air inlet (8) and said air outlet (7) being formed by angularly offset and separate gaps between an inside segment (33) and an outside segment (34) essentially extending respectively in direction of said roll axis (23),
- at least one rotatable compressor (1) with a plurality of airfoil blades (6) is provided radial inside said at least one housing (2) between said air inlet (8) and said air outlet (7), said at least one rotatable compressor (1) being drivable by said at least one driving unit about a fan axis (5) and
- each chord of said airfoil blades (6) is essentially radial oriented with regard to said fan axis (5).

2. The helicopter according to claim 1,
characterized in that said inside segment (33) and said outside segment (34) of the at least one housing (2) are pivotable around the fan axis (5).

3. The helicopter according to claim 2,
characterized in that remote control means are provided for remote control of the angular position of said inside segment (33) and said outside segment (34) of the housing (2).

4. The helicopter according to claim 1,
characterized in that the air outlet (7) of the housing (2) is designed as a diffusor.

5. The helicopter according to claim 1,
characterized in that an output shaft (32) is provided from the main gear box and said rotatable compressor (1) is driven by said output shaft (32).

6. The helicopter according to claim 1,
characterized in that the rotatable compressor (1) is driven electrically.

7. The helicopter according to claim 1,
characterized in that auxiliary forward propelling devices are provided and the rotatable compressor (1) is adapted to drive said auxiliary forward propelling devices, e.g. propeller, etc..

8. The helicopter according to claim 1,
characterized in that the housing (2) of the cross-flow fan is split into a front section (14), an aft section (15) and/or a mid section (16), the front section (14) being closest to the yaw axis (13), the aft section (15) being distal to the yaw axis (13) and the mid section (16) being between the front section (14) and the aft section (15), said front section (14), the aft section (15) and/or the mid section (16) being separately and independently from each other pivotable about the fan axis (5).

9. The helicopter according to claim 1,
characterized in that two cross-flow fans (24), each with a compressor (1) and a housing (2), are mounted parallel to each other and symmetric to a midplane (20) on the fuselage (4).

10. The helicopter according to claim 1,
characterized in that a width of the air inlet (8) is greater than the width of the air outlet (7).

11. The helicopter according to claim 1,
characterized in that the angular offset varies from 10° to 90° for an angle measured between a side from the fan axis (5) to a lateral inlet delimitation (35) of the air inlet (8) and a side to a lateral outlet delimitation (36) of the air outlet (7) next to said lateral inlet delimitation (35) of the air inlet (8).

12. The helicopter according to claim 1,
characterized in that the angles from the fan axis (5) of the compressor (1) to the lateral inlet delimitations (35, 21) of the air inlet (8) in the azimuth direction relative to the yaw axis (13) vary for the lateral inlet delimitation (35) between 350° +/- 50° and between 10° +/- 50° to the opposed lateral inlet delimitation (21) with the yaw axis 13 directed to the main rotor corresponding to 0° and the degrees positive in clockwise direction.

13. The helicopter according to claim 12,
characterized in that the angles from the fan axis (5) of the compressor (1) to the lateral outlet delimitations (36, 21) of the air outlet (7) in the azimuth direction relative to the yaw axis (13) vary on the lateral outlet delimitation (36) between 215° +/- 50° and between 255° +/- 50° to the opposed lateral outlet delimitation (21).

Fig.1

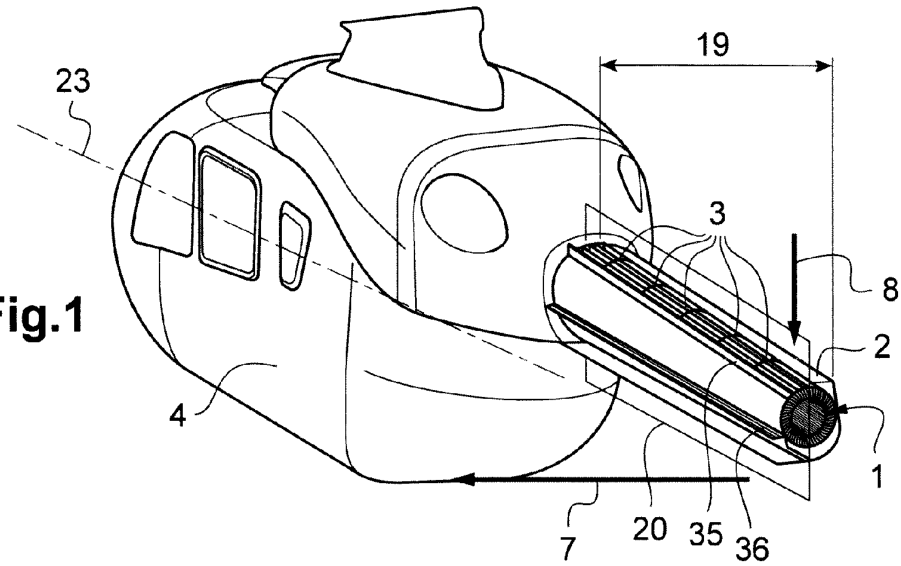

19
23
3
8
2
4
1
7
20
35
36

Fig.2

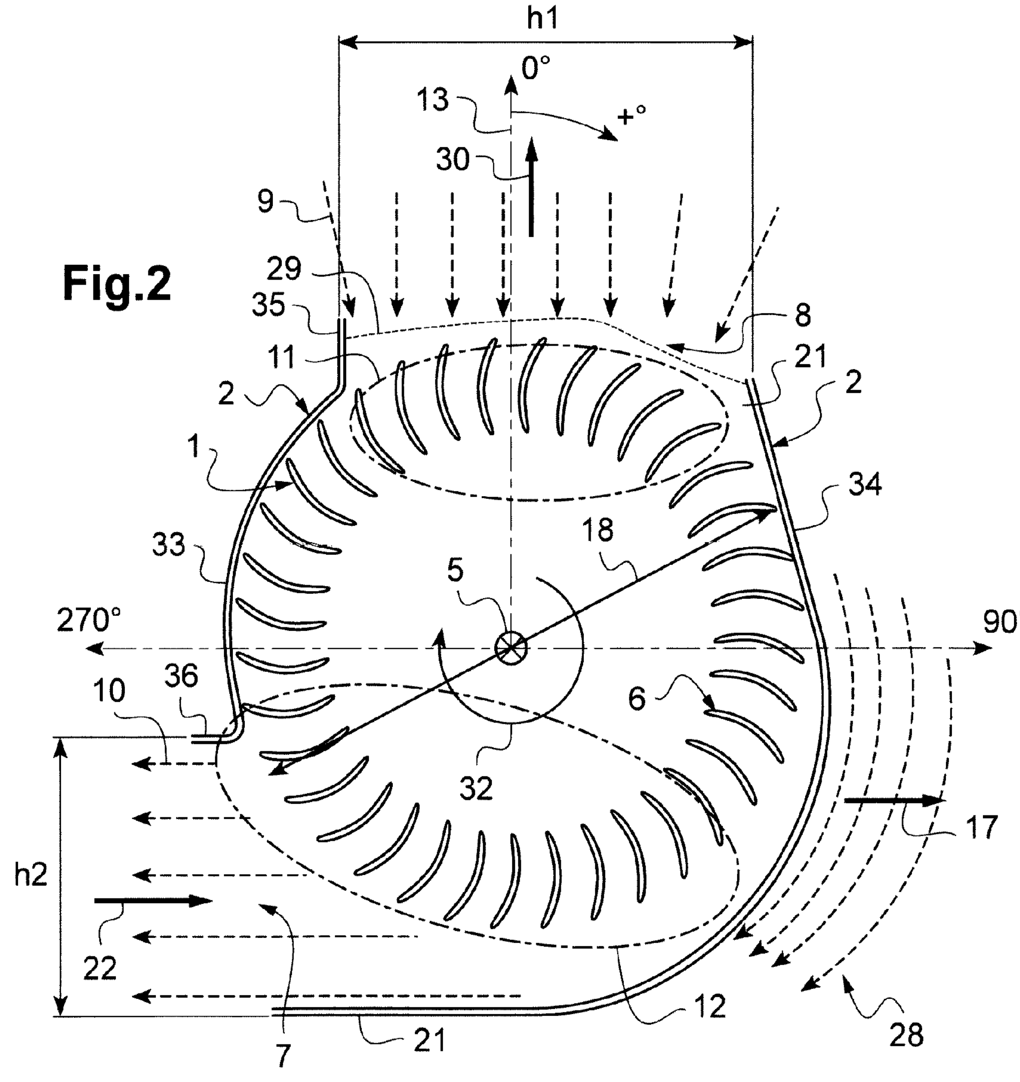

h1
0°
13
+°
30
9
29
35
8
11
21
2
2
1
34
18
33
5
270°
90°
36
10
6
32
17
h2
22
12
28
7
21

Fig.3

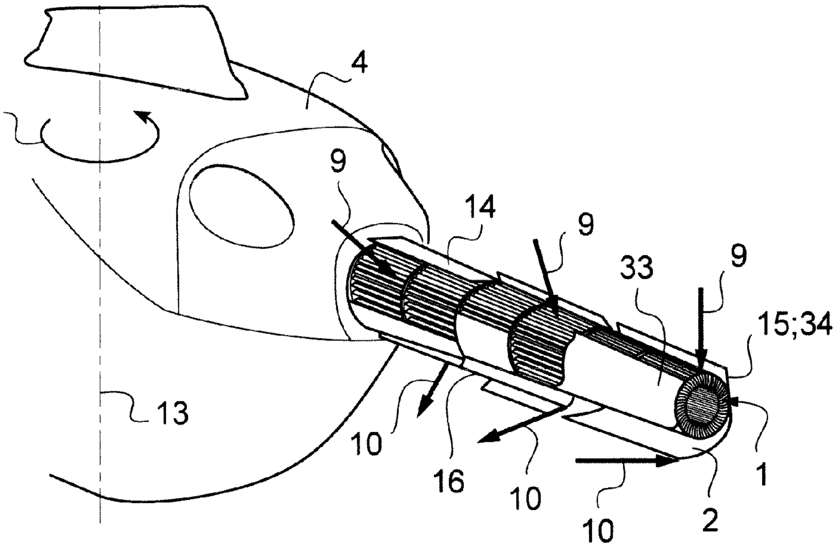
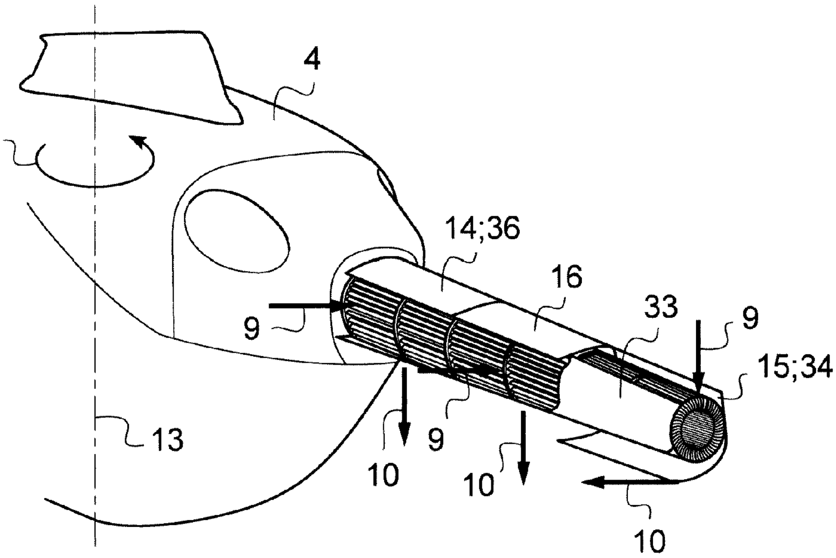


Fig.4



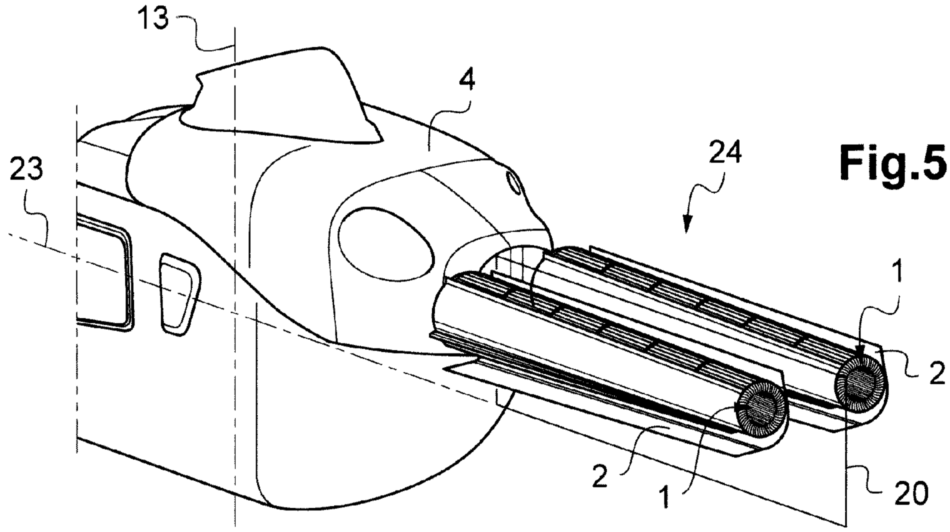


Fig.5

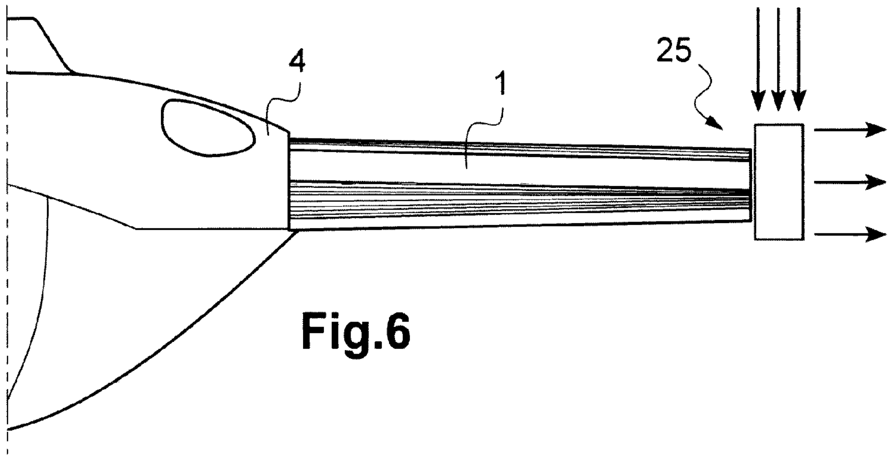


Fig.6

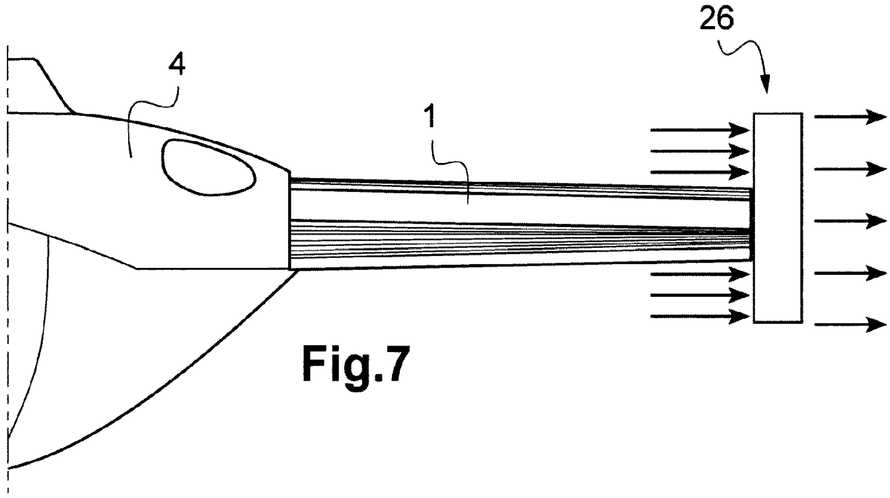


Fig.7

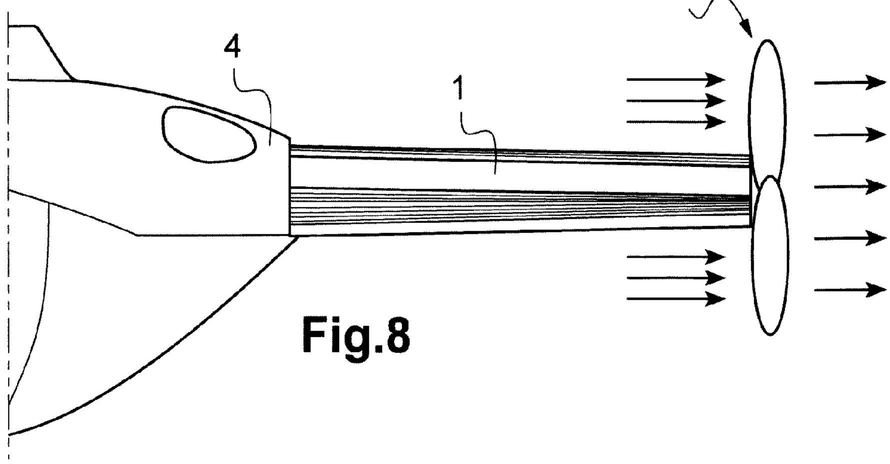


Fig.8

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European Patent Office
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EUROPEAN SEARCH REPORT

Application Number
EP 13 40 0011

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y A	US 2013/119186 A1 (HEID OLIVER [DE]) 16 May 2013 (2013-05-16) * paragraphs [0025] - [0036]; figures 1,2 *	1,5,6,9, 11-13 2-4,7,10 8	INV. B64C27/82
Y A	EP 2 511 177 A1 (EUROCOPTER DEUTSCHLAND [DE]) 17 October 2012 (2012-10-17) * paragraphs [0021], [0022], [0024]; figures 2-5 *	7 1-6,8	
Y A	US 2 486 272 A (ANTOINE GAZDA) 25 October 1949 (1949-10-25) * column 3, lines 34-63; figures 1,2,5-7 *	2-4,10 1	
A	US 4 660 785 A (MUNSKI MICHAEL S [US]) 28 April 1987 (1987-04-28) * column 3, line 43 - column 5, line 46; figures 1-4 *	1-13	

TECHNICAL FIELDS SEARCHED (IPC)

B64C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	22 October 2013	Busto, Mario

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 40 0011

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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22-10-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013119186 A1	16-05-2013	CN 103052564 A	17-04-2013
		DE 102010032217 A1	26-01-2012
		EP 2598399 A1	05-06-2013
		US 2013119186 A1	16-05-2013
		WO 2012013365 A1	02-02-2012
EP 2511177 A1	17-10-2012	EP 2511177 A1	17-10-2012
		US 2012256042 A1	11-10-2012
US 2486272 A	25-10-1949	NONE	
US 4660785 A	28-04-1987	CA 1236444 A1	10-05-1988
		EP 0250555 A1	07-01-1988
		US 4660785 A	28-04-1987
		WO 8703554 A1	18-06-1987

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- GB 9617440 A **[0007]**
- GB 9902653 A **[0008]**
- GB 200320870 A **[0009]**
- US 20120160955 A1 **[0010]**

(19) 대한민국특허청(KR)
(12) 등록특허공보(B1)

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B64C 29/00 (2006.01) *B64C 29/02* (2006.01)
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US5265827B
JP04317891A
전체 청구항 수 : 총 19 항

(73) 특허권자
재단법인서울대학교산학협력재단
서울특별시 관악구 봉천7동 산4의 2번지
(72) 발명자
김승조
서울 관악구 신림동 산 56-1 서울대학교 301동 1308호
(74) 대리인
장한특허법인

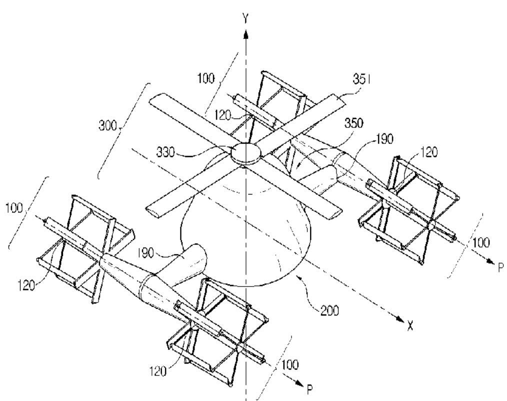
심사관 : 류시웅

(54) 수직 이착륙 비행체

(57) 요 약

본 발명은 수직 이착륙 비행체에 관한 것으로서, 그 구성은, 동체를 수직으로 이착륙시키는 비행메카니즘을 구비한 수직 이착륙 비행체에 있어서, 양력을 발생시키는 주로터 시스템과 양력과 추력을 발생시키는 사이클로이드 로터 시스템을 포함하되, 상기 주로터 시스템은, 상기 동체에 장착되는 제1구동원과; 상기 동체의 양측면을 관통하는 수평선이 포함된 평면과 수직한 평면에 포함된 수직선을 회전축으로 하여, 상기 제1구동원에 의해 회전하는 제1회전중심부와; 상기 제1회전중심부에 중심을 둔 원주 상에 배치되고, 상기 수평선이 포함된 평면과 평행한 평면상에 배치되는 복수의 제1블레이드를 포함하여, 상기 제1블레이드가 회전하면서 양력을 발생시키는 제1로터부;를 포함하고, 상기 사이클로이드 로터 시스템은, 상기 동체에 장착되는 제2구동원과; 상기 수평선이 포함된 평면상에서 상기 수평선과 평행한 평행선을 회전축으로 하여, 상기 제2구동원에 의해 회전하는 제2회전중심부와; 상기 제2회전중심부에 중심을 둔 원주 상에 배치되고, 상기 수평선과 평행하게 배치되는 복수의 제2블레이드를 포함하여, 상기 제2블레이드가 회전하면서 양력과 추력을 발생시키는 제2로터부와; 일단은 상기 제2블레이드를 회전가능하게 지지하고, 타단은 상기 제2회전중심부에 결합된 지지부재와; 상기 제2블레이드의 상기 지지부재에 대한 회전축으로부터 소정 간격 이격된 제2블레이드의 작용점에 일단이 연결된 복수의 연결부재와, 상기 각 연결부재의 타단이 연결되고 상기 제2회전중심부의 중심을 기준 위치로 하며 상기 제2로터부와 같이 회전하는 회전디스크 및, 상기 회전디스크의 중심을 기준 위치로부터 병진 및 회전시킴으로써 그 회전디스크와 상기 연결부재로 연결된 상기 제2블레이드의 피치각 크기 및 위상이 변화되게 하는 조절수단을 구비한 피치제어부;를 포함하는 것을 특징으로 하며, 주로터 시스템과 사이클로이드 로터 시스템으로 분리하여 각각 다른 역할을 수행함으로써, 그 제어가 용이하고, 시스템의 변환 과정이 간단하고 순간적으로 가능하기 때문에 양력 발생뿐만 아니라 자세제어와 방향전환에 유리하고, 고기동성의 특성을 가지므로 정찰, 탐사, 감시, 운반 등의 역할을 담당하기에 용이하며, 시스템이 복잡해짐에 따라 발생할 수 있는 오작동을 미연에 방지할 수 있는 효과가 있다.

대표도 - 도1



특허청구의 범위

청구항 1

동체를 수직으로 이착륙시키는 비행메카니즘을 구비한 수직 이착륙 비행체에 있어서,

양력을 발생시키는 주로터 시스템과 양력과 추력을 발생시키는 사이클로이드 로터 시스템을 포함하되,

상기 주로터 시스템은,

상기 동체에 장착되는 제1구동원과;

상기 동체의 양측면을 관통하는 수평선이 포함된 평면과 수직한 평면에 포함된 수직선을 회전축으로 하여, 상기 제1구동원에 의해 회전하는 제1회전중심부와;

상기 제1회전중심부에 중심을 둔 원주 상에 배치되고, 상기 수평선이 포함된 평면과 평행한 평면상에 배치되는 복수의 제1블레이드를 포함하여, 상기 제1블레이드가 회전하면서 양력을 발생시키는 제1로터부;를 포함하고,

상기 사이클로이드 로터 시스템은,

상기 동체에 장착되는 제2구동원과;

상기 수평선이 포함된 평면상에서 상기 수평선과 평행한 평행선을 회전축으로 하여, 상기 제2구동원에 의해 회전하는 제2회전중심부와;

상기 제2회전중심부에 중심을 둔 원주 상에 배치되고, 상기 수평선과 평행하게 배치되는 복수의 제2블레이드를 포함하여, 상기 제2블레이드가 회전하면서 양력과 추력을 발생시키는 제2로터부와;

일단은 상기 제2블레이드를 회전가능하게 지지하고, 타단은 상기 제2회전중심부에 결합된 지지부재와;

상기 제2블레이드의 상기 지지부재에 대한 회전축으로부터 소정 간격 이격된 제2블레이드의 작용점에 일단이 연결된 복수의 연결부재와, 상기 각 연결부재의 타단이 연결되고 상기 제2회전중심부의 중심을 기준 위치로 하며 상기 제2로터부와 같이 회전하는 회전디스크 및, 상기 회전디스크의 중심을 기준 위치로부터 병진 및 회전시킴으로써 그 회전디스크와 상기 연결부재로 연결된 상기 제2블레이드의 피치각 크기 및 위상이 변화되게 하는 조절수단을 구비한 피치제어부;를 포함하는 것을 특징으로 하는 수직 이착륙 비행체.

청구항 2

제 1항에 있어서,

상기 사이클로이드 로터 시스템은 상기 동체의 전,후방으로 양측에 각각 네 개가 구비되는 것을 특징으로 하는 수직 이착륙 비행체.

청구항 3

제 2항에 있어서,

상기 제2회전중심부는 상하방향으로 동체의 무게 중심 아래쪽에 배치되는 것을 특징으로 하는 수직 이착륙 비행체.

청구항 4

제 2항에 있어서,

상기 동체의 전방 양측에 배치된 상기 두 개의 사이클로이드 로터 시스템과 후방 양측에 배치된 상기 두 개의 사이클로이드 로터 시스템은 서로 반대방향으로 각각 회전되는 것을 특징으로 하는 수직 이착륙 비행체.

청구항 5

제 1항에 있어서,

상기 사이클로이드 로터 시스템은 상기 동체의 양측에 각각 두 개가 구비되고,

상기 두 개의 사이클로이드 로터 시스템은 서로 반대방향으로 회전되는 것을 특징으로 하는 수직 이착륙

비행체.

청구항 6

제 5항에 있어서,

상기 제2회전중심부는 상하방향으로는 동체의 무게 중심 아래쪽에, 전후 방향으로는 무게 중심에 배치되는 것을 특징으로 하는 수직 이착륙 비행체.

청구항 7

제 1항에 있어서,

상기 제2블레이드의 단면은 대칭형 익형인 것을 특징으로 하는 수직 이착륙 비행체.

청구항 8

제 1항에 있어서,

상기 제2블레이드는 섬유 강화 복합재료로 이루어진 것을 특징으로 하는 수직 이착륙 비행체.

청구항 9

제 1항에 있어서,

상기 제2블레이드는 상기 지지부재에 외팔보 형태로 지지된 것을 특징으로 하는 수직 이착륙 비행체.

청구항 10

제 1항에 있어서,

상기 제2블레이드의 중간 부분을 지지하는 보조지지부재가 더 구비되는 것을 특징으로 하는 수직 이착륙 비행체.

청구항 11

제 10항에 있어서,

상기 보조지지부재는 상기 제2블레이드의 끝단을 지지하는 것을 특징으로 하는 수직 이착륙 비행체.

청구항 12

제 1항에 있어서,

상기 제2블레이드의 회전축은 그 단면의 무게중심에 위치되는 것을 특징으로 하는 수직 이착륙 비행체.

청구항 13

제 1항에 있어서,

상기 연결부재 중 하나는 상기 회전디스크에 고정된 것을 특징으로 하는 수직 이착륙 비행체.

청구항 14

제 1항에 있어서,

상기 피치제어부의 조절수단은, 상기 회전디스크가 탑재되는 가이드부와, 상기 가이드부를 가이드레일을 따라 병진이동시키는 가이드부구동원과, 상기 가이드부가 탑재되는 방향조절블록 및 상기 방향조절블록을 회전이동시키는 방향조절블록구동원을 구비하는 것을 특징으로 하는 수직 이착륙 비행체.

청구항 15

제 14항에 있어서,

상기 회전디스크와 상기 가이드부는 볼베어링을 통해 연결되는 것을 특징으로 하는 수직 이착륙 비행체.

청구항 16

제 15항에 있어서,

상기 가이드부는 상기 볼베어링의 내륜에 결합되는 편심축을 포함하는 것을 특징으로 하는 수직 이착륙 비행체.

청구항 17

제1항에 있어서,

상기 제2블레이드는 상기 회전디스크가 기준위치에 있을 때, 그 폭방향이 상기 제2로터부를 이루는 원주상의 접선방향과 일치하도록 위치되는 것을 특징으로 하는 수직 이착륙 비행체.

청구항 18

동체를 수직으로 이착륙시키는 비행메카니즘을 구비한 수직 이착륙 비행체에 있어서,

상기 비행메카니즘은 양력을 발생시키는 주로터 시스템과, 상기 동체의 전방 양측에 각각 두 개가 구비되어 양력과 추력을 발생시키는 제1사이클로이드 로터 시스템과, 상기 동체의 후방에 한 개가 구비되어 양력과 추력을 발생시키는 제2사이클로이드 로터 시스템을 포함하되,

상기 주로터 시스템은,

상기 동체에 장착되는 제1구동원과;

상기 동체의 양측면을 관통하는 수평선이 포함된 평면과 수직한 평면에 포함된 수직선을 회전축으로 하여, 상기 제1구동원에 의해 회전하는 제1회전중심부와;

상기 제1회전중심부에 중심을 둔 원주 상에 배치되고, 상기 수평선이 포함된 평면과 평행한 평면상에 배치되는 복수의 제1블레이드를 포함하여, 상기 제1블레이드가 회전하면서 양력을 발생시키는 제1로터부;를 포함하고,

상기 제1사이클로이드 로터 시스템은,

상기 동체에 장착되는 제2구동원과;

상기 수평선이 포함된 평면상에서 상기 수평선과 평행한 평행선을 회전축으로 하여, 상기 제2구동원에 의해 회전하는 제2회전중심부와;

상기 제2회전중심부에 중심을 둔 원주 상에 배치되고, 상기 수평선과 평행하게 배치되는 복수의 제2블레이드를 포함하여, 상기 제2블레이드가 회전하면서 양력과 추력을 발생시키는 제2로터부와;

일단은 상기 제2블레이드를 회전가능하게 지지하고, 타단은 상기 제2회전중심부에 결합된 제1지지부재와;

상기 복수의 제2블레이드의 상기 제1지지부재에 대한 회전축으로부터 소정 간격 이격된 제2블레이드의 작용점에 일단이 연결된 복수의 제1연결부재와, 상기 각 제1연결부재의 타단이 연결되고 상기 제2회전중심부의 중심을 기준 위치로 하며 상기 제2로터부와 같이 회전하는 제1회전디스크 및, 상기 제1회전디스크의 중심을 기준 위치로부터 병진 및 회전시킴으로써 그 회전디스크와 상기 제1연결부재로 연결된 상기 제2블레이드의 피치각 크기 및 위상이 변화되게 하는 조절수단을 구비한 제1피치제어부;를 포함하고,

상기 제2사이클로이드 로터 시스템은,

상기 동체에 장착되는 제3구동원과;

상기 수평선이 포함된 평면상에서 상기 수평선과 수직한 직선을 회전축으로 하여, 상기 제3구동원에 의해 회전하는 제3회전중심부와;

상기 제3회전중심부에 중심을 둔 원주 상에 배치되고, 상기 수평선과 수직하게 배치되는 복수의 제3블레이드를 포함하여, 상기 제3블레이드가 회전하면서 양력과 추력을 발생시키는 제3로터부와;

일단은 상기 제3블레이드를 회전가능하게 지지하고, 타단은 상기 제3회전중심부에 결합된 제2지지부재와;

상기 복수의 제3블레이드의 상기 제2지지부재에 대한 회전축으로부터 소정 간격 이격된 제3블레이드의 작용점에 일단이 연결된 복수의 제2연결부재와, 상기 각 제2연결부재의 타단이 연결되고 상기 제3회전중심부의 중심을 기준 위치로 하며 상기 제3로터부와 같이 회전하는 제2회전디스크 및, 상기 제2회전디스크의 중심을 기준 위치로

부터 병진 및 회전시킴으로써 그 회전디스크와 상기 제2연결부재로 연결된 상기 제3블레이드의 피치각 크기 및 위상이 변화되게 하는 조절수단을 구비한 제2피치제어부;를 포함하는 것을 특징으로 하는 수직 이착륙 비행체.

청구항 19

제 18항에 있어서,

상기 두 개의 제1사이클로이드 로터 시스템은 같은방향으로 회전되는 것을 특징으로 하는 수직 이착륙 비행체.

명 세 서

발명의 상세한 설명

발명의 목적

발명이 속하는 기술 및 그 분야의 종래기술

<19> 본 발명은 수직 이착륙이 가능한 비행체에 관한 것으로, 더 상세하게는 사이클로이드 블레이드 시스템을 구비한 수직 이착륙 비행체에 관한 것이다.

<20> 일반적으로 비행체는, 소정 거리를 활주하면서 양력을 얻어서 이륙하는 방식과, 회전날개인 로우터의 회전으로부터 양력을 얻어 제자리에서 수직으로 이착륙하는 방식으로 분류된다. 이중에서 수직 이착륙이 가능한 비행체의 전형적인 예로는 도 11에 도시된 바와 같은 헬리콥터(10)를 들 수 있다. 헬리콥터(10)는 로터(12)가 설치된 수직축(11)을 회전시키면서 양력을 발생시키고, 이 로터(12)가 회전하면서 그리는 평면을 틸트(tilt)시킴으로써 비행방향으로 분력을 얻어 전진하는 메카니즘을 갖고 있다.

<21> 그러나 이와 같은 전형적인 수직 이착륙 비행체는 로터(12)가 양력, 추력, 방향전환을 모두 담당하고 있어 복잡한 제어 메카니즘이 필요하다.

<22> 즉, 수직 상승 및 하강을 위해서 컬렉티브 피치 조종을 통해 블레이드 피치각을 변화시켜야 하고, 피칭 및 롤링 운동과 전,후진 비행을 위해서는 싸이클릭 피치 조종을 통해 경사판을 앞뒤 좌우로 기울여서 로터 블레이드 회전면을 경사지게 해야한다.

<23> 이러한 구조는 주로터 시스템의 제어 메카니즘을 복잡하게 만들어 시스템 오작동의 주요원인이 되고 있으며, 회전하는 로터(12)의 바로 아래에 동체(13)가 있기 때문에 공기의 흐름이 방해되어 힘의 이용 효율이 좋지 않은 문제점이 있다.

<24> 따라서, 이러한 단점들을 해소할 수 있는 새로운 구조의 수직 이착륙 비행체가 요구되고 있다.

발명이 이루고자 하는 기술적 과제

<25> 본 발명은 전술한 문제점을 해결하기 위하여 안출된 것으로, 주로터 시스템과 사이클로이드 로터 시스템으로 분리하여 각각 다른 역할을 수행함으로써, 그 제어가 용이하고, 시스템의 변환 과정이 간단하고 순간적으로 가능하기 때문에 양력 발생뿐만 아니라 자세제어와 방향전환에 유리하고, 고기동성의 특성을 가지므로 정찰, 탐사, 감시, 운반 등의 역할을 담당하기에 용이하며, 시스템이 복잡해짐에 따라 발생할 수 있는 오작동을 미연에 방지할 수 있는 수직 이착륙 비행체를 제공하는 데 그 목적이 있다.

발명의 구성 및 작용

<26> 전술한 목적을 달성하기 위한 본 발명의 수직 이착륙 비행체는, 동체를 수직으로 이착륙시키는 비행메카니즘을 구비한 수직 이착륙 비행체에 있어서, 양력을 발생시키는 주로터 시스템과 양력과 추력을 발생시키는 사이클로이드 로터 시스템을 포함하되, 상기 주로터 시스템은, 상기 동체에 장착되는 제1구동원과; 상기 동체의 양측면을 관통하는 수평선이 포함된 평면과 수직한 평면에 포함된 수직선을 회전축으로 하여, 상기 제1구동원에 의해 회전하는 제1회전중심부와; 상기 제1회전중심부에 중심을 둔 원주 상에 배치되고, 상기 수평선이 포함된 평면과 평행한 평면상에 배치되는 복수의 제1블레이드를 포함하여, 상기 제1블레이드가 회전하면서 양력을 발생시키는 제1로터부;를 포함하고, 상기 사이클로이드 로터 시스템은, 상기 동체에 장착되는 제2구동원과; 상기 수평선이 포함된 평면상에서 상기 수평선과 평행한 평행선을 회전축으로 하여, 상기 제2구동원에 의해 회전하는 제2회전중심부와; 상기 제2회전중심부에 중심을 둔 원주 상에 배치되고, 상기 수평선과 평행하게 배치되는 복수의 제2

블레이드를 포함하여, 상기 제2블레이드가 회전하면서 양력과 추력을 발생시키는 제2로터부와; 일단은 상기 제2블레이드를 회전가능하게 지지하고, 타단은 상기 제2회전중심부에 결합된 지지부재와; 상기 제2블레이드의 상기 지지부재에 대한 회전축으로부터 소정 간격 이격된 제2블레이드의 작용점에 일단이 연결된 복수의 연결부재와, 상기 각 연결부재의 타단이 연결되고 상기 제2회전중심부의 중심을 기준 위치로 하며 상기 제2로터부와 같이 회전하는 회전디스크 및, 상기 회전디스크의 중심을 기준 위치로부터 병진 및 회전시킴으로써 그 회전디스크와 상기 연결부재로 연결된 상기 제2블레이드의 피치각 크기 및 위상이 변화되게 하는 조절수단을 구비한 피치제어부;를 포함하는 것을 특징으로 한다.

<27> 이하, 본 발명의 바람직한 일실시예를 첨부도면을 참조하여 상세히 설명하면 다음과 같다.

<28> 도 1은 본 발명의 제1실시예에 따른 수직 이착륙 비행체의 외관을 도시한 도면이고, 도 2a 및 도 2b는 도 1의 평면도 및 측면도이며, 도 3은 도 1의 주로터 시스템을 확대하여 도시한 도면이고, 도 4a 및 도 4b는 도 1에 도시된 사이클로이드 로터 시스템을 확대하여 도시한 도면이며, 도 5는 도 4a의 피치제어부를 확대하여 도시한 도면이고, 도 6은 도 4a에 도시된 사이클로이드 로터 시스템의 변형 가능한 구조의 예를 보인 도면이며, 도 7은 도 4a에 도시된 피치제어부의 변형 가능한 예를 도시한 도면이고, 도 8a 내지 도 8c는 도 4a에 도시된 사이클로이드 로터 시스템을 이용한 비행체의 이륙과 비행 과정을 설명하기 위한 도면이며, 도 9는 본 발명의 제2실시예에 따른 수직 이착륙 비행체의 외관을 도시한 도면이고, 도 10은 본 발명의 제3실시예에 따른 수직 이착륙 비행체의 외관을 도시한 도면이다.

<29> 도 1 및 도 9 및 도 10에 도시한 바와 같이, 본 발명의 수직 이착륙 비행체는 양력을 발생시키는 주로터 시스템과 양력과 추력을 발생시키는 사이클로이드 로터 시스템을 포함한다.

<30> 먼저, 제1실시예에 따른 수직 이착륙 비행체를 설명하기로 한다.

<31> 도 1 및 도 2a 및 도 2b를 참조하여 설명하면, 제1실시예에 따른 수직 이착륙 비행체는 주로터 시스템(300)과 사이클로이드 로터 시스템(100)을 포함한다.

<32> 주로터 시스템(300)은, 도 3에 도시한 바와 같이, 제1구동원(310)과 제1회전중심부(330)와 제1로터부(350)를 포함한다.

<33> 제1구동원(310)은 동체(200)에 장착된다.

<34> 제1회전중심부(330)는 동체(200)의 양측면을 관통하는 수평선(X)이 포함된 평면과 수직한 평면에 포함된 수직선(Y)을 회전축으로 하여, 제1구동원(310)에 의해 회전한다.

<35> 제1구동원(310)과 제1회전중심부(330) 사이에는 예컨대 도 3에 도시된 바와 같이 기어박스(320) 등이 동력전달수단으로서 사용될 수 있으며, 이외에도 벨트를 이용한 동력 전달 구조도 채용될 수 있음은 물론이다.

<36> 제1로터부(350)는 제1회전중심부(330)에 중심을 둔 원주 상에 배치되고, 수평선(X)이 포함된 평면과 평행한 평면상에 배치되는 복수의 제1블레이드(351)를 포함하여, 제1블레이드(351)가 회전하면서 양력을 발생시킨다.

<37> 본 실시예에서 사이클로이드 로터 시스템(100)은 동체(200)의 전,후방으로 양측에 각각 네 개가 구비된다.

<38> 도 4a 및 4b는 상기한 네 개의 사이클로이드 로터 시스템(100) 중 하나를 보다 상세하게 도시한 것이다. 도시된 바와 같이, 사이클로이드 로터 시스템(100)은, 동체(200)에 장착되는 제2구동원(150)과, 수평선(X)이 포함된 평면상에서 수평선(X)과 평행한 평행선(P)을 회전축으로 하여, 제2구동원(150)에 의해 회전하는 제2회전중심부(120)와, 제2회전중심부(120)에 중심을 둔 원주 상에 서로 균등하게 배치되는 복수의 제2블레이드(111)를 포함하는 제2로터부(110)와, 제2회전중심부(120)와 제2블레이드(111)를 각각 연결하며 제2블레이드(111)를 외팔보 형태로 지지하는 복수의 지지부재(130)와, 제2블레이드(111)의 피치각을 변화시키기 위해 제2블레이드(111)의 작용점에 작용력을 부여하는 피치제어부(140)를 기본적으로 구비하게 된다. 참조부호 120a는 제2회전중심부(120)의 덮개를 나타낸다.

<39> 제2회전중심부(120)는 상하방향으로 동체(200)의 무게 중심 아래쪽에 배치되는 것이 반토크를 감당하는 측면 등을 고려할 때 바람직하다.

<40> 지지부재(130)는 이 제2회전중심부(120)에 견고하게 고정된다.

<41> 제2블레이드(111)는 양력과 추력의 조정을 위해 피치각을 가변시킬 수 있게 의도된 것으로, 본 실시예에서는 그 단면 형상을 비행기의 날개에 주로 사용되는 대칭형의 익형으로 예시하였다. 그러나 피치각을 가변시킬 수만 있

다면 비대칭 익형도 채용할 수 있음은 물론이다. 이러한 제2블레이드(111)는 그 길이방향으로 수평선과 평행하게 배치되어, 회전 시 유입되는 바람의 방향과 실질적으로 직각을 이루도록 배치된다.

<42> 그리고 제2블레이드(111)의 폭방향 위치가 제2로터부(110)를 이루는 원주상의 접선방향과 일치한 상태를 제2블레이드(111)의 피치각 변화가 없는 기준위치로 삼는다. 이 상태에서 대칭형 익형을 가진 제2블레이드(111)가 제2로터부(110)의 원주를 따라 돌아간다면 양력은 발생하지 않게 된다. 따라서, 이와 같이 제2블레이드(111)의 피치각 변화가 없는 기준위치에서의 시스템 구동은 주로 워밍업 시에 사용된다.

<43> 한편, 이러한 제2블레이드(111)는 회전하면서 발생하는 원심력에 의한 하중에 영향을 받게 되므로 요구되는 강성을 가지면서도 무게가 가벼운 것이 구조적인 안전성이나 운용의 효율성 면에서 바람직하다. 따라서 제2블레이드(111)는 무게대 강성비가 뛰어난 섬유 강화 복합재료로 제작하는 것이 바람직하며, 이에는 유리섬유나 탄소섬유 등이 있다. 복합재료를 이용하여 제2블레이드(111)를 형성하는 것은 통상적인 기술에 의해 가능하다. 이러한 복합재료를 사용하는 경우 피치제어부(140)에 가해지는 하중을 감소시켜 구조적인 파손을 방지하고 수명을 연장시킬 수 있다. 또한, 제2블레이드(111)의 개수는 비행체의 무게 등에 따라 달라질 수 있다.

<44> 지지부재(130)는 일단이 제2회전중심부(120)에 고정되어 있고, 타단에 마련된 회전축(131)은 피치각이 변할 수 있도록 제2블레이드(111)를 회전가능하게 지지한다. 이때, 이러한 회전축(131)의 위치는 제2블레이드(111) 단면의 무게중심에 놓이도록 하는 것이 제2블레이드(111)의 불필요한 진동에 의한 손상을 방지하는데 유리하다.

<45> 다음으로, 도 5는 제2회전중심부(120) 내부에 설치된 피치제어부(140)를 확대하여 도시한 것이다.

<46> 도 5를 참조하여 설명하면, 피치제어부(140)는 제2블레이드(111)의 회전축(131)으로부터 폭 방향으로 소정 간격 이격된 작용점(132a)에 일단이 연결된 연결부재(142)와, 연결부재(142)의 타단이 연결되고 제2회전중심부(120)의 중심을 기준위치로 하여 회전하는 회전디스크(141)와, 회전디스크(141)의 중심을 기준위치로부터 직선 및 회전이동시킴으로써 양력과 추력을 발생시키는 제2블레이드(111)의 피치각 크기를 정현적으로 변화시키고 그 힘의 방향을 조정하기 위해 제2블레이드(111)의 위상을 변화시키는 조절수단(143)을 구비한다.

<47> 연결부재(142)는 제2블레이드(111)에 의해 작용하는 인장력과 압축력에 견디는 재질의 형상을 가진 통상의 로드이며, 이 로드(142)는 제2블레이드(111)의 피치각을 변화시키면서 연결부가 회전할 수 있게 베어링을 이용하여 연결하는 것이 바람직하다. 또한, 회전디스크(141)와도 베어링을 이용하여 연결하게 되는데, 그 중 하나의 로드(142')는 회전디스크(141)에 직접 고정시켜준다. 로드(142)가 제2블레이드(111)와 연결되는 작용점(132a)은 제2블레이드(111)의 피치각 변화의 범위와, 후술할 조절수단(143)의 작동범위를 고려하여 정한다.

<48> 또한, 로드(142)의 연결을 위한 작용점(132a)은 제2블레이드(111) 상에 직접 마련할 수도 있지만, 제조상의 문제와 제2블레이드(111) 표면을 타고 흐르는 공기흐름의 난류화를 방지하기 위해 별도의 중간부재(132)를 이용하여 마련하는 것이 바람직하다. 즉, 제2블레이드(111)를 중간부재(132)에 체결하고, 그 중간부재(132)를 지지부재(130)에 고정된 회전축(131)에 회전가능하게 결합시키면서, 중간부재부재(132) 일측에 작용점(132a)에 마련하는 것이다. 회전축(131)은 내부에 베어링(미도시)이 설치된 것으로, 중간부재(132)에 형성된 샤프트(미도시)가 그 베어링의 내륜에 끼워져 고정된다.

<49> 다음으로, 로드(142)는 하나(142')를 제외하고는 회전디스크(141)와 베어링으로 연결되며, 로드(142)들 중 기준이 되는 로드(142')는 회전디스크(141)에 기구학적인 작동을 위해 고정된다. 이렇게 고정되는 로드(142')는 제2블레이드(111)의 회전시 다른 로드들(142)에 비해 큰 하중이 걸리므로 더욱 강건하게 제작되어야 한다.

<50> 또한, 회전디스크(141)는 볼베어링(143c)을 통하여 조절수단(143)에 장착된다. 즉, 회전디스크(141)는 볼베어링(143c)의 외륜에 연결되어 편심축(143a')에 대해 회전 가능한 상태로 설치되어 있다.

<51> 조절수단(143)은, 회전디스크(141)가 탑재되는 가이드부(143a)와, 가이드부(143a)를 직선상으로 안내하기 위한 가이드 레일(143b)과, 가이드부(143a)를 병진 이동시키는 가이드부구동원(143e)과, 가이드부(143a)를 탑재하여 제2회전중심부(120) 안에 회전가능하게 설치된 방향조절블록(143d) 및, 그것을 회전구동시키기 위한 방향조절블록구동원(143f)을 구비한다.

<52> 가이드부(143a)는 그 중앙에 마련된 편심축(143a')이 볼베어링(143c)의 내륜에 결합됨으로써 회전판(141)과 연결된다. 따라서, 이 가이드부(143a)가 가이드 레일(143b)을 따라 이동하면, 회전디스크(141)가 직선운동을 하게 되어 제2블레이드(111)의 피치각 크기가 조절된다.

<53> 또한, 방향조절블록구동원(143f)을 이용하여 방향조절블록(143d)을 원하는 각도만큼 회전시키면, 이에 탑재된 가이드부(143a)의 편심축(143a')도 그만큼 회전되면서 제2블레이드(111)의 위상이 변화되어 힘의 작용방향이 바

꿔게 된다. 이때, 제2블레이드(111) 또는 제2회전중심부(120)의 회전에는 아무런 영향도 미치지 않는다. 물론, 이와 같이 방향조절블록(143d)의 회전에 따라 편심축(143a')의 위치가 돌아가려면, 편심축(143a')이 방향조절블록(143d)의 회전중심과 동축상에 있으면 안되고 소정 간격 이격되어 있어야 한다.

<54> 본 실시예에서는 제2블레이드(111)의 보다 안정적인 지지를 보장하기 위해 도 4b와 같이 보조지지부재(130a)가 더 설치되어 있다. 이 보조지지부재(130a)는 제2회전중심부(120)에서 연장된 지지축(120b)에 일단이 고정되어 있고, 타단은 제2블레이드(111)의 끝단에 마련된 결합부(111a)에 결합되어 제2블레이드(111)를 회전가능한 상태로 지지하고 있다. 이렇게 되면, 각 제2블레이드(111)를 두 지점에서 지지해주기 때문에, 보다 안정적인 지지구조를 구현할 수 있게 된다.

<55> 한편, 본 실시예서와 달리, 실시예에 따라 도 6에 도시한 바와 같이 제2블레이드(111)의 일단만을 지지부재(130)에 지지시킨 외팔보 형태로 실시할 수 있으나, 보다 안정적인 지지를 위해서는 상기와 같이 보조지지부재(130a)가 구비되는 것이 바람직하다 할 것이다.

<56> 한편, 도 7은 상기한 가이드부구동원(143e)과 방향조절블록구동원(143f)의 변형 가능한 예를 보인 것이다. 여기서는 가이드 레일(143b) 중 가운데 것을 직접 리드스크류로 구성하여서 가이드부구동원(143e)의 구동에 따라 가이드부(143a)가 직선 이동되게 하고, 방향조절블록(143d)의 회전축에 직접 방향조절블록구동원(143f)을 연결하여 방향조절블록(143d)을 회전시킬 수 있도록 하고 있다. 다만, 이때에는 제2구동원(150)과 방향조절블록구동원(143f)과의 배치 상 중첩을 피하기 위해 도면과 같이 회전축(101)과 제2구동원(150)을 벨트(160')로 연결하여 구동하는 것이 바람직하다.

<57> 본 실시예에서는 도 1 및 도 2a 및 도 2b에 도시한 바와 같이, 전방 양측에 배치된 두 개의 사이클로이드 로터 시스템(100)이 하나의 제2구동원(미도시)에 연결되어 함께 회전하고, 제2회전중심부(120)는 동체(200)로부터 이격되도록 배치되며, 제2회전중심부(120)와 동체(200)를 연결하는 연결부재(190)가 마련되어 있다. 또한, 후방 양측에 배치된 두 개의 사이클로이드 로터 시스템(100)도 상기와 마찬가지로 구성되어 있으며, 이렇게 구성될 경우 동체의 크기를 작게 하여 정찰, 탐사, 감시, 운반 등 회전익 항공기로 이용할 수 있다.

<58> 상기와 같이 구성된 수직 이착륙 비행체의 작동을 설명하면 다음과 같다.

<59> 우선, 동체(200)의 전방 양측에 배치된 두 개의 사이클로이드 로터 시스템(100)과 후방 양측에 배치된 두 개의 사이클로이드 로터 시스템(100)은 서로 반대방향으로 회전하도록 구성된다. 왜냐하면, 각 시스템의 제2로터부(110)가 고속으로 회전하면 그에 따라 동체(200)도 회전하려는 토크가 받기 때문에, 이를 상쇄시킬 수 있도록 전방측과 후방측의 사이클로이드 로터 시스템(100)을 서로 반대방향으로 회전되게 하는 것이다. 따라서, 비행의 안정성을 확보하기 위해 이와 같이 전후방측 사이클로이드 로터 시스템(100)을 반대로 구동시킨다.

<60> 일단 이륙에 앞서서, 비행체가 지상에 착륙해 있는 상태로 주로터 시스템(300)과 사이클로이드 로터 시스템(100)을 작동시켜 보는 워밍 업 단계가 필요하다.

<61> 이때에는 주로터 시스템(300)의 제1블레이드(351)는 제1구동원(310)에 의해 서서히 회전하게 되며, 양력은 속도에 비례하므로 제1블레이드(351)가 회전하더라도 양력은 발생하지 않는다.

<62> 또한, 사이클로이드 로터 시스템(100)의 제2블레이드(111)의 편심각이 영인 상태 즉, 도 8a에 도시된 바와 같이, 제2블레이드(111)의 폭방향 위치가 제2로터부(110)를 이루는 원주상의 접선방향과 일치한 상태가 된다. 이 상태에서는 제2블레이드(111)가 제2로터부(110)의 원주를 따라 회전하더라도 양력은 발생하지 않고, 시스템의 워밍 업만 진행된다.

<63> 이후, 워밍 업이 어느 정도 완료되어 비행체를 이륙시키고자 할 때에는 제1구동원(310)에 의해 제1블레이드(351)는 빠른 속도로 회전하여 양력을 발생시킨다.

<64> 또한, 피치제어부(140)의 가이드부(143a)를 직선 이동시켜서 양력이 발생되도록 제2블레이드(111)의 피치각을 조정한다. 이때 양력의 작용 방향은 피치각의 설정에 따라, 비행체를 수직으로 상승시키는 방향이 될 수도 있고, 수직 상승방향과 전진방향이 합성된 방향이 될 수도 있다. 여기서는, 이륙 시 양력의 작용방향이 수직 상승방향인 것으로 가정한다.

<65> 따라서, 제2회전중심부(120)가 계속해서 회전하게 되면, 제2블레이드(111)에 양력이 작용하여 수직 상승방향으로 비행체가 떠오르게 된다. 이때의 제2블레이드(111)의 피치각 상태를 예를 들면 도 8b와 같은 상태라고 볼 수 있다.

<66> 그리고 이러한 과정에서 양력의 대소는 제2블레이드(111)의 피치각을 더 변화시킴으로써 조정할 수 있다. 즉, 가이드부(143a)를 가이드레일(143b)을 따라 직선 이동시켜서 회전디스크(141)를 변위시키면, 로드(142)를 통해 연결된 제2블레이드(111)가 회전하게 되면서 피치각이 더 크거나 작게 변하게 된다. 따라서, 제2블레이드(111)의 회전으로부터 얻어지는 양력의 크기가 조절되는 것이다. 이 피치각은 도 8c에서 b로 표시된 피치제어부(140)의 편심크기 즉, 가이드부(143a)가 직선 이동한 거리에 비례하여 조절된다. b가 영인 경우, 즉 편심 크기가 영인 경우에는 각 제2블레이드(111)의 피치각 각도는 영이 되고, 편심 크기 b가 커질수록 각 제2블레이드(111)의 최대 피치각은 커지게 된다.

<67> 이와 같이 지상에서 이륙한 비행체를 전진시키기 위해서는 제2블레이드(111)로부터 얻어진 힘의 작용 방향을 수직 상승방향에서 상승 및 전진방향으로 바꿔줘야 한다. 이를 위해서는, 도 8c와 같이 상기 방향조절블록(143d)을 회전시킴으로써 제2블레이드(111)의 위상 자체를 변화시킨다. 즉, 방향조절블록구동원(143f)을 가동하여 방향 조절부(111)를 회전시키면, 이에 고정된 가이드부(143a)가 회전하게 되어 도 8c에서 a로 표시된 만큼의 편심각이 발생하게 되고 이는 회전디스크(141) 및 로드(142)를 통해 제2블레이드(111)에 전달되어 제2블레이드(111) 전체의 위상변화를 가져온다. 이렇게 되면, 제2블레이드(111)가 회전하면서 얻어지는 전체적인 힘의 작용방향이 그 위상변화를 따라 이동하게 되며, 예를 들어 수직 상승방향으로 힘이 작용하던 상태에서 위상을 전진방향 쪽으로 변화시키면 비행체가 상승과 동시에 전진방향의 힘을 받아서 앞으로 나아가게 된다.

<68> 그러므로, 상기와 같은 과정을 통해 제2블레이드(111)의 피치각과 위상의 변화를 능동적으로 제어함으로써, 비행체의 수직 이착륙 및 비행을 간단하게 조정할 수 있게 된다.

<69> 상기와 같이, 주로터 시스템의 제1블레이드는 오직 양력 발생의 역할을 담당한다. 따라서, 제1블레이드의 회전면을 기울일 필요가 없고, 제1블레이드는 수평선이 포함된 평면과 평행한 평면상에 배치되어 회전하므로 그 구조가 매우 간단해진다. 또한, 사이클로이드 로터 시스템은 이륙 및 제자리 비행시 양력 발생뿐만 아니라 추력과 방향전환, 자세 제어 등의 역할을 담당한다.

<70> 이와 같이, 주로터 시스템과 사이클로이드 로터 시스템으로 분리하여 각각 다른 역할을 수행함으로써, 그 제어가 용이하고, 시스템의 변환 과정이 간단하고 순간적으로 가능하기 때문에 양력 발생뿐만 아니라 자세제어와 방향전환에 유리하다.

<71> 또한, 고기동성의 특성을 가지므로 정찰, 탐사, 감시, 운반 등의 역할을 담당하기에 용이하다.

<72> 나아가, 시스템을 각각 분리함으로써, 시스템이 복잡해짐에 따라 발생할 수 있는 오작동을 미연에 방지할 수 있다.

<73> 한편, 제2실시예에 따른 수직 이착륙 비행체를 도 9에 도시하였다.

<74> 도 9에 도시한 바와 같이, 제2실시예에 따른 수직 이착륙 비행체는 주로터 시스템(300)과 사이클로이드 로터 시스템(100)을 포함하며, 사이클로이드 로터 시스템(100)은 동체(200)의 양측에 각각 두 개가 구비된다.

<75> 두 개의 사이클로이드 로터 시스템(100)은 서로 반대방향으로 회전되는 것이 비행의 안정성을 확보한다는 측면에서 바람직하다.

<76> 본 실시예에서의 주로터 시스템(300)과 사이클로이드 로터 시스템(100)의 구조 및 작동은 상기의 제1실시예에서와 동일하므로 여기에서는 주로터 시스템(300)과 사이클로이드 로터 시스템(100)의 상세한 설명을 생략하기로 한다.

<77> 사이클로이드 로터 시스템의 제2회전중심부는 상하방향으로는 동체(200)의 무게 중심 아래쪽에, 전후 방향으로는 무게 중심에 배치되는 것이 반토크를 감당하는 측면 등을 고려할 때 바람직하다.

<78> 한편, 제3실시예에 따른 수직 이착륙 비행체를 도 10에 도시하였다.

<79> 도 10에 도시한 바와 같이, 제3실시예에 따른 수직 이착륙 비행체는 양력을 발생시키는 주로터 시스템(300)과, 동체(200)의 전방 양측에 각각 두 개가 구비되어 양력과 추력을 발생시키는 제1사이클로이드 로터 시스템(100)과, 동체(200)의 후방에 한 개가 구비되어 양력과 추력을 발생시키는 제2사이클로이드 로터 시스템(400)을 포함한다.

<80> 제1사이클로이드 로터 시스템(100)은, 동체(200)에 장착되는 제2구동원(미도시)과, 동체(200)의 양측면을 관통하는 수평선(X)이 포함된 평면상에서 수평선(X)과 평행한 평행선(P)을 회전축으로 하여 제2구동원에 의해 회전하는 제2회전중심부(120)와, 제2회전중심부(120)에 중심을 둔 원주 상에 배치되고 수평선(X)과 평행하게 배치되

는 복수의 제2블레이드를 포함하는 제2로터부(110)와, 제2회전중심부와 제2블레이드를 각각 연결하며 제2블레이드를 외팔보 형태로 지지하는 복수의 제1지지부재(130)와, 제2블레이드의 피치각을 변화시키기 위해 제2블레이드의 작용점에 작용력을 부여하는 제1피치제어부(미도시)를 포함한다.

<81> 제2사이클로이드 로터 시스템(400)은, 동체(200)에 장착되는 제3구동원(미도시)과, 수평선(X)이 포함된 평면상에서 수평선(X)과 수직한 직선(Z)을 회전축으로 하여 제3구동원에 의해 회전하는 제3회전중심부(420)와, 제3회전중심부에 중심을 둔 원주 상에 배치되고 수평선(X)과 수직하게 배치되는 복수의 제3블레이드를 포함하는 제3로터부(410)와, 제3회전중심부와 제3블레이드를 각각 연결하며 제3블레이드를 외팔보 형태로 지지하는 복수의 제2지지부재(430)와, 제3블레이드의 피치각을 변화시키기 위해 제3블레이드의 작용점에 작용력을 부여하는 제2피치제어부(미도시)를 포함한다.

<82> 본 실시예에서의 주로터 시스템(300)과 제1,2사이클로이드 로터 시스템(100,400)의 구조 및 작동은 상기의 제1실시예에서 주로터 시스템과 사이클로이드 로터 시스템의 구조 및 작동과 동일하므로 여기에서는 주로터 시스템(300)과 제1,2사이클로이드 로터 시스템(100,400)의 상세한 설명을 생략하기로 한다.

<83> 상술한 바와 같이, 본 발명의 바람직한 실시예를 참조하여 설명하였지만, 해당기술분야의 숙련된 당업자는 하기의 특허청구범위에 기재된 본 발명의 사상 및 영역으로부터 벗어나지 않는 범위 내에서 본 발명을 다양하게 수정 또는 변형하여 실시할 수 있다.

발명의 효과

<84> 이상에서 설명한 바와 같은 본 발명의 수직 이착륙 비행체에 따르면, 다음과 같은 효과가 있다.

<85> 주로터 시스템과 사이클로이드 로터 시스템으로 분리하여 각각 다른 역할을 수행함으로써, 그 제어가 용이하고, 시스템의 변환 과정이 간단하고 순간적으로 가능하기 때문에 양력 발생뿐만 아니라 자세제어와 방향전환에 유리하다.

<86> 또한, 고기동성의 특성을 가지므로 정찰, 탐사, 감시, 운반 등의 역할을 담당하기에 용이하다.

<87> 나아가, 시스템을 각각 분리함으로써, 시스템이 복잡해짐에 따라 발생할 수 있는 오작동을 미연에 방지할 수 있다.

도면의 간단한 설명

<1> 도 1은 본 발명의 제1실시예에 따른 수직 이착륙 비행체의 외관을 도시한 도면.

<2> 도 2a 및 도 2b는 도 1의 평면도 및 측면도.

<3> 도 3은 도 1의 주로터 시스템을 확대하여 도시한 도면.

<4> 도 4a 및 도 4b는 도 1에 도시된 사이클로이드 로터 시스템을 확대하여 도시한 도면.

<5> 도 5는 도 4a의 피치제어부를 확대하여 도시한 도면.

<6> 도 6은 도 4a에 도시된 사이클로이드 로터 시스템의 변형 가능한 구조의 예를 보인 도면.

<7> 도 7은 도 4a에 도시된 피치제어부의 변형 가능한 예를 도시한 도면.

<8> 도 8a 내지 도 8c는 도 4a에 도시된 사이클로이드 로터 시스템을 이용한 비행체의 이륙과 비행 과정을 설명하기 위한 도면.

<9> 도 9는 본 발명의 제2실시예에 따른 수직 이착륙 비행체의 외관을 도시한 도면.

<10> 도 10은 본 발명의 제3실시예에 따른 수직 이착륙 비행체의 외관을 도시한 도면.

<11> 도 11은 종래의 수직 이착륙 비행체를 도시한 도면,

<12> <도면의 주요 부분에 대한 부호의 설명>

<13> 100...사이클로이드 로터 시스템 110...제2로터부

<14> 111...제2블레이드 120...제2회전중심부

<15> 130...지지부재 140...피치제어부

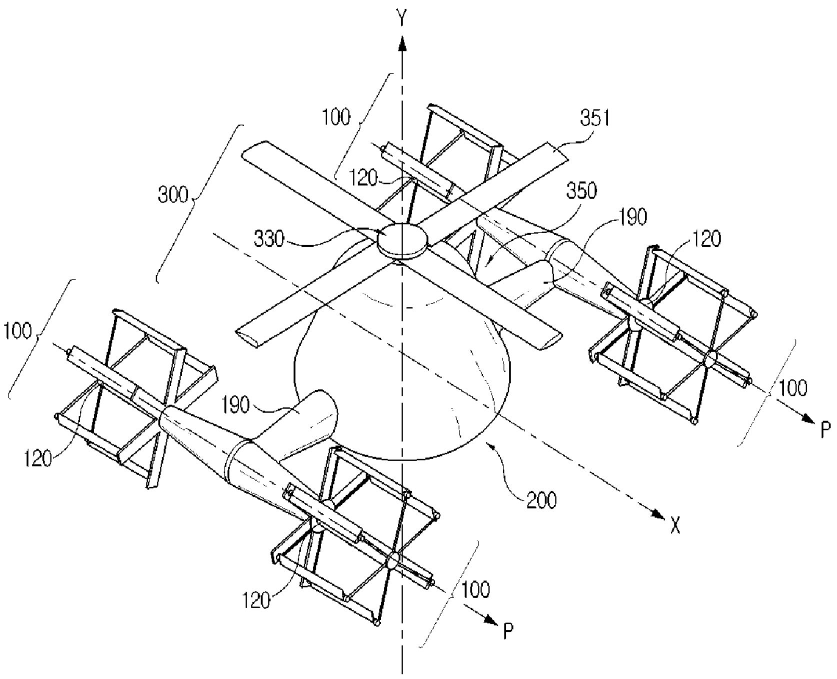
<16> 150...제2구동원 200...동체

<17> 300...주로터 시스템 310...제1구동원

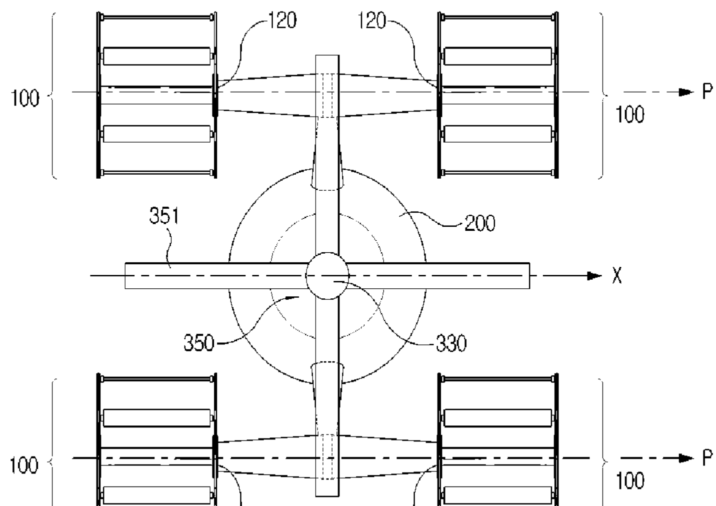
<18> 330...제1회전중심부 350...제1로터부

도면

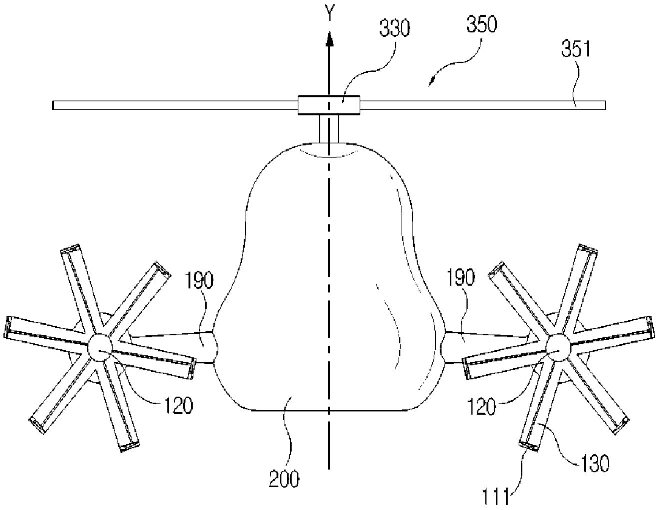
도면1



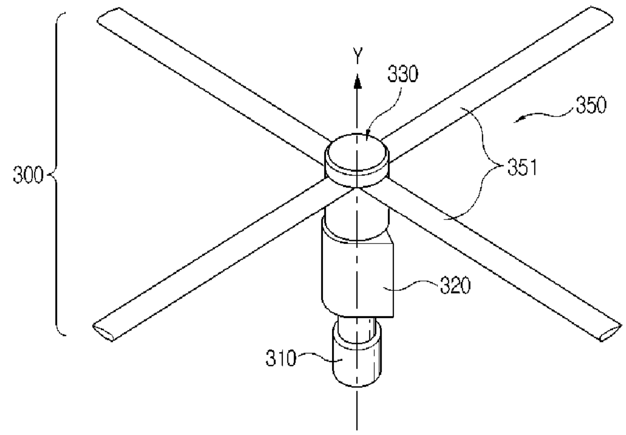
도면2a



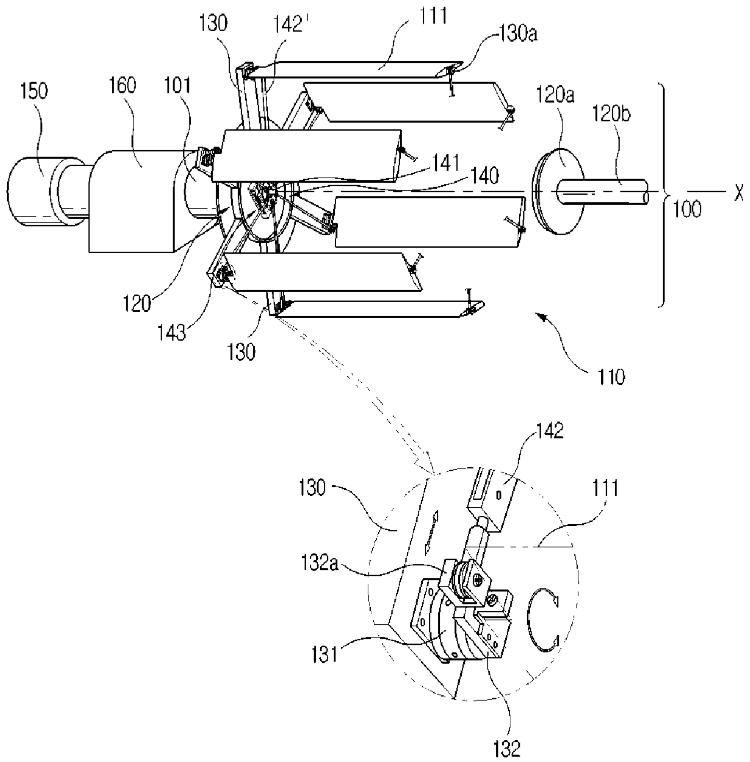
도면2b


Y
330
350
351
190
190
120
120
130
200
111

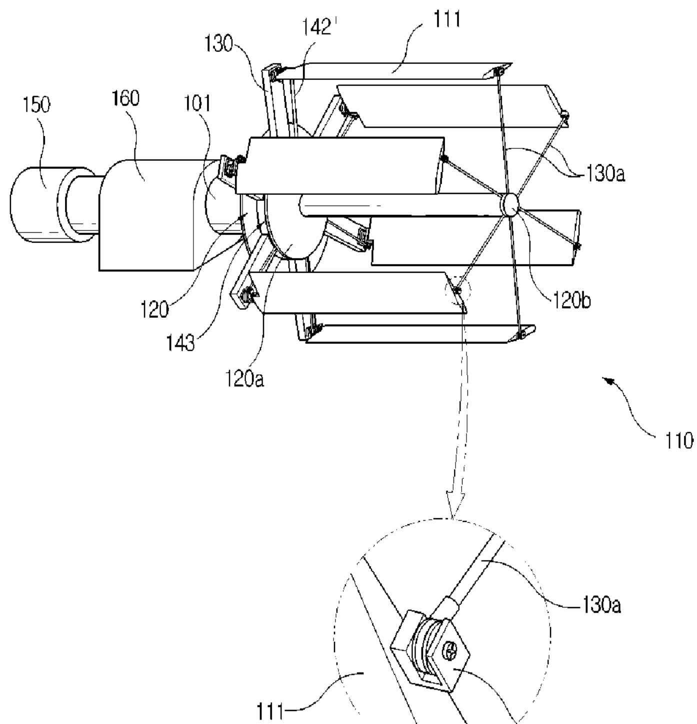
도면3


Y
330
350
351
300
320
310

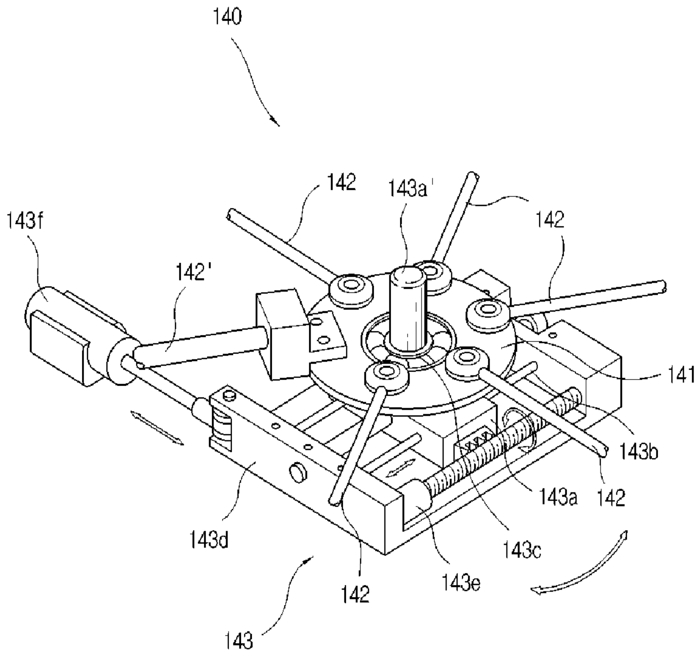
도면4a


150
160
101
130
142'
111
130a
120a
120b
141
140
X
100
120
143
130
110
142
130
111
132a
131
132

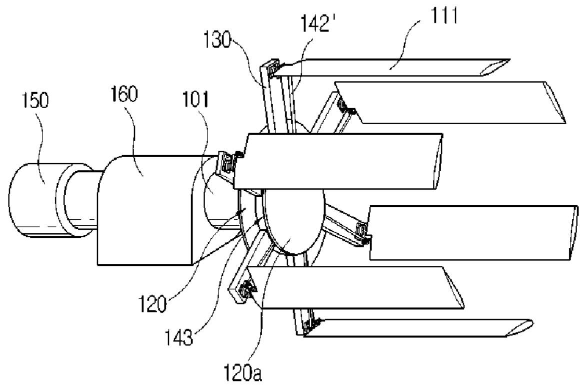
도면4b


130
142'
111
150
160
101
130a
120b
120
143
120a
110
130a
111
111a

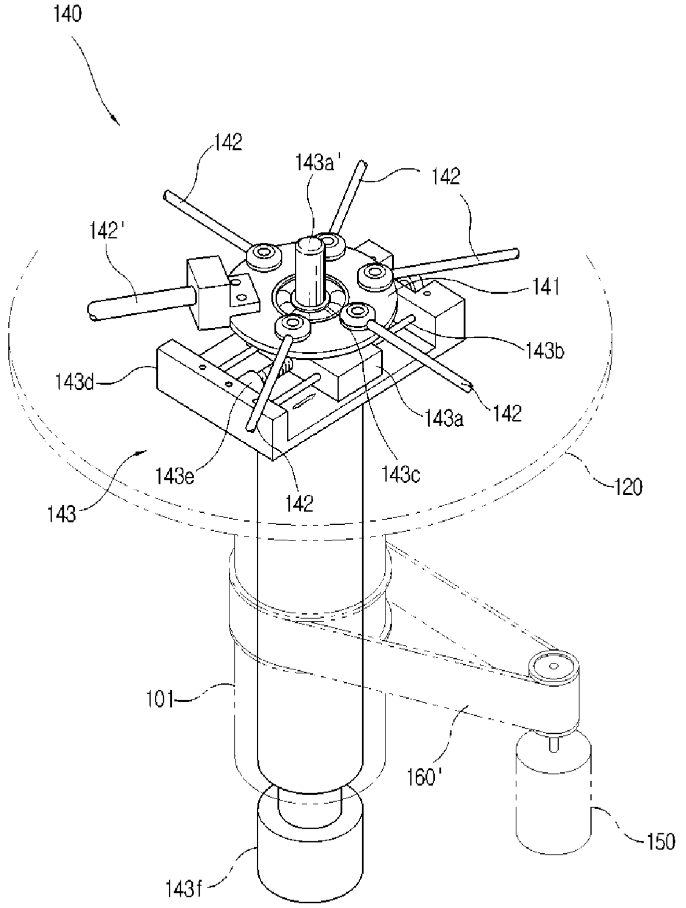
도면5


140
142
143a'
142
143f
142'
141
143b
143a
142
143d
143c
142
143e
143

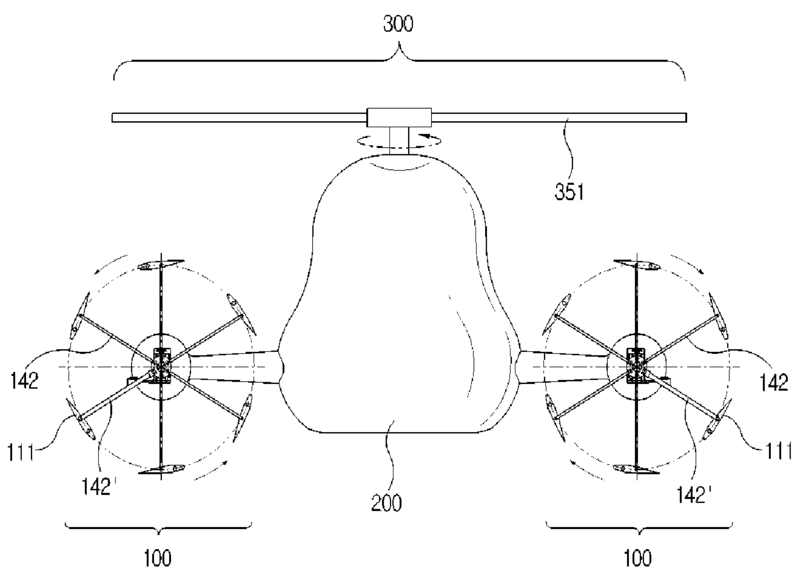
도면6


142'
111
130
150
160
101
120
143
120a

도면7


140
142
143a'
142
142'
142
141
143b
143d
142
143a
143e
143c
120
143
142
101
160'
150
143f

도면8a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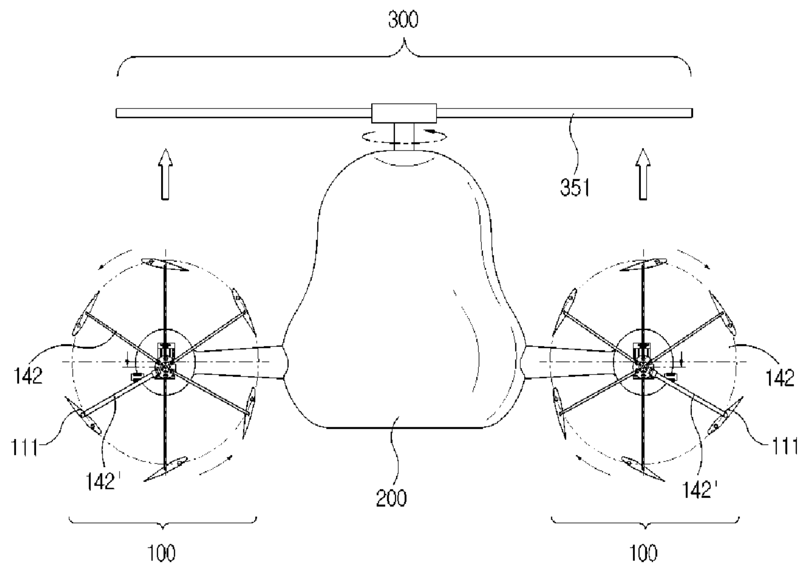
351
142
142
111
111
142'
142'
200
100
100

도면8b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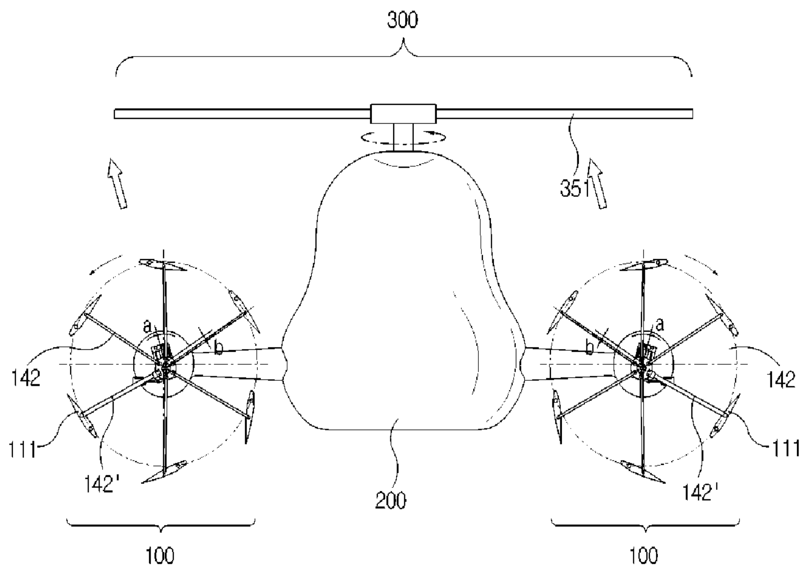
142
142
111
111
142'
142'
200
100
100

도면8c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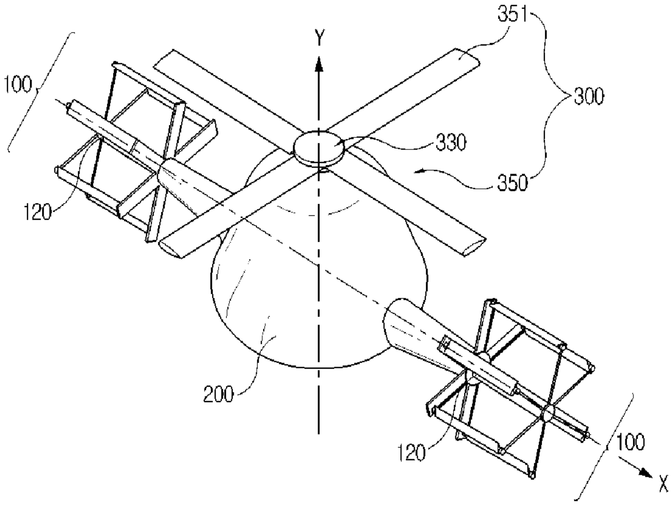
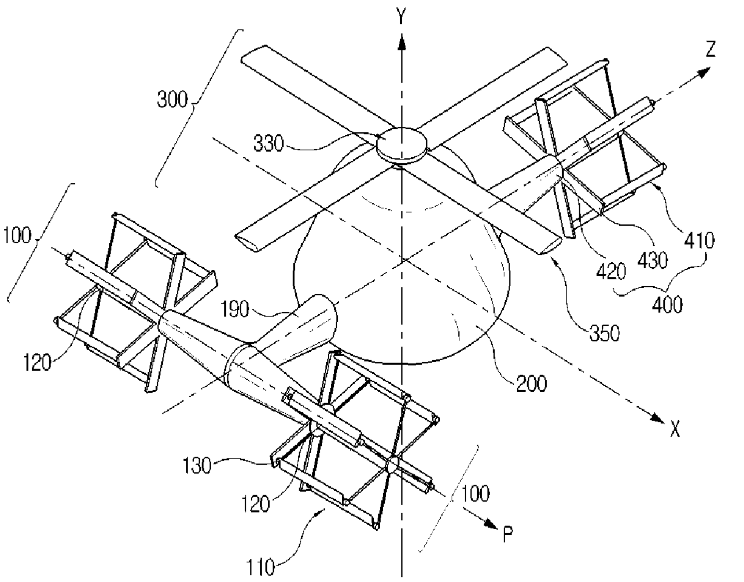
351
a
b
a
b
142
142
111
111
142'
142'
200
100
100

도면9


351
Y
100
300
330
350
120
200
120
100
X

도면10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Z
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410
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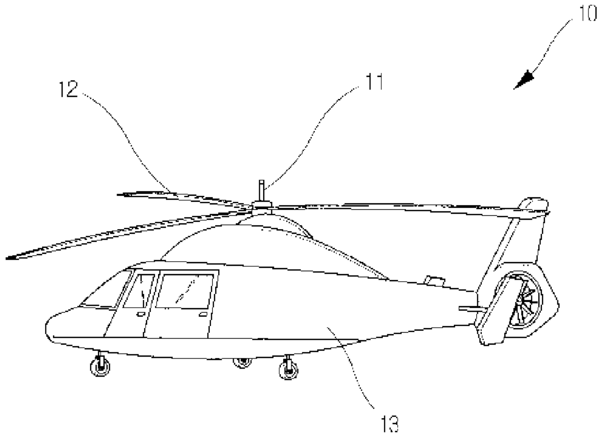
400
190
350
120
200
X
130
120
100
P
110

도면11



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(71) Anmelder *(für alle Bestimmungsstaaten mit Ausnahme von US)*: **IP2H AG** [CH/CH]; Hofweg 11, CH-3013 Bern (CH).

(72) Erfinder; und
(75) Erfinder/Anmelder *(nur für US)*: **ARNOLD, Jörg** [DE/CH]; Hofweg 11, CH-3013 Bern (CH).

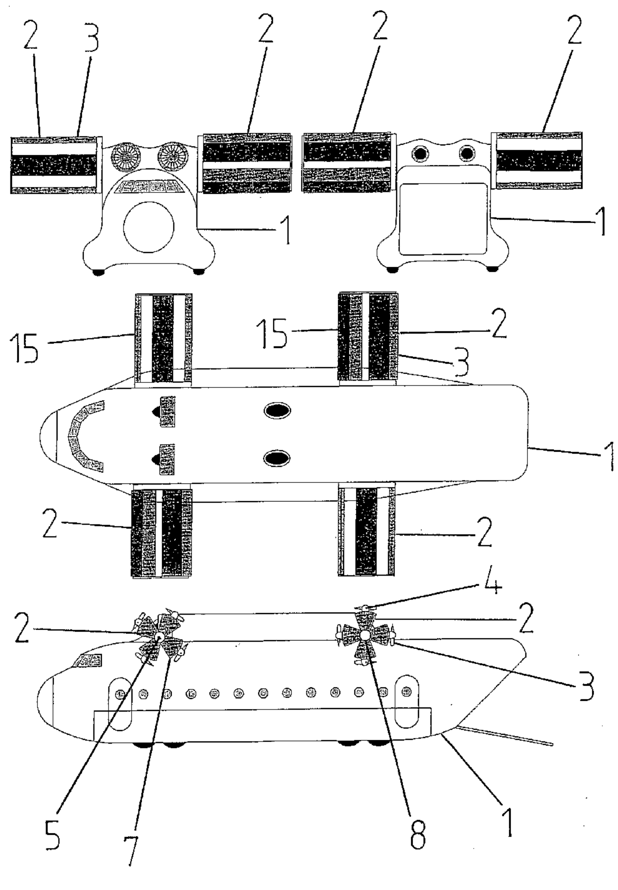
(74) Anwalt: ULLRICH & NAUMANN; Luisenstrasse 14, 69115 Heidelberg (DE).

(81) Bestimmungsstaaten *(soweit nicht anders angegeben, für jede verfügbare nationale Schutzrechtsart)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

[Fortsetzung auf der nächsten Seite]

(54) Title: AIRCRAFT

(54) Bezeichnung: LUFTFAHRZEUG



(57) Abstract: The invention relates to an aircraft comprising a fuselage (1) and a propulsion device (2) that is coupled to the fuselage (1) and that generates a definable lift. Said propulsion device (2) comprises several impeller blades (3) and the latter (3) can be pivoted through a pre-definable blade angle about a pivoting axis (4). The aircraft has been configured and developed in such a way that the impeller blades (3) are mounted to rotate about a rotational axis (5), the blade angle can be modified during the rotation of the impeller blades to generate lift and the respective pivoting axes (4) of the impeller blades (3) run substantially parallel to the rotational axis (5).

(57) Zusammenfassung: Ein Luftfahrzeug mit einem Rumpf (1) und einer mit dem Rumpf (1) gekoppelten Antriebseinrichtung (2) zur Erzeugung eines definierbaren Auftriebs, wobei die Antriebseinrichtung (2) mehrere Flügelblätter (3) aufweist und wobei die Flügelblätter (3) um einen vorgebbaren Blattwinkel um eine Schwenkachse (4) verschwenkbar sind, ist derart ausgestaltet und weitergebildet, dass die Flügelblätter (3) um eine Rotationsachse (5) drehbar gelagert sind, dass der Blattwinkel zur Erzeugung des Auftriebs während der Drehung veränderbar ist und dass die jeweiligen Schwenkachsen (4) der Flügelblätter (3) im Wesentlichen parallel zur Rotationsachse (5) angeordnet sind.

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(84) Bestimmungsstaaten *(soweit nicht anders angegeben, für jede verfügbare regionale Schutzrechtsart)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), eurasisches (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), europäisches (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Veröffentlicht:

— *ohne internationalen Recherchenbericht und erneut zu veröffentlichen nach Erhalt des Berichts*

Zur Erklärung der Zweibuchstaben-Codes und der anderen Abkürzungen wird auf die Erklärungen ("Guidance Notes on Codes and Abbreviations") am Anfang jeder regulären Ausgabe der PCT-Gazette verwiesen.

LUFTFAHRZEUG

Die vorliegende Erfindung betrifft ein Luftfahrzeug mit einem Rumpf und einer mit dem Rumpf gekoppelten Antriebseinrichtung zur Erzeugung eines definierbaren Auftriebs, wobei die Antriebseinrichtung mehrere Flügelblätter aufweist und wobei die Flügelblätter um einen vorgebbaren Blattwinkel um eine Schwenkachse verschwenkbar sind.

Luftfahrzeuge der eingangs genannten Art sind aus der Praxis bekannt und existieren in den unterschiedlichsten Ausführungsformen und Größen. Dabei sind insbesondere Hubschrauber oder Helikopter bekannt, bei denen durch den Umlauf von einem oder mehreren Hubschraubern – Rotoren – um eine nahezu senkrechte Achse aerodynamisch eine Kraft – Rotorschub – erzeugt wird, deren senkrechte Komponente den Auftrieb liefert. Durch eine Steuerung der Flügelblätter kann die Richtung des Rotorschubs aus der Senkrechten ausgelenkt werden, wodurch eine Horizontalkomponente auftritt, die als Vortriebskraft dient, die den Hubschrauber oder Helikopter aber auch rückwärts oder seitwärts bewegen kann. Die Flügelblätter sind um einen vorgebbaren Blattwinkel um eine Schwenkachse verschwenkbar. Hierdurch wird eine Anstellwinkelverstellung erzeugt. Bei einem Hubschrauber oder Helikopter sind die Flügelblätter radial zu einer Rotationsachse angeordnet.

Die bekannten Luftfahrzeuge verfügen über einen oder mehrere Rotoren mit je zwei oder mehreren radial angeordneten Rotor- oder Flügelblättern, die mit einem Ende an der Rotationsachse bzw. dem Rotorkopf befestigt sind. Die Flügelblätter der Rotoren überstreichen bei ihrer Rotation eine Kreisfläche, deren Flächennormale parallel bzw. koaxial zu der gemeinsamen Senkrechten auf der Längs- und Querachse der Helikopterflugzelle oder des Rumpfs steht oder nur wenige Grad gegen diese Senkrechte verkippt ist. Aus diesem Konstruktionsprinzip heraus resultieren verschiedene flugstatische und flugdynamische Nachteile der bisher bekannten Hubschrauber oder Helikopter.

Ein Nachteil der bekannten Hubschrauber oder Helikopter besteht im Konkreten darin, dass der Rumpf beim Manövrieren nur Vorwärts-, Rückwärts- oder Seitwärtsbewegungen ausführen kann, die mit Nickbewegungen oder Rollbewegungen des

Rumpfs bzw. der Hubschrauberflugzelle gekoppelt sind. Dadurch ist ein Manövrieren des Rumpfs unter Parallelhaltung aller Lageachsen nicht möglich. Beim Manövrieren werden immer mindestens zwei Lageachsen verkippt. Ein Satellit kann im Gegensatz hierzu Bewegungsmanöver durchführen, bei denen alle drei Lageachsen des Satelliten parallel bleiben. Hubschraubern sind solche „Shift-Manöver" nicht möglich.

Ein weiterer Nachteil besteht darin, dass alle Hubschraubertypen über so genannte Überkopf-Tragrotoren verfügen, bei denen die Flügelblätter bzw. der Flügelblattkreis den Rumpf nach vorne und zur Seite weit überragen. Hubschrauber müssen deshalb immer einen ausreichenden Abstand zu Hindernissen einhalten und sie können deshalb nicht an Objekten andocken, um z. B. Personen oder Güter übernehmen zu können. Der Zugang von Personen oder Gütern in den Hubschrauber kann bislang nur von unten in den Rumpf erfolgen. Dies schränkt die Fähigkeit der Hubschrauber für Rettungs- und Bergungsmanöver ein. Bei der Verwendung nur eines Überkopf-Tragrotors entsteht wegen der Reaktivkräfte aufgrund des Luftwiderstands gegen den Rotor ein Drehmoment, das den Hubschrauber permanent um die Hochachse des Rumpfs zu verdrehen sucht und üblicherweise mittels eines zweiten Rotors, beispielsweise eines Heckrotors, kompensiert werden muss. Dieser Heckrotor ist störanfällig und häufig Ursache für Hubschrauberabstürze und Bruchlandungen.

Des Weiteren ist bei den bekannten Hubschraubern problematisch, dass beim Richtungsflug eines Hubschraubers Flügelblätter mit Bewegungen gegen den Luftfahrtstrom und Flügelblätter mit Bewegungen in Richtung des Luftfahrtstroms unterschiedlich durch die Luft angeströmt werden. Dadurch ändert sich die Flugdynamik des Hubschraubers beim Richtungsflug mit der Fluggeschwindigkeit. Speziell werden bei sehr schnellem Vorwärtsflug die Flügelblätter mit Bewegungen gegen den Luftfahrtstrom von ihrer Blattvorderkante her angeströmt. Die Bewegungsgeschwindigkeit von Flügelblättern in der Luft addiert sich aus der Kreisbahngeschwindigkeit des Flügelblatts und der Geschwindigkeit des Luftfahrtstroms. Dies begrenzt die mögliche anwendbare Kombination aus Fahrtgeschwindigkeit und Tragkraft des Hubschraubers und die anwendbare Kombination aus Flügelblattdrehzahl und Fluggeschwindigkeit auf den Bereich, in dem die Flügelblattspitzen noch nicht in den Überschallgeschwindigkeitsbereich gelangen und deshalb noch nicht durch Schockwellen beschädigt werden können.

Flügelblätter mit Bewegung in Richtung des Luftfahrtstroms werden – ausgehend vom Inneren des Rotorkreises – teilweise von der Hinterkante des Flügelblatts her angeströmt. Dies trifft für alle Bereiche der Flügelblätter zu, deren Kreisbahngeschwindigkeitsanteil in Richtung des Luftfahrtstroms kleiner ist als die Strömungsgeschwindigkeit des Luftfahrtstroms. Diese Flügelblätter tragen mit zunehmender Fluggeschwindigkeit immer weniger zum Auftrieb des Hubschraubers bei und erzeugen ein fluggeschwindigkeitsabhängiges Rollmoment auf die Hubschrauberflugzelle bzw. auf den Rumpf, welchem entgegengesteuert werden muss.

Diese Problematik führt zur Begrenzung der anwendbaren Höchstgeschwindigkeit von Hubschraubern auf heute typischerweise 400 km/h und zu einem mit steigender Fluggeschwindigkeit zunehmenden Energieaufwand, der nicht der Fluggeschwindigkeit oder der Tragkraft des Hubschraubers zu Gute kommt. Heutige Hubschrauber sind deshalb bezüglich ihrer Flugleistung sehr energieineffizient und erreichen deshalb nur Flugreichweiten von typischerweise 1000 km.

Die Steuerung eines Hubschraubers erfolgt über die Verstellung der Flügelblattanstellwinkel und bei manchen experimentellen Hubschraubern zusätzlich über die Verkippung der Rotorachse bzw. Rotationsachse. Da die Flügelblätter sowohl zyklisch als auch kollektiv verstellt werden müssen, ist in nachteiliger Weise eine aufwendige Taumelscheibensteuerung und eine komplizierte Rotorkopfkonstruktion erforderlich. Diese komplizierte Konstruktion erlaubt heutzutage nur die Auslegung von Rotorköpfen mit nicht mehr als 8 Flügelblättern und Tragfähigkeiten der Rotorköpfe von bis zu 60 t.

Übliche Hubschrauber sind im Prinzip Pendel, bei denen der Rumpf unter dem Rotorkopf als Aufhängungspunkt pendelt. Die Fluglage des Rumpfs ist hier abhängig vom dynamischen Flugzustand, z. B. Vorwärts-, Rückwärts-, Seitwärts- oder Schwebeflug. Es kann keine vom dynamischen Flugzustand unabhängige Fluglage des Rumpfs eingestellt werden, beispielsweise ist einem Hubschrauber kein Messerflug möglich. Es sind allerdings Versuche bekannt, bei denen mit neigbaren oder verkippbaren Rotorköpfen experimentiert wird. Diese ergeben aber noch anfälligere und kompliziertere Antriebskonstruktionen.

Der vorliegenden Erfindung liegt nunmehr die Aufgabe zugrunde, ein Luftfahrzeug anzugeben, bei dem mindestens eines der obigen Probleme beseitigt ist und eine einfache Konstruktion realisiert ist.

Erfindungsgemäß ist die voranstehende Aufgabe durch ein Luftfahrzeug mit den Merkmalen des Patentanspruchs 1 gelöst. Danach ist das Luftfahrzeug derart ausgestaltet und weitergebildet, dass die Flügelblätter um eine Rotationsachse drehbar gelagert sind, dass der Blattwinkel zur Erzeugung des Auftriebs während der Drehung veränderbar ist und dass die jeweiligen Schwenkachsen der Flügelblätter im Wesentlichen parallel zur Rotationsachse angeordnet sind.

In erfindungsgemäßer Weise ist zunächst erkannt worden, dass ein Luftfahrzeug der eingangs genannten Art nicht zwangsweise als Hubschrauber mit Überkopf-Tragrotor ausgebildet sein muss, bei dem die Flügelblätter und damit auch die Schwenkachsen der Flügelblätter im Wesentlichen radial zur Rotationsachse angeordnet sind. In weiter erfindungsgemäßer Weise ist erkannt worden, dass eine besonders einfache Konstruktion der Antriebseinrichtung dadurch realisierbar ist, dass die Flügelblätter um eine Rotationsachse drehbar gelagert sind, wobei die jeweiligen Schwenkachsen der Flügelblätter im Wesentlichen parallel zur Rotationsachse angeordnet sind. Mit anderen Worten sind die jeweiligen Schwenkachsen und die Rotationsachse im Wesentlichen derart parallel angeordnet, dass sich die Flügelblätter um diese gemeinsame Rotationsachse während ihrer Drehung parallel verschieben. Zur Erzeugung eines kontrollierten Auftriebs ist während der Drehung der Flügelblätter um die Rotationsachse der Blattwinkel veränderbar. Je nach Vorgabe der Blattwinkelverstellung lässt sich ein unterschiedlich großer und in unterschiedliche Richtungen gerichteter Schub realisieren.

Mit der erfindungsgemäßen Ausgestaltung des Luftfahrzeug ist es insbesondere nicht erforderlich, Überkopf-Tragrotoren zu verwenden, die üblicherweise weit über den Rumpf des Luftfahrzeugs hinaus stehen und daher die Zugänglichkeit zum Rumpf erschweren und die Möglichkeit des Andockens des Rumpfs an beispielsweise ein Gebäude verhindern.

Im Konkreten könnten die jeweiligen Schwenkachsen der Flügelblätter im Wesentlichen äquidistant zueinander angeordnet sein. Hierdurch ist ein besonders gleichmäßiger und unwuchtfreier Bewegungsablauf der Flügelblätter um die Rotationsachse ermöglicht. Im gleichen Sinn könnten die Schwenkachsen der Flügelblätter jeweils im Wesentlichen im gleichen Abstand zur Rotationsachse angeordnet sein.

Im Konkreten könnten die Schwenkachsen der Flügelblätter nicht nur im Wesentlichen parallel zur Rotationsachse sondern auch im Wesentlichen parallel zueinander angeordnet sein. Hierdurch ist insgesamt eine besonders homogene und quasi symmetrische Ausgestaltung der Anordnung aus Flügelblättern um die Rotationsachse realisierbar.

Im Hinblick auf eine besonders einfache und sichere Einstellung des Blattwinkels der Flügelblätter könnten die Schwenkachsen der Flügelblätter durch den Schwerpunkt der Flügelblätter verlaufend angeordnet sein. Dabei könnte die Schwenkachse genau durch den Flächenschwerpunkt des Flügelblattquerschnittsprofils verlaufen.

Im Hinblick auf die Realisierung einer Neutralstellung der Flügelblätter hinsichtlich ihrer Verschwenkung um die Schwenkachse, d. h. zur Erzeugung einer Stellung, bei der die Flügelblätter während ihres Drehens um die Rotationsachse keinen Schub und keine Luftablenkung erzeugen, könnte das Querschnittsprofil der Flügelblätter zur Rotationsachse hin konkav gekrümmt sein. Das Querschnittsprofil der Flügelblätter könnte dabei quasi vollständig in einer Zylinderwand eines gedachten Kreiszylinders liegen. Ein derartiger, sich drehender Kreiszylinder würde keinen Schub und keine Luftablenkung erzeugen.

Die Schwenkachse eines jeden Flügelblatts könnte aus dem Flügelblattquerschnittsprofil senkrecht herausragen und damit quasi parallel oder koaxial zur Flügelblattlängsachse verlaufen.

Im Hinblick auf eine sichere Steuerung der Flügelblätter und ein sicheres Verschwenken der Flügelblätter um die Schwenkachse könnten die Flügelblätter an mindestens einem Ende jeweils eine Steuerachse als Angriffspunkt für ein Verschwenken der Flügelblätter um die Schwenkachse aufweisen. Diese Steuerachse könnte senkrecht aus dem Flügelblattquerschnittsprofil herausragen und – in Drehrichtung des Flügelblatts um die Rotationsachse gesehen – vor oder hinter der Schwenkachse angeordnet sein. Über die Steuerachse könnte das Flügelblatt ausgelenkt bzw. der Flügelblattanstellwinkel oder Blattwinkel eingestellt werden. Es könnten sowohl positive als auch negative Blattwinkel – bezogen auf die Neutralstellung des Flügelblatts – eingestellt werden. Wie bereits erwähnt, bedeutet die Neutralstellung des Flügelblatts, dass in dieser Stellung bei um die Rotationsachse rotierenden Flügelblättern keine stehende Luft von den Flügelblättern abgelenkt wird, sondern lediglich geschnitten wird. Der Abstand der Steuerachse zur Schwenkachse bestimmt dabei das Übersetzungsverhältnis beim Ansteuern des Blattwinkels.

Im Hinblick auf eine besonders sichere Lagerung und einen besonders sicheren Antrieb der Flügelblätter könnten die Flügelblätter an einem Ende an oder in einem Antriebselement schwenkbar gelagert sein. Dabei könnte das Antriebselement in konstruktiv einfacher Weise um die Rotationsachse drehbar sein oder auf der Rotationsachse drehbar gelagert sein. Hierzu könnte das Antriebselement eine Lagerachse oder Hohlachse aufweisen, die zu einer den Flügelblättern abgewandten Seite orientiert sein könnte.

In konstruktiv besonders einfacher Weise könnte das Antriebselement als Antriebsscheibe, Antriebskreisscheibe oder Antriebsring ausgebildet sein, auf der oder auf dem die Flügelblätter drehbar gelagert sind.

Die Schwenkachsen oder Flügelblätter könnten senkrecht zu dem Antriebselement, der Antriebsscheibe, der Antriebskreisscheibe oder dem Antriebsring angeordnet sein. Dabei könnten die Flügelblätter oder Schwenkachsen auf der der Lagerachse entgegengesetzten Seite angeordnet sein. Des Weiteren könnten die Schwenkachsen kreisförmig am Rand des Antriebselements oder der Antriebsscheibe oder der Antriebskreisscheibe oder am Rand des Antriebsrings angeordnet sein. Hierbei ist eine Anordnung der Schwenkachsen in gleichen Abständen zueinander bevorzugt. Dabei könnte die Anordnung von parallelen Flügelblättern eine kreiszylindrische Rotorwalze bilden.

Grundsätzlich können je nach Durchmesser des Antriebselements und der Breite der Flügelblätter beliebig viele Flügelblätter am Antriebselement oder an der Rotorwalze angeordnet werden. Das Flügelblatt könnte mit seiner Schwenkachse senkrecht in dem Antriebselement angeordnet sein und um diese Schwenkachse drehbar gelagert sein.

Die Lagerachse oder Hohlachse des Antriebselements könnte senkrecht auf dem Antriebselement oder der Fläche der Antriebsscheibe bzw. Antriebskreisscheibe stehen. Hinsichtlich eines sicheren Antriebs des Antriebselements könnte das Antriebselement mit einem Zahnriemen, einer Kette oder einem Zahnradgetriebe gekoppelt sein. Hierzu könnte das Antriebselement einen Zahnkranz auf einem Kreisumfang oder einem Kreisrand des Antriebselements oder auf dem Umfang der Lagerachse aufweisen. Hierdurch könnte die Lagerachse als Antriebswelle ausgebildet sein.

Zur sicheren Kopplung mit den Flügelblättern könnte das Antriebselement Vertiefungen oder Durchgänge zur Lagerung der Schwenkachsen der Flügelblätter aufweisen. Alternativ oder zusätzlich hierzu könnte das Antriebselement Vertiefungen oder Durchgänge für die Steuerachsen der Flügelblätter aufweisen. Die Steuerachsen könnten dabei derart dimensioniert sein, dass sie durch die Vertiefungen oder Durchgänge im Antriebselement hindurchragen. Die Vertiefungen oder Durchgänge könnten als Ausbrüche, Durchbrüche, Löcher oder Schlitze in dem Antriebselement ausgebildet sein. Insbesondere könnten die Vertiefungen oder Durchgänge für die Steuerachsen der Flügelblätter als vorzugsweise gekrümmte Langlöcher ausgebildet sein.

Im Hinblick auf eine Gewichtsersparnis könnte das Antriebselement Vertiefungen, Ausnehmungen, Durchgänge, Ausbrüche, Durchbrüche, Löcher oder Schlitze aufweisen, so dass das Antriebselement ein sternförmiges, ringförmiges oder speichenartiges Aussehen aufweisen könnte.

Hinsichtlich eines sicheren Einstellens des Blattwinkels der Flügelblätter könnte das Antriebselement zum Verschwenken der Flügelblätter um ihre Schwenkachse mit einem Steuerelement zusammenwirken. Das Steuerelement könnte dabei ausschließlich für die Einstellung des Blattwinkels mittels Bewegung der Steuerachsen verantwortlich sein. Hierbei könnte das Steuerelement von der Drehung der Flügelblätter und/oder des Antriebselements entkoppelt sein. Mit anderen Worten dreht das Steuerelement beim Drehen der Flügelblätter um die Rotationsachse nicht mit. In konstruktiv besonders einfacher Weise könnte das Steuerelement auf der Rotationsachse gelagert sein.

Hinsichtlich einer sicheren Steuerung der Schwenkachsen könnte das Steuerelement eine Zykloidsteuerung aufweisen. Grundsätzlich könnte das Steuerelement relativ zur Rotationsachse in einer Führung verschiebbar sein, um eine sichere Einstellung oder Vorgabe des Blattwinkels zu erreichen. Hierzu könnte das Steuerelement so gelagert bzw. geführt sein, dass es eine bestimmte Strecke oder Auslenkung in alle Richtungen senkrecht zur Rotationsachse verschoben werden kann.

Bei einer besonders einfachen Ausgestaltung könnte die Führung zwei senkrecht zueinander angeordnete Linearführungen im Sinne einer Kreuztischführung aufweisen. Alternativ hierzu könnte die Führung in ebenfalls konstruktiv einfacher Weise eine Drehführung in Verbindung mit einer Linearführung im Sinne einer verlängerbaren Drehhebelführung aufweisen.

Als weiter bevorzugte Ausgestaltung könnte die Führung zwei Drehführungen im Sinne einer doppelten Exzenterscheibenführung aufweisen. Die oben genannten Elemente der Führung könnten als Steuerschieber bezeichnet werden. Die Exzenterscheibenführung weist den Vorteil auf, dass sie direkt auf der Lagerachse oder Hohlachse des Antriebselements angeordnet sein kann oder von dieser gestützt werden kann.

Im Hinblick auf eine voneinander unabhängige und sichere Steuerung oder Bewegung der Exzenterscheiben der Exzenterscheibenführung könnte jeder Exzenterscheibe jeweils ein Stellmotor zugeordnet sein. Dabei könnte insbesondere zwei Exzenterscheiben der Exzenterscheibenführung jeweils ein Stellmotor zugeordnet sein.

Eine Exzenterscheibenführung könnte zwei Exzenterscheiben aufweisen, und zwar eine innere Exzenterscheibe, die mit ihrer Exzenterbohrung kugelgelagert auf der Lagerachse des Antriebselements angeordnet sein könnte, und eine äußere Exzenterscheibe, die kugelgelagert um oder auf der inneren Exzenterscheibe angeordnet sein könnte. Dabei könnte die Exzenterbohrung der äußeren Exzenterscheibe die innere Exzenterscheibe aufnehmen. Auf der äußeren Exzenterscheibe könnte das Steuerelement kugelgelagert und/oder zentriert angeordnet sein oder laufen. Beide Exzenterscheiben können sich dabei frei umeinander bzw. ineinander drehen. Falls die Exzenterscheiben gegeneinander verdreht werden, wird das Steuerelement ausgelenkt. Die Exzentrizitäten der Exzenterscheiben sind derart gewählt, dass für eine relative Winkellage der Exzenterscheiben zueinander der Drehpunkt der äußeren Exzenterscheibe mit dem Drehpunkt der Lagerachse des Antriebselements übereinstimmt. Falls sich die Exzenterscheiben in dieser relativen Winkellage zueinander ruhend um die Lagerachse des Antriebselements drehen, bleibt die Lage des Steuerelements unverändert und unausgelenkt.

Mit der Exzenterscheibenführung kann wie folgt gesteuert werden. Ausgehend von der gegenseitigen Winkellage der Exzenterscheiben, bei der keine Auslenkung des Steuerelements vorliegt, werden beide Exzenterscheiben relativ zueinander ruhend um den Winkel verdreht, bei dem die gewünschte Auslenkungsrichtung liegt. Anschließend werden beide Exzenterscheiben so gegeneinander verdreht, dass die äußere Exzenterscheibe um die doppelte Winkelbetragsdrehung der inneren Exzenterscheibe doppelt so schnell entgegengedreht wird. Dabei entsteht eine zum Exzenterscheibendrehwinkel – Auslenkungsbetragwinkel – proportionale Auslenkung des Steuerelements in der gewünschten Auslenkungsrichtung. Diese doppelte Exzenterscheibensteuerung ist also eine Vektorsteuerung, bei der zuerst die Auslenkungsrichtung oder der Auslenkungsrichtungswinkel und danach der Auslenkungsbetrag oder der Auslenkungsbetragwinkel eingestellt wird. Jedem Steuerbefehl bzw. der zugeordneten Steuerposition – „Steuerknüppelstellung“ – könnte eine Auslenkung bzw. ein Auslenkungsrichtungswinkel und ein Auslenkungsbetragwinkel zugeordnet sein.

Die Steuerung könnte nun derart stattfinden, dass das Steuern in aufeinander folgende diskrete Steuerpositionen zerlegt wird. Von einer Steuerposition wird sukzessiv in die Folgende übergegangen, indem der zugeordnete Auslenkungsrichtungswinkel in den folgenden zugeordneten Auslenkungsrichtungswinkel und der zugeordnete Auslenkungsbetragwinkel in den folgenden zugeordneten Auslenkungsbetragwinkel überführt wird. Je feiner die diskrete Zerlegung gewählt wird, umso feiner, bzw. simultaner ist das Steuern möglich. Die Exzenterscheiben könnten dabei durch zwei Stellmotoren, beispielsweise zwei Schrittmotoren, verstellt werden. Ein Stellmotor hält und verdreht dabei die innere Exzenterscheibe und ein Stellmotor hält und verdreht dabei die äußere Exzenterscheibe. Hierzu könnte jede Exzenterscheibe mit einem Zahnkranz versehen sein, in den der Stellmotor über ein Ritzel eingreifen könnte. Die Exzenterscheiben stehen bei rotierenden Flügelblättern außerhalb des Steuervorgangs still.

Im Hinblick auf eine besonders sichere Lagerung und/oder Führung der Steuerachsen könnte das Steuerelement eine Ringnut oder Kreisnut zur Aufnahme der Steuerachsen der Flügelblätter aufweisen. Während des Drehens der Flügelblätter um die Rotationsachse könnten die Steuerachsen in der Ringnut oder Kreisnut umlaufen. In weiter konstruktiv einfacher Weise könnte das Steuerelement als Steuerring oder Steuerscheibe ausgebildet sein. Dabei könnte eine Ringnut oder Kreisnut im äußeren Bereich des Steuerrings oder der Steuerscheibe ausgebildet sein.

Wird nun das Steuerelement bei rotierendem Antriebselement über die Führung des Steuerelements in eine Richtung ausgelenkt, so folgen die Steuerachsen der Flügelblätter, die in einer Ringnut oder Kreisnut umlaufen könnten, zyklisch dieser Auslenkung. Dies realisiert eine zyklische Flügelblattverstellung. Bei einem Umlauf werden die Steuerachsen der Flügelblätter aus ihrer Neutralstellung sowohl einmal positiv maximal als auch einmal negativ maximal ausgelenkt und durchlaufen zwischen diesen beiden Extremalauslenkungen zweimal ihre Neutralstellung. In den beiden auf einer Ringnutbahn des Steuerelements gegenüberliegenden Neutralstellungen wird die ruhende Luft von den Flügelblättern nicht abgelenkt. In den beiden Extremalstellungen wird die stehende Luft wegen der Bewegungsrichtungsumkehr der Flügelblätter auf ihrer Kreisbahn in diesen Punkten in die gleiche Richtung maximal abgelenkt.

Die Extremalstellungen der Flügelblätter liegen auf Positionen auf der Verschiebungsachse oder in der Auslenkungsrichtung des Steuerelements. Die Neutralstellungen liegen an Positionen vor, die hierzu um jeweils 90 Grad verschoben sind. Falls die Steuerachsen der Flügelblätter – in Drehrichtung der Flügelblätter gesehen – vor den Schwenkachsen der Flügelblätter am Flügelblatt angeordnet sind, so ist die Verschiebungsrichtung des Steuerelements identisch mit der Schubrichtung, die durch die Luftablenkung vorgegeben wird. Falls die Steuerachsen der Flügelblätter hinter den Schwenkachsen angeordnet sind, so ergibt sich die umgekehrte Wirkung.

Zur Steigerung der Effizienz der Antriebseinrichtung könnte die Ringnut oder der Steuerring eine von der Kreisform abweichende Gestaltung aufweisen. Es ist also nicht zwangsläufig eine kreisförmige Ausgestaltung der Ringnut oder des Steuerrings vorgesehen. Im Konkreten könnte die abweichende Gestaltung eine drehwinkelabhängige Anstellwinkelfunktion oder überlagerte Anstellwinkelfunktionen liefern. Die Effizienz der Antriebseinrichtung ist hierdurch variierbar. Weiter im Konkreten könnte die Anstellwinkelfunktion dem Ausdruck $a \cdot \cos(x)^w$ proportional sein, wobei a der Anstellwinkel der Flügelblätter in Grad ist und w vorzugsweise eine ganze Zahl – vorzugsweise 11 – ist.

Mit anderen Worten könnte die Form des Steuerrings oder der Ringnut weiter optimiert werden, um die Effizienz der um eine Rotationsachse drehbaren Flügelblätter oder die Effizienz einer Rotorwalze zu steigern. Zur Bereitstellung dieses Effekts könnte anstelle einer kreisförmigen Ringnut oder anstelle eines kreisförmigen Steuerrings eine abweichende Form realisiert werden, die eine drehwinkelabhängige Anstellwinkelfunktion $a \cdot \cos(x)^w$ liefert. Dies ist nur ein Demonstrationsbeispiel für die Optimierungsfähigkeit der Effizienz der um eine Rotationsachse drehbaren Flügelblätter oder der Rotorwalze. In der Realität eignen sich Ringnutformen besser, die überlagerte Anstellwinkelfunktionen liefern, da dann die Rotorwalzeneffizienz oder Effizienz der um eine Rotationsachse drehbaren Flügelblätter nicht auf Kosten des maximalen Rotorwalzen- oder Flügelblätterschubs optimiert werden kann.

Solche Ringnutformen oder Steuerringformen oder Flügelblattbahnkurven lassen sich aus der Überlagerung eines Kreises – Basiskreis – mit zwei oder vier periodischen und symmetrischen „Ausbuchtungen“ auf dem Kreis erzeugen, so dass den Kurven der möglichen Überlagerungsfunktionen der Basiskreis einbeschrieben werden kann und ein Quadrat umschrieben werden kann. Es liegt dann also eine ganze Schar von Kurven vor. Im Grenzfall wäre eine Annäherung eines Quadrates um den Kreis denkbar.

Einfache Beispiele solcher Überlagerungskurven sind für zwei Ausbuchtungen Ellipsen und für vier Ausbuchtungen Epizykloiden und Astroiden oder einfache Quadrate oder Rechtecke mit gerundeten Ecken. Im Falle der Verwendung nicht kreisförmiger Steuerringe oder Ringnuten mit einer starken Abweichung zur Kreisform ist die Steuerung der Flügelblätter oder der Rotorwalze abzuwandeln. Es könnten dann je zwei nebeneinander oder hintereinander liegende Steuerelemente oder Nutenringe mit gleicher oder wenig voneinander abweichender Nutenringform an einem Ende der Rotorwalze oder an den beiden Enden der Rotorwalze verwendet werden. In dem einen Nutenring, der neben der Antriebsscheibe und/oder neben der Führungsscheibe liegt und relativ zu ihr festliegt, laufen die Flügelblattschwenkachsen – Flügelblattdrehachsen – um und im anderen Nutenring – dem Steuerring – laufen die Flügelblattsteuerachsen oder Flügelblattanlenkachsen um. Dieser Nutenring kann nach wie vor relativ zur Antriebsscheibe oder Führungsscheibe verdreht und verschoben werden.

Die Antriebsscheibe und die Führungsscheibe sind zusätzlich anstelle mit Bohrungen für die Flügelblattschwenkachsenaufnahme mit radialen Schlitzen oder Langlöchern versehen, in denen die Flügelblattschwenkachsen radial gleiten können. Die Antriebsscheibe und die Führungsscheibe haben dann den Charakter einer Mitnehmerscheibe. In dieser konstruktiven Ausführung mit paarweisen Steuerelementen bzw. Nutenringen könnten sowohl die Flügelblattschwenkachsen als auch die Flügelblattsteuerachsen radial geführt und bewegt werden. Es liegt dann anstelle einer kreiszylindrischen Rotorwalze oder Anordnung von Flügelblättern eine zylindrische Rotorwalze mit beispielsweise ellipsoider, epizyklischer oder asteroider oder eckengerundet quadratischer oder eckengerundet rechteckiger Querschnittsbahn vor, auf der sich die Flügelblätter bewegen können.

Bei einer konstruktiv einfachen Ausgestaltung könnte die Lagerachse oder Hohlachse des Antriebselements vorzugsweise zentrisch durch das Steuerelement hindurch verlaufend angeordnet sein. Dabei könnte das Steuerelement konzentrisch hinter oder unter dem Antriebselement angeordnet sein. Dabei könnte die Lagerachse des Antriebselements, die gleichzeitig Antriebswelle sein kann, durch das Steuerelement hindurchgeführt sein. Das Antriebselement und das Steuerelement könnten hierbei parallel zueinander angeordnet sein. Bei einer Ausgestaltung des Antriebselements als Antriebsscheibe und des Steuerelements als Steuerring könnte die Antriebsscheibenkreisfläche parallel oder koplaner zur Fläche angeordnet sein, in der der Steuerring liegt.

Die Enden der Steuerachsen der Flügelblätter könnten bei Drehung der Antriebsscheibe spielfrei in der Ringnut oder Kreisnut des Steuerelements laufen. Dabei sind die Steuerachsen durch das Antriebselement oder die Antriebsscheibe hindurch gesteckt. Die Spielfreiheit könnte z. B. durch eine entsprechende Rollenlagerung erreicht werden, in der die Enden der Steuerachsen sitzen. Im einfachsten Fall könnte diese Rollenlagerung mittels zweier radial leicht versetzter Wälzlager realisiert werden, die auf dem Ende der Steuerachse sitzen. Das eine Wälzlager hält dabei lediglich einen Druckkontakt zur einen Ringnutinnenwand und das andere Wälzlager hält lediglich einen Druckkontakt zur anderen oder gegenüberliegenden Ringnutinnenwand.

Die zyklische Verstellung der Flügelblätter könnte alternativ mittels den aus der marinen Antriebstechnik bekannten Zykloidsteuerungen für Paddelantriebe realisiert werden, wie sie beispielsweise im Schneider-Voith-Antrieb vorliegen. Diese bekannten Konstruktionsprinzipien eignen sich allerdings weniger für schnell rotierende Rotorwalzen, da die Paddelansteuerungsmechanik über hohe bewegte Massen verfügt, deren zyklische Beschleunigung zu hohen Reaktionskräften und Vibrationen führt. Die Erfindung hingegen gewährleistet minimale Massenbeschleunigungen, da lediglich die Flügelblätter zyklisch um ihre Längsachse und keine weiteren Steuermechanismus-Massen zyklisch beschleunigt werden müssen.

Im Hinblick auf ein besonders stabiles Flugverhalten könnte die Antriebseinrichtung mindestens zwei Anordnungen aus um jeweils eine Rotationsachse drehbaren Flügelblättern aufweisen. Hierdurch lassen sich unerwünschte Drehmomente um die Hochachse des Luftfahrzeugs vermeiden.

Zur Realisierung eines sicheren Auftriebs könnte die Rotationsachse oder könnten die Rotationsachsen in einer im Wesentlichen horizontalen Ebene angeordnet sein. Hierdurch ist eine maximale Schubumsetzung in vertikaler Richtung ermöglicht.

Im Hinblick auf einen besonders schmalen Aufbau des Luftfahrzeugs könnte die Rotationsachse oder könnten die Rotationsachsen parallel zu einer in Vorwärts-

Flugrichtung verlaufenden Längsachse des Rumpfs angeordnet sein. Bei einer alternativen Ausgestaltung könnte die Rotationsachse oder könnten die Rotationsachsen senkrecht zu einer in Vorwärts-Flugrichtung verlaufenden Längsachse des Rumpfs angeordnet sein. Grundsätzlich sind beide zuletzt genannten Anordnungen der Rotationsachse oder der Rotationsachsen im Hinblick auf die Flugstabilität des Luftfahrzeugs günstig.

Bei einer konkreten und konstruktiv besonders einfachen Ausgestaltung könnten mehrere Flügelblätter eine um jeweils eine der Rotationsachsen rotierbare Walze bilden, wobei die Antriebseinrichtung mindestens zwei derartige Walzen aufweisen könnte.

Zur Erzeugung stabiler Fluglagen könnten die Walzen in Richtung der Längsachse gegeneinander versetzt sein. Auf jeder Längsseite des Rumpfs könnte mindestens eine derartige Walze angeordnet sein. Es sind jedoch auch mehrere Walzen auf jeder Längsseite des Rumpfs denkbar. Bei einer Ausgestaltung mit mehreren Walzen lässt sich ein stärkerer Auftrieb erzeugen, wodurch höhere Lasten durch das Luftfahrzeug transportierbar wären.

Zur Vermeidung unerwünschter Drehmomente könnten zumindest zwei Walzen gegensinnig drehbar sein.

Bei einer konkreten und konstruktiv einfachen Ausgestaltung könnten auf jeder Längsseite des Rumpfs mindestens zwei Walzen angeordnet sein und könnten die Rotationsachsen sich gegenüberliegender Walzen fluchten. Damit ist letztendlich eine Anordnung der Walzen mit Rotationsachsen realisiert, die senkrecht zu einer in Vorwärts-Flugrichtung verlaufenden Längsachse des Rumpfs angeordnet sind.

Im Hinblick auf eine besonders vielseitige und individuelle Steuerung des Luftfahrzeugs könnte jede Walze separat steuerbar sein. Bei einer vereinfachten Steuerung könnten mehrere Walzen zusammen im gleichen Sinn steuerbar sein.

Aufgrund des Wirkprinzips einer Walze aus um eine Rotationsachse rotierbaren Flügelblättern liegt die Auftriebs- bzw. Vortriebserzeugung senkrecht zur Walzenlängsachse bzw. Rotationsachse. Die Walzen als Antriebe bzw. ihre Rotationsachsen könnten deshalb parallel bzw. koaxial zur Querachse des Luftfahrzeugs am Rumpf angeordnet werden. Es sollten aber mindestens zwei in Längsachsenrichtung des Rumpfs gegeneinander versetzte Walzen – je eine auf jeder Seite des Rumpfs – verwendet werden, um ein hinsichtlich der Fluglage statisch bestimmtes und besonders stabiles System zu erreichen. Zur Vermeidung unerwünschter Drehmomente könnten die beiden Rotorwalzen gegensinnig rotieren. Die Anwendung von zwei Walzen auf der gleichen Höhe der Längsachse könnte im Schwerpunkt des Luftfahrzeugs liegen und würde je nach dem, ob die Rotorwalzen sich gleichsinnig oder gegensinnig drehen, ein Drehmoment um die Querachse oder um die Hochachse des Rumpfs erzeugen. Die notwendige statische Fluglagenstabilität wäre hier nicht gegeben.

Unter Berücksichtigung der Möglichkeit eines Ausfalls einer Rotorwalze könnte eine besonders sichere Ausgestaltung der Erfindung die Verwendung von vier Rotorwalzen aufweisen, wobei sich je zwei Rotorwalzen auf beiden Seiten des Rumpfs gegenüberliegen bzw. eine gemeinsame Rotorwalzenlängsachse bzw. Rotationsachse bilden. Je ein solches Rotorwalzenpaar könnte im vorderen Bereich und im hinteren Bereich des Rumpfs vorgesehen werden.

Durch die Verwendung von zwei bzw. vier in Längsachsenrichtung des Rumpfs versetzte Rotorwalzen kann das Luftfahrzeug Vorwärts- und Rückwärtsmanöver durchführen, ohne zu nicken. Dazu müssten die vordere und die hintere Rotorwalze bzw. das vordere oder hintere Rotorwalzenpaar lediglich hinsichtlich ihrer Schuberzeugung gleich gesteuert werden. Andererseits könnte ein Vorwärts- und Rückwärtsmanöver durch eine unterschiedlich starke Schuberzeugung des vorderen und des hinteren Antriebs durchgeführt werden. Dies führt dann wieder zu einem Drehmoment um die Querachse des Rumpfs und damit zur bekannten Nickbewegung, bei der in der Kräfteparallelogrammzerlegung der Schubvektoren eine Komponente in Vorwärts- oder Rückwärtsrichtung erzeugt wird.

Für Seitwärtsmanöver der Erfindung kann gleiches wie zu Vorwärts- und Rückwärtsmanövern gesagt werden. Seitwärtsmanöver könnten durch eine unterschiedliche Schubsteuerung der linken oder der rechten Rotorwalzen bzw. des linken oder des rechten Antriebs durchgeführt werden. Dadurch entsteht ein Drehmoment um die Längsachse des Rumpfs und durch die folgende Rollbewegung resultieren wieder Schubvektoren in Seitwärtsrichtung.

Durch eine weitere Ausgestaltung des erfindungsgemäßen Luftfahrzeugs könnte jedoch auch eine Seitwärtsbewegung ohne eine resultierende Rollbewegung erzeugt werden. Hierzu könnten die Flügelblätter an ihrem anderen, dem Antriebselement abgewandten Ende an oder in einem Führungselement mittels jeweils einer Schwenkachse schwenkbar gelagert sein. Ein derartiges Führungselement kann Biegemomente der rotierenden Flügelblätter aufnehmen, die durch die zyklische Luftablenkung und die Zentrifugalkräfte der Rotation auftreten. Mit dem Führungselement kann die Anordnung aus Flügelblättern oder die Rotorwalze mit wesentlich höheren Drehzahlen rotieren und sie kann wesentlich mehr Schubreaktionskräfte aufnehmen bzw. wesentlich mehr Vortriebsschub und Auftriebsschub erzeugen.

Das Führungselement könnte im Wesentlichen wie das Antriebselement – vorzugsweise scheibenförmig – ausgebildet sein. Hierbei könnte ein Führungselement als Führungsscheibe ausgebildet werden.

Das Führungselement könnte durch eine zentrische Unterstützungsachse oder eine Hohlachse zwischen dem Antriebselement und dem Führungselement unterstützt und an das Antriebselement angekoppelt werden. Das Führungselement könnte folglich mit dem Antriebselement mitdrehbar angeordnet sein. Im Konkreten könnte das Führungselement und das Antriebselement mittels einer Achse oder der Rotationsachse gekoppelt sein. Dabei könnte die Längsachse der Unterstützungsachse, Hohlachse, Achse oder Rotationsachse durch das Zentrum des Antriebselements und des Führungselements verlaufen, wobei die Längsachse der Unterstützungsachse oder Hohlachse mit der Rotorwalzenlängsachse bzw. der Rotationsachse zusammenfällt.

Die Unterstützungsachse des Führungselements oder der Führungsscheibe entspricht der Lagerachse des Antriebselements oder der Antriebsscheibe. Dabei kann man die Unterstützungsachse als führungselementseitige Verlängerung der Lagerachse des Antriebselements ansehen. Da die Unterstützungsachse oder Hohlachse das Führungselement mitnimmt bzw. antreibt, könnte sie gleichzeitig Antriebswelle für das Führungselement sein.

Im Hinblick auf eine besonders einfache Seitwärtsbewegung des Luftfahrzeugs ohne eine resultierende Rollbewegung könnte dem Führungselement ein Führungsrotor aus mehreren Rotorblättern zugeordnet sein. Die Rotorblätter könnten in konstruktiv besonders einfacher Weise an dem Führungselement angelenkt sein. Die Rotorblätter könnten im Konkreten zwischen der Nabe des Führungselements und dem Rand des Führungselements radial angeordnet sein. Hierzu könnte das Führungselement entsprechende Durchgänge und/oder Lagersitze aufweisen. Ein derartiger Führungsrotor könnte dem Heckrotor herkömmlicher Hubschrauber entsprechen und im Prinzip konstruktionsgleich sein.

Der Führungsrotor könnte über ein durch die Rotationsachse verlaufendes Gestänge angetrieben sein. Ein derartiges Gestänge könnte eine Schubstange aufweisen, die durch die Unterstützungsachse und die Lagerachse des Antriebselements geführt ist. Der Führungsrotor könnte durch die Schubstange und durch Umlenkhebel angelenkt sein. Führungsrotoren der Rotorwalzen ermöglichen eine Seitwärtsbewegung des Luftfahrzeugs ohne eine resultierende Rollbewegung. Dazu könnten alle Führungsrotoren hinsichtlich ihres Schubs gleich gesteuert werden.

Ein Drehmanöver des Luftfahrzeugs um die Hochachse des Rumpfs könnte entweder durch eine ungleichmäßige Schubsteuerung der Rotorwalzen oder der Führungsrotoren durchgeführt werden. Dazu müssten nur jeweils zwei gegenüberliegende Rotorwalzen oder Führungsrotoren, die nicht dem gleichen Rotorwalzenpaar angehören, in geeigneter Weise hinsichtlich ihres Schubs angesteuert werden.

Zum Steigen oder Sinken des Luftfahrzeugs könnte der Auftriebsschub des vorderen und des hinteren Antriebs gleich gesteuert werden. Die Erhöhung des Steigschubs könnte über die Vergrößerung des Blattwinkels und/oder über eine Drehzahlerhöhung der Rotorwalzen erreicht werden. Hierbei wird ein wesentlicher Unterschied der Erfindung zu herkömmlichen Hubschraubern offenbar. Herkömmliche Hubschrauber erzeugen nämlich ihren Steigschub über eine kollektive Vergrößerung des Blattwinkels und/oder eine Drehzahlerhöhung des Rotors. Bei der vorliegenden Erfindung hingegen wird der Steigschub über die zyklische Blattverstellung erreicht.

Zur Erreichung des Ausrichtung bzw. Trimmung der Fluglage des Rumpfs könnten die vorderen oder hinteren bzw. die seitlichen gegenüberliegenden Antriebe hinsichtlich ihres Schubs unterschiedlich angesteuert werden. Die Erfindung ermöglicht, über die Trimmungsfähigkeit unterschiedliche permanente Fluglagen einzuhalten, und zwar unabhängig vom dynamischen Flugzustand.

Das erfindungsgemäße Luftfahrzeug kann die gleichen flugdynamischen Zustände eines herkömmlichen Hubschraubers ohne die Verwendung einer kollektiven Blattverstellung erreichen. Die konstruktive Ausführung des erfindungsgemäßen Luftfahrzeugs ist deshalb wesentlich einfacher. Darüber hinaus kann das erfindungsgemäße Luftfahrzeug Manöver mit vollkommen entkoppelten Bewegungen bzw. reine Translationsbewegungen oder Shiftmanöver ohne damit verbundene Nick- und/oder Rollbewegungen durchführen. Derartige Manöver oder Bewegungen sind herkömmlichen Hubschraubern nicht möglich. Zudem kann die Fluglage des Rumpfs getrimmt werden. Der Hubschrauber kann alle Lagen im gesamten Bereich von 360 Grad um die Querachse des Rumpfs stabil einnehmen. Da das erfindungsgemäße Luftfahrzeuge über zwei oder vier Rotorwalzen mit im Prinzip beliebiger Anzahl von Flügelblättern je Rotorwalze verfügen kann, kann ein wesentlich höherer Auftriebsschub erreicht werden und können somit wesentlich höhere Hublasten transportiert werden, als dies mit herkömmlichen Hubschraubern möglich ist.

Bei einer Anordnung der Rotorwalzenlängsachse bzw. der Rotationsachse parallel bzw. koaxial zur Querachse des Rumpfs zeigt sich immer noch der Nachteil, dass die Flügelblätter, die sich entgegen dem Luftfahrtstrom bewegen, und solche, die sich in Richtung des Luftfahrtstroms bewegen, in ineffizienter Weise drehzahlabhängig und fluggeschwindigkeitsabhängig unterschiedlich angeströmt werden. Zusätzlich besteht bei dieser Konstruktion immer noch der Nachteil, dass sich die Fluggeschwindigkeit zur Bahngeschwindigkeit der Flügelblätter addiert und so die maximale Fluggeschwindigkeit stark begrenzt bleibt. Diese Nachteile können durch die folgende Ausgestaltung des erfindungsgemäßen Luftfahrzeugs behoben werden.

Dazu werden die Rotorwalzenlängsachsen bzw. die Rotationsachsen nicht mehr parallel bzw. koaxial zur Rumpfquerachse angeordnet, sondern parallel bzw. koaxial zur Rumpflängsachse. Für eine Antriebseinrichtung könnten dann mindestens zwei Rotorwalzen hintereinander mit gemeinsamer Rotorwalzenlängsachse bzw. Rotationsachse eingesetzt werden, um die erforderlichen Manövrierdrehmomente erzeugen zu können. Bei der Verwendung von nur zwei Rotorwalzen könnten diese hintereinander und über Kopf über dem Rumpf angeordnet werden. Bei der Verwendung von vier Rotorwalzen könnten diese auch seitlich mit je zwei hintereinander liegenden Rotorwalzen auf jeder Seite am Rumpf angeordnet werden. Je zwei hintereinander liegende oder nebeneinander liegende bzw. gegenüber liegende Rotorwalzen können dann zur Vermeidung unerwünschter Drehmomente gegensinnig rotieren.

Bei einer besonders günstigen Anordnung könnten neben- oder hintereinander angeordnete Anordnungen von Flügelblättern oder Walzen quasi gespiegelt angeordnet sein. Man kann hier auch von einer verbundenen und gespiegelten Hintereinanderanordnung der Rotorwalzen sprechen. Bei dieser Anordnung ist nur ein Führungselement für beide Rotorwalzen erforderlich und es reicht der Antrieb eines einzigen Antriebselements aus, da die Rotorwalzen über das gemeinsame Führungselement bzw. die beidseitigen Unterstützungsachsen fest miteinander gekoppelt werden können. Bei dieser Anordnung mit nur einem Antrieb könnten allerdings Manövrierdrehmomente nur noch durch die zyklische Flügelblattverstellung und nicht mehr durch eine unterschiedliche Drehzahlsteuerung für beide Rotorwalzen erreicht werden. Außerdem können die Drehmomente, die durch den Luftwiderstand gegen die rotierenden Rotorblätter entstehen, nicht mehr durch eine getrennt angetriebene gegensinnige Rotation der Rotorwalzen kompensiert werden.

Eine noch größere konstruktive Vereinfachung des erfindungsgemäßen Luftfahrzeugs könnte dadurch erreicht werden, dass an beiden Enden der Flügelblätter jeweils ein vom jeweils anderen Steuerelement unabhängig betätigbares Steuerelement angeordnet ist. Beispielsweise könnte nur noch eine Rotorwalze verwendet werden, die allerdings zwei Steuerelemente oder Steuerringe aufweist. Die Flügelblätter könnten dann an jedem ihrer Enden entweder in einem Antriebselement oder in einem Führungselement gelagert und an jedem ihrer Enden in Steuerelementen oder Steuerringnuten geführt werden. Bei dieser Ausführung könnten Manövrierdrehmomente, die senkrecht zur Rotorwalzenlängsachse bzw. Rotationsachse verlaufen, durch eine zyklische Torsion der Flügelblätter erreicht werden. Die Torsion erfolgt durch eine relative Verschiebung der beiden Steuerelemente oder

Steuerringe zueinander. Dadurch ändert sich der Blattwinkel und der punktuelle Schub der Flügelblätter von einem Ende der Flügelblätter zum anderen Ende hin stetig. Bei der vorher beschriebenen Ausgestaltung des erfindungsgemäßen Luftfahrzeugs werden Manövrierdrehmomente durch unterschiedliche Gesamtschubvektoren der einzelnen Rotorwalzen erzeugt. Eine Rotorwalze mit Torsionssteuerung wirkt wie zwei getrennt steuerbare Rotorwalzen.

Durch die zur Längsachse des Rumpfs parallele bzw. koaxiale Ausrichtung der Rotorwalzenlängsachsen bzw. Rotationsachsen ändert sich die Zuordnung der Schuberzeugung zu den Flugmanövern. Seitliche Shiftmanöver oder Drehmanöver um die Hochachse des Rumpfs können nicht mehr mittels der Führungsrotoren durchgeführt werden, sondern nur noch durch die Schubsteuerung der Rotorwalzen. Vorwärts gerichtete Shiftmanöver können hingegen nicht mehr mittels der Rotorwalzen, sondern nur noch durch die Führungsrotoren durchgeführt werden. Da es energetisch günstiger ist, den Vortrieb des Luftfahrzeugs nicht wie üblich durch die gekoppelte Nickbewegung zu erreichen, sondern im Rahmen einer rein translatorischen Bewegung, könnten die relativ schwachen Führungsrotoren durch kräftige Verstellpropeller ersetzt werden.

Bei einer derartigen Ausgestaltung des erfindungsgemäßen Luftfahrzeugs könnte ein Antriebsstrang aus Antriebskomponenten der Antriebseinrichtung wie folgt aufgebaut sein: Verstellpropeller, Wellenleistungsturbine mit Rumpfbefestigung und beidseitig durchgeführter Turbinen-Leistungswelle, vorderes Steuerelement oder vorderer Steuerring, Antriebselement oder Antriebsscheibe der vorderen Rotorwalze, vordere parallele Flügelblätter, Führungselement oder Führungsscheibe mit beidseitiger Unterstützungsachse, hintere parallele Flügelblätter, Antriebselement oder Antriebsscheibe der hinteren Rotorwalze, hinteres Steuerelement oder hinterer Steuerring und hintere Lagerachsenaufnahme mit Rumpfbefestigung des Antriebselements oder der Antriebsscheibe der hinteren Rotorwalze, wobei der Verstellpropeller vorne auf der Turbinenwelle sitzt und die Lagerachse bzw. Lagerwelle des ersten Antriebselements oder der ersten Antriebsscheibe hinter der Turbine ebenfalls mit der durchgeführten Turbinenwelle gekoppelt ist. Die Turbine im Antriebsstrang ersetzt die sonst noch notwendige Lagerachsenaufnahme mit Rumpfbefestigung für das vordere Antriebselement oder die vordere Antriebsscheibe.

Alternativ könnte die Antriebsturbine oder könnten die Antriebsturbinen auch in dem Rumpf oder auf dem Rumpf angeordnet sein und den Antriebsstrang über ein Getriebe antreiben. Bei dieser alternativen Ausgestaltung könnte eine Antriebsturbine zwei Seitenantriebsstränge antreiben oder bei der Verwendung von zwei Antriebsturbinen könnten diese einfacher über ein Getriebe gekoppelt werden, um dem Ausfall einer Antriebsturbine vorzubeugen.

Im Rahmen einer konkreten Ausgestaltung könnte mindestens eine Antriebsturbine im Rumpf des Luftfahrzeugs angeordnet sein. Hierdurch ist eine geschützte Anordnung der Antriebsturbine gewährleistet.

Die Anordnung der Antriebsturbine oder der Antriebsturbinen im Rumpf hätte den weiteren Vorteil, dass die Turbinenabgase seitlich aus dem Rumpf heraus direkt an die Rotorwalze oder über die Rotorwalze geleitet werden könnten. Damit könnte der über der Rotorwalze entstehende und von der Rotorwalze selbst erzeugte Unterdruck durch das Zuströmen der Turbinenabgase teilweise ausgeglichen werden und somit der notwendige selbstinduzierte Antriebsleistungsaufwand teilweise vermindert werden. Die heißen Turbinenabgase könnten dann gleichzeitig eine mögliche Vereisung der Rotorwalze verhindern und die heißen Turbinenabgase könnten derart verwirbelt und nach unten abgelenkt werden, dass sie keine anderen Turbineneinlässe anderer Antriebsturbinen erreichen und zum Ausfall anderer Turbinen führen können.

Der Verstellpropeller müsste so ausgelegt werden, dass über seine Propellerblattverstellung sowohl Vorwärtsschub als auch Rückwärtsschub erreicht werden können. Um den induzierten Leistungsaufwand weiter zu reduzieren, könnte sowohl vor einer Rotorwalze als auch hinter dieser Rotorwalze jeweils ein Verstellpropeller oder Propeller angeordnet werden. Der vordere Propeller könnte dann als Zugpropeller und der hintere als Druckpropeller ausgelegt werden. Zwischen den Verstellpropellern oder Propellern – beispielsweise zwischen dem Zugpropeller und dem Druckpropeller – könnten zwei oder mehrere hintereinander angeordnete Rotorwalzen angeordnet sein.

Im Schwebeflug des Luftfahrzeugs könnte man die beiden obigen Propeller gegeneinander drückend betreiben. Beide Propeller könnten für den Schwebeflug so eingestellt werden, dass sich ihre Vortriebswirkung gegenseitig kompensiert aber trotzdem zusätzliche Luftmasse der Rotorwalze oder den entsprechenden Rotorwalzen zugeführt wird.

Der Propeller kann zusätzlich zum teilweisen Drehmomentausgleich genutzt werden, um ein nicht kompensierbares Restdrehmoment, das durch die Rotorwalzenrotation bzw. den reaktiven Luftwiderstand entsteht, zu kompensieren. Ein solches nicht kompensierbares Drehmoment tritt beispielsweise bei der Verwendung einer einzigen torsionsgesteuerten Rotorwalze auf – siehe oben. Dazu kann mittels eines Umkehrgetriebes die Propellerrotation gegensinnig zur Rotorwalzenrotation eingestellt werden. Dieser Drehmomentausgleich ist besonders interessant für kleinere erfindungsgemäße Luftfahrzeuge mit nur einem Antriebsstrang.

Bei einer weiteren vorteilhaften Ausführungsform könnte am Rumpf mindestens eine Hilfstragfläche oder Tragfläche angeordnet sein, an der oder an denen die Rotorwalze oder Rotorwalzen angeordnet oder aufgehängt sind.

Ein auftretendes oder nicht kompensierbares, vom Luftwiderstand herrührendes Drehmoment hat auf das erfindungsgemäße Luftfahrzeug nicht die gravierende Auswirkung, wie auf einen herkömmlichen Hubschrauber. Beim herkömmlichen Hubschrauber muss dieses Drehmoment üblicherweise durch einen zweiten Rotor, beispielsweise einen Heckrotor, unbedingt kompensiert werden, um eine permanente Rotation des Rumpfs um seine Hochachse zu verhindern. Beim erfindungsgemäßen Luftfahrzeug treten solche Drehmomente um die Hochachse nicht auf. Entsprechende Drehmomente treten lediglich um die Längsachse des Rumpfs auf und führen allerhöchstens zu einer seitlichen Pendelauslenkung des Rumpfs. Das erfindungsgemäße Luftfahrzeug ist flugstatisch wesentlich stabiler als herkömmliche Hubschrauber.

Durch die Anordnung der Rotorwalzenlängsachsen bzw. Rotationsachsen parallel bzw. koaxial zur Längsachse des Rumpfs bleibt bei der Vorwärtsbewegung des Hubschraubers die Geschwindigkeitsüberlagerung der Fahrtgeschwindigkeit mit der Rotor-Bahngeschwindigkeit aus, denn beide Geschwindigkeitskomponenten stehen senkrecht zueinander.

Das erfindungsgemäße Luftfahrzeug ermöglicht deshalb wesentlich höhere maximale Fluggeschwindigkeiten als herkömmliche Hubschrauber. Im Prinzip sind die maximalen Fluggeschwindigkeiten von Turboprop-Flugzeugen auch bei dem erfindungsgemäßen Luftfahrzeug möglich. Darüber hinaus besteht die Erwartung, dass das erfindungsgemäße Luftfahrzeug sogar noch schneller als ein Turboprop-Flugzeug gleicher Antriebsleistung fliegen kann, weil das erfindungsgemäße Luftfahrzeug kein Flugzeugleitwerk und keine Flugzeugtragflügel aufweist, die einen erheblichen zusätzlichen Luftwiderstand gegenüber dem erfindungsgemäßen Luftfahrzeug erzeugen. Das erfindungsgemäße Luftfahrzeug weist die Flugdynamik sowohl eines herkömmlichen Hubschraubers als auch eines herkömmlichen Flugzeugs auf und kann deshalb flugdynamisch wie ein Hubschrauber oder ein Flugzeug geflogen werden. Der Flugbetrieb des erfindungsgemäßen Luftfahrzeugs ist gegenüber herkömmlichen Hubschraubern wesentlich energieeffizienter, da mit zunehmender Fluggeschwindigkeit keine zunehmenden Rollmomente auftreten. Somit vermeidet das erfindungsgemäße Luftfahrzeug sämtliche bekannten, in der Einleitung genannten Nachteile herkömmlicher Hubschrauber. Zudem können wegen der zur Rumpflängsachse parallelen bzw. koaxialen Anordnungsmöglichkeit der Rotorwalzen zwei oder mehr Rotorwalzen am Rumpf seitlich hintereinander und seitlich nebeneinander angeordnet werden. Dadurch sind große Rumpfkonstruktionen mit Traglasten von um die 200 Tonnen oder alternativ von mehr als 200 Passagieren realisierbar.

Durch die vorgenannten Vorteile und wegen der fehlenden überhängenden Überkopf-Tragrotoren sind mit dem erfindungsgemäßen Luftfahrzeug Andockmanöver und damit schwierige Transport-, Rettungs- und Bergungsmanöver möglich. Hierzu könnte dem Rumpf eine Andockeinrichtung zur Zuführung oder Entladung von Transportgut und/oder zum Ein- oder Ausstieg von Personen zugeordnet sein. In konstruktiv einfacher Weise könnte die Andockeinrichtung einen Tunnel, eine Brücke oder einen Korb aufweisen. Im Hinblick auf eine von einem Cockpit des Luftfahrzeugs gut einsehbare Andockeinrichtung könnte die Andockeinrichtung am vorderen Ende des Rumpfs angeordnet sein.

Das erfindungsgemäße Luftfahrzeug könnte beispielsweise mit einer Fluchtröhre oder einem Fangkorb an der Luftfahrzeugnase ausgerüstet werden, durch die zu rettende Personen, Tiere oder Güter in das rettende Luftfahrzeug gelangen könnten. Umgekehrt könnten Hilfs- oder Rettungskräfte und Hilfs- oder Rettungsmaterial nach dem Andocken abgesetzt werden. Dies ist ein enormer Vorteil, weil beispielsweise in Hochhäusern die Hilfs- und Rettungskräfte im Rettungsfall aus Sicherheitsgründen keine Fahrstühle benutzen dürfen und damit gezwungen sind, Gerätschaften gegebenenfalls über viele Stockwerke über die Treppenhäuser zu transportieren.

Im Hinblick auf ein sicheres Andocken des Luftfahrzeugs an beispielsweise einem Gebäude könnte der Andockeinrichtung eine vorzugsweise trichterförmige Aufnahme für die Andockeinrichtung zugeordnet sein. Eine derartige Aufnahme könnte an einem Gebäude befestigt sein und zur Ankopplung eines Luftfahrzeugs für die Aufnahme einer Andockeinrichtung bereit sein. Dies könnte ein zielgerichtetes Andocken des Luftfahrzeugs erleichtern.

Im Hinblick auf eine besonders stabile Ankopplung des Luftfahrzeugs an beispielsweise ein Gebäude oder an die Aufnahme könnte die Andockeinrichtung eine Verriegelungseinrichtung aufweisen. Eine derartige Verriegelungseinrichtung könnte beispielsweise Verriegelungswarzen an der Andockeinrichtung und Verriegelungswarzenaufnahmen an der Aufnahme aufweisen.

Mit anderen Worten könnte ein Luftfahrzeug über eine Andockeinrichtung verfügen, die genau in dafür vorgesehene Führungen oder Aufnahmen oder Verriegelungen passt, welche beispielsweise an Fluchtfenstern, Fluchttüren, Fluchtluken oder allen Arten von Rettungszugängen und Fluchtausgängen außen an beispielsweise hohen Gebäuden angebracht sind. Das Luftfahrzeug könnte dort andocken, sich verankern und nach dem Öffnen von Rettungszugängen oder Fluchtausgängen und der Aufnahme von Personen, Tieren oder Gütern wieder ablegen.

Der Andockeinrichtung könnte eine trichterförmige Führung zugeordnet sein, in die eine Andocknase vollständig passt. Die Andocknase könnte beim Eingleiten in die trichterförmige Führung mit ihren Verriegelungswarzen in die am Ende der trichterförmigen Führung befindlichen Verriegelungswarzenaufnahmen geführt werden. Die Verriegelungswarzenaufnahmen könnten beispielsweise in einer symmetrischen 3-Punkt-Anordnung vorliegen oder beispielsweise in einer symmetrischen 4-Punkt-Anordnung um den Rand der Durchgangsöffnung am Ende der trichterförmigen

Führung vorliegen. Die Verriegelung und/oder Entriegelung könnte von dem erfindungsgemäßen Luftfahrzeug aus mechanisch durch Schubstangen oder elektromechanisch betätigt werden. Als Verriegelung könnte eine Hakenverriegelung, Spreizverriegelung, Zangenverriegelung, Drehwarzenverriegelung, oder Querverriegelung in Form von beispielsweise einer Rollen-, Bolzen- oder Gabelverriegelung ihre Anwendung finden.

Die Durchgangsöffnung der trichterförmigen Führung könnte durch ein Luk, eine Türe oder eine Fensterscheibe verschlossen sein, die sich von außen öffnen lässt. Die Führung könnte so in das Innere eines Gebäudes versetzt sein, dass sie außen bündig mit der Gebäudefassade abschließt und damit optisch nicht stört. In Hochhäusern könnten solche Führungen beispielsweise an allen Gebäudeseiten und beispielsweise nach einer vorgebbaren Anzahl von Etagen wiederkehrend installiert sein. Die Führung könnte ebenfalls an festen oder schwenkbaren Auslegern angebracht sein. Eine derartige Ausgestaltung könnte beispielsweise auf Bohrinseln, Förderplattformen, Fabrikanlagen oder großen Schiffen auf See günstiger sein. Für den normalen Personen- oder Gütertransport könnten diese Führungen ebenfalls an hohen Gebäuden oder Türmen als Airport-Terminals vorhanden sein.

Aus den oben genannten technischen Vorteilen des erfindungsgemäßen Luftfahrzeugs entstehen wirtschaftliche, logistische und strategische Vorteile gegenüber dem herkömmlichen zivilen und militärischen Flugbetrieb.

Da das erfindungsgemäße Luftfahrzeug prinzipiell das gleiche Frachtgewicht oder die gleiche Passagierzahl transportieren kann wie Mittel- oder Langstreckenflugzeuge und vergleichbar hohe Fluggeschwindigkeiten und Reichweiten aufweist, stellt das erfindungsgemäße Luftfahrzeug eine erhebliche Konkurrenz zum normalen Flugzeugmittel- und Flugzeuglangstreckenbereich dar, wobei jedoch gleichzeitig weitergehend ökologische, wirtschaftliche und logistische Vorteile vorliegen. Das erfindungsgemäße Luftfahrzeug kann Landeplätze aus großer Höhe im senkrechten Sinkflug anfliegen und in gleicher Weise starten. Dadurch wird die von herkömmlichen Flugzeugen bekannte Lärmbelastung in den Landeplatz umgebenden Wohnbereichen vermieden.

Das erfindungsgemäße Luftfahrzeug benötigt keine kostenintensive Infrastruktur wie beispielsweise Flugplätze mit weitläufigen Flugzeuglandebahnen. Dadurch werden die Transportkosten bei einem erfindungsgemäßen Luftfahrzeug gesenkt und kann das erfindungsgemäße Luftfahrzeug beliebige Städte und deren Innenstädte direkt anfliegen, auch wenn diese Städte keinen Flughafen aufweisen. Es könnten infrastrukturarme Flugnetze aufgebaut werden. Dies ist besonders für die wirtschaftliche Entwicklung von Ländern vorteilhaft, die nicht über die Mittel verfügen, eine Infrastruktur aus herkömmlichen Flughäfen aufzubauen.

Im Langstreckenflugbetrieb, beispielsweise über Ozeane hinweg, kann das erfindungsgemäße Luftfahrzeug im Gegensatz zu normalen Flugzeugen auf hoher See positionierte Mutterschiffe anfliegen, um Wartung, Betankung oder Notlandungen durchzuführen. Das erfindungsgemäße Luftfahrzeug kann bei Notlandungen mit geringer Geschwindigkeit auf Wasser oder Land aufsetzen und so die übliche Zerstörung der Flugzeuge bei Wassernotlandungen oder die häufige Zerstörung der Flugzeuge bei Notlandungen auf dem Land verhindern. Das erfindungsgemäße Luftfahrzeug ist wesentlich sicherer als herkömmliche Mittel- und Langestreckenflugzeuge.

Aufgrund der hohen Traglast, Manövrierbarkeit und Andockfähigkeit des erfindungsgemäßen Luftfahrzeugs können Bergungs- und Rettungsaktionen durchgeführt werden, die mit herkömmlichen Hubschraubern nicht möglich sind. Mit der Erfindung hätten Opfer des Anschlags auf das World-Trade-Center in New York aus den damals unzugänglichen Gebäudeetagen gerettet werden können. Mit der Erfindung kann eine Versorgung oder Evakuierung von Krisen- oder Katastrophengebieten besser und schneller durchgeführt werden als mit den bisher zur Verfügung stehenden Transportmitteln.

Bei der militärischen Anwendung ermöglicht das erfindungsgemäße Luftfahrzeug vollkommen neue, wesentlich effizientere Operationen und Strategien. So können beispielsweise große Material- oder Truppenbewegungen, die bisher nur über langsame, kombinierte Transportwege aus beispielsweise Schiffstransport- und/oder Großflugzeugtransport- und/oder Landtransport möglich sind, mit dem erfindungsgemäßen Luftfahrzeug wesentlich schneller direkt in die militärischen Zielgebiete geführt werden. Die durch das erfindungsgemäße Luftfahrzeug mögliche Zeitersparnis und Aufwandsersparnis ist von enormer militärisch-strategischer Bedeutung. Beispielsweise brauchen im Rahmen von militärischen Operationen keine Flugplätze mehr besetzt, angelegt und gesichert werden. Hochseeschiffe können an jedem Punkt auf offener See versorgt werden, ohne dass sie Kreuzungspunkte mit Tenderschiffen anlaufen müssen oder auf Tenderschiffe warten müssen.

Es gibt nun verschiedene Möglichkeiten, die Lehre der vorliegenden Erfindung in vorteilhafter Weise auszugestalten und weiterzubilden. Dazu ist einerseits auf die nachgeordneten Ansprüche, andererseits auf die nachfolgende Erläuterung bevorzugter Ausführungsbeispiele des erfindungsgemäßen Luftfahrzeugs anhand der Zeichnung zu verweisen. In Verbindung mit der Erläuterung der bevorzugten Ausführungsbeispiele des erfindungsgemäßen Luftfahrzeugs anhand der Zeichnung werden auch im Allgemeinen bevorzugte Ausgestaltungen und Weiterbildungen der Lehre erläutert. In der Zeichnung zeigen

Fig. 1 in schematischen Vorder-, Rück-, Drauf- und Seitenansichten ein erstes Ausführungsbeispiel eines erfindungsgemäßen Luftfahrzeugs,

Fig. 2 in schematischen Vorder-, Rück-, Drauf- und Seitenansichten ein zweites Ausführungsbeispiel eines erfindungsgemäßen Luftfahrzeugs,

Fig. 3 in schematischen Vorder-, Drauf- und Seitenansichten das Luftfahrzeug aus Fig. 2 mit einer am vorderen Teil des Rumpfs angeordneten Andockeinrichtung,

Fig. 4 ein Flügelblatt der Antriebseinrichtung in einem schematischen Querschnitt,

Fig. 5 in einer Draufsicht eine Antriebsscheibe für die Flügelblätter,

Fig. 6 in einer Draufsicht einen Steuerring mit kreisförmiger Ringnut und einer Exzenterscheibenführung,

Fig. 7 in einer Draufsicht die Antriebsscheibe mit durch gestrichelte Linien angedeutetem Steuerring in der Neutralstellung des Steuerrings,

Fig. 8 in einer Draufsicht die Antriebsscheibe mit durch gestrichelte Linien angedeutetem Steuerring in einer Betriebsstellung, wobei die Schubkraft in Pfeilrichtung verläuft,

Fig. 9 in einer schematischen Seitenansicht ein weiteres Ausführungsbeispiel eines erfindungsgemäßen Luftfahrzeugs und

Fig. 10 in einer schematischen Vorder- und Rückansicht das Ausführungsbeispiel aus Fig. 9.

Fig. 1 zeigt in schematischen Vorder-, Rück-, Drauf- und Seitenansichten ein erstes Ausführungsbeispiel eines erfindungsgemäßen Luftfahrzeugs. Das Luftfahrzeug weist einen Rumpf 1 und eine mit dem Rumpf 1 gekoppelte Antriebseinrichtung 2 zur Erzeugung eines definierbaren Auftriebs auf. Die Antriebseinrichtung 2 weist mehrere Flügelblätter 3 auf, die um einen vorgebbaren Blattwinkel um eine Schwenkachse 4 verschwenkbar sind. Die Flügelblätter 3 sind um eine Rotationsachse 5 drehbar gelagert und der Blattwinkel ist zur Erzeugung des Auftriebs während der Drehung veränderbar. Des Weiteren sind die jeweiligen Schwenkachsen 4 der Flügelblätter 3 im Wesentlichen parallel zur Rotationsachse 5 angeordnet. Dabei sind die Schwenkachsen 4 der Flügelblätter 3 auch im Wesentlichen parallel zueinander angeordnet.

Weiterhin sind die Schwenkachsen 4 äquidistant zueinander und im gleichen Abstand zur Rotationsachse 5 angeordnet.

Die Flügelblätter 3 sind an einem Ende in einem Antriebselement 7 mit ihrer Schwenkachse 4 schwenkbar gelagert. Des Weiteren weist jedes Flügelblatt 3 eine Steuerachse 6 als Angriffspunkt für ein Verschwenken der Flügelblätter 3 um die Schwenkachse 4 auf. Das Antriebselement 7 weist eine Lagerachse 8 auf.

Bei dem hier gezeigten Ausführungsbeispiel bilden mehrere Flügelblätter 3 eine um jeweils eine der Rotationsachsen 5 rotierbare Walze 15, wobei die Antriebseinrichtung 2 insgesamt vier derartige Walzen 15 aufweist. Auf jeder Längsseite des Rumpfs 1 sind zwei Walzen 15 angeordnet. Dabei fluchten die Rotationsachsen 5 sich gegenüberliegender Walzen 15.

Fig. 2 zeigt in schematischen Vorder-, Rück-, Drauf- und Seitenansichten ein zweites Ausführungsbeispiel eines erfindungsgemäßen Luftfahrzeugs. Bei diesem Ausführungsbeispiel sind Walzen 15 parallel zu einer in Vorwärts-Flugrichtung verlaufenden Längsachse des Rumpfs 1 angeordnet. Die Flügelblätter 3 der Walzen 15 sind torsionsgesteuert und weisen an beiden Enden ein Steuerelement zur Steuerung der Steuerachse auf.

An einem Führungselement 16 ist ein Führungsrotor 17 für Vorwärtsbewegungen oder Rückwärtsbewegungen angeordnet. Der Führungsrotor 17 ist aus mehreren Rotorblättern 18 aufgebaut. Bei dem hier gezeigten Ausführungsbeispiel sind zwei Wellenleistungsantriebsturbinen überkopf angeordnet.

Fig. 3 zeigt in schematischen Vorder-, Drauf- und Seitenansichten das Ausführungsbeispiel eines Luftfahrzeugs aus Fig. 2, wobei dem Rumpf 1 eine Andockeinrichtung 19 zur Zuführung oder Entladung von Transportgut und/oder zum Ein- oder Ausstieg von Personen zugeordnet ist. Die Andockeinrichtung 19 ist als Fluchtröhre ausgebildet.

Fig. 4 zeigt in einer schematischen Ansicht das Querschnittsprofil eines Flügelblatts 3. Dabei ist einerseits die Schwenkachse 4 und andererseits die Steuerachse 6 erkennbar.

Fig. 5 zeigt in einer Draufsicht ein als Antriebsscheibe ausgebildetes Antriebselement 7, das eine Lagerachse 8 aufweist. Das Antriebselement 7 weist Durchgänge 9 zur Lagerung der Schwenkachsen 4 der Flügelblätter 3 auf. Des Weiteren weist das Antriebselement 7 Durchgänge 10 für die Steuerachsen 6 der Flügelblätter 3 auf. Die Durchgänge 10 sind als gekrümmte Langlöcher ausgebildet. Aus Gründen der Gewichtsersparnis weist das Antriebselement 7 Durchgänge 11 auf.

Fig. 6 zeigt in einer schematischen Draufsicht ein als Steuerring ausgebildetes Steuerelement 12 mit einer im Bereich des äußeren Rands des Steuerrings verlaufenden Ringnut 14 zur Führung der Steuerachse 6 eines Flügelblatts 3. Zur Verschiebung des Steuerelements 12 relativ zur Rotationsachse 5 ist das Steuerelement 12 in einer Führung verschiebbar, die als Exzenterscheibenführung 13 ausgebildet ist. Bei einer beispielhaften Anordnung ist das Steuerelement 12 parallel zum Antriebselement 7 angeordnet, wobei die Steuerachse 6 eines Flügelblatts 3 durch den Durchgang 10 im Antriebselement 7 hindurchgesteckt und dann in der Ringnut 14 des Steuerelements 12 gelagert ist.

Fig. 7 zeigt in einer schematischen Draufsicht eine Anordnung des Antriebselements 7 mit dahinter angeordnetem Steuerelement 12 einer Walze 15. Das Steuerelement 12 ist lediglich durch gestrichelte Linien und nur in seinem äußeren Randbereich dargestellt. Das Steuerelement 12 befindet sich in Fig. 7 in seiner Neutralstellung, wobei kein Schub und keine Luftablenkung durch die Flügelblätter 3 erzeugt werden. Das Querschnittsprofil des Flügelblatts 3 ist zur Rotationsachse 5 hin konkav gekrümmt. Die Flügelblätter 3 sind quasi in einem gedachten Kreiszylinder angeordnet, der durch die Krümmung der Flügelblätter 3 erzeugt wird.

In Fig. 8 ist das Steuerelement 12 mittels der Führung relativ zur Rotationsachse 5 verschoben. Dabei wird ein Schub in der Schubrichtung 20 erzeugt. Man kann in Fig. 8 das Prinzip der zyklischen Flügelblattverstellung mittels des Steuerelements 12 erkennen, wobei die Flügelblätter 3 während einer Drehung des Antriebselements 7 relativ zum Steuerelement 12 einmal zwischen ihren extremen Auslenkungen verschwenkt werden. Auf einer durch die Schubrichtung 20 definierten und durch die Rotationsachse 5 verlaufenden Linie befinden sich quasi die beiden extremen Auslenkungspositionen der Flügelblätter 3. In den um 90 Grad hierzu versetzten Positionen befinden sich die Flügelblätter 3 wieder in ihrer Neutralstellung, in der sie keinen Schub und keine Luftablenkung erzeugen. Die Drehrichtung der Flügelblätter 3 bei dem in Fig. 8 gezeigten Ausführungsbeispiel ist im Uhrzeigersinn.

Fig. 9 zeigt in einer schematischen Seitenansicht ein weiteres Ausführungsbeispiel eines erfindungsgemäßen Luftfahrzeugs mit einem Rumpf 1, wobei vor einer Rotorwalze 15 ein Zugpropeller 21 und hinter einer weiteren Rotorwalze 15 ein Druckpropeller 22 angeordnet sind. Des Weiteren sind Turbinenauslässe 23 im Bereich der Rotorwalzen 15 angeordnet.

Fig. 10 zeigt in einer schematischen Vorder- und Rückansicht das Ausführungsbeispiel aus Fig. 9, wobei an dem Rumpf 1 Hilfstragflächen oder Tragflächen 24 angeordnet sind. Die Rotorwalzen 15 sind an den Tragflächen 24 angeordnet oder aufgehängt. Die Zugpropeller 21 sind vor den Rotorwalzen 15 und die Druckpropeller 22 hinter den Rotorwalzen 15 angeordnet.

Hinsichtlich weiterer vorteilhafter Ausgestaltungen des erfindungsgemäßen Luftfahrzeugs wird zur Vermeidung von Wiederholungen auf den allgemeinen Teil der Beschreibung sowie auf die beigefügten Patentansprüche verwiesen.

Schließlich sei ausdrücklich darauf hingewiesen, dass die voranstehend beschriebenen Ausführungsbeispiele des erfindungsgemäßen Luftfahrzeugs lediglich zur Erörterung der beanspruchten Lehre dienen, diese jedoch nicht auf diese Ausführungsbeispiele einschränkt.

Patentansprüche

1. Luftfahrzeug mit einem Rumpf (1) und einer mit dem Rumpf (1) gekoppelten Antriebseinrichtung (2) zur Erzeugung eines definierbaren Auftriebs, wobei die Antriebseinrichtung (2) mehrere Flügelblätter (3) aufweist und wobei die Flügelblätter (3) um einen vorgebbaren Blattwinkel um eine Schwenkachse (4) verschwenkbar sind,
d a d u r c h g e k e n n z e i c h n e t, dass die Flügelblätter (3) um eine Rotationsachse (5) drehbar gelagert sind, dass der Blattwinkel zur Erzeugung des Auftriebs während der Drehung veränderbar ist und dass die jeweiligen Schwenkachsen (4) der Flügelblätter (3) im Wesentlichen parallel zur Rotationsachse (5) angeordnet sind.

2. Luftfahrzeug nach Anspruch 1, dadurch gekennzeichnet, dass die jeweiligen Schwenkachsen (4) der Flügelblätter (3) im Wesentlichen äquidistant zueinander angeordnet sind.

3. Luftfahrzeug nach Anspruch 1 oder 2, dadurch gekennzeichnet, dass die Schwenkachsen (4) der Flügelblätter (3) jeweils im Wesentlichen im gleichen Abstand zur Rotationsachse (5) angeordnet sind.

4. Luftfahrzeug nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, dass die Schwenkachsen (4) der Flügelblätter (3) im Wesentlichen parallel zueinander angeordnet sind.

5. Luftfahrzeug nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, dass die Schwenkachsen (4) der Flügelblätter (3) durch den Schwerpunkt der Flügelblätter (3) verlaufend angeordnet sind.

6. Luftfahrzeug nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, dass das Querschnittsprofil der Flügelblätter (3) zur Rotationsachse (5) hin konkav gekrümmt ist.

7. Luftfahrzeug nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, dass die Flügelblätter (3) an mindestens einem Ende jeweils eine Steuerachse (6) als Angriffspunkt für ein Verschwenken der Flügelblätter (3) um die Schwenkachse (4) aufweisen.

8. Luftfahrzeug nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, dass die Flügelblätter (3) an einem Ende an oder in einem Antriebselement (7) schwenkbar gelagert sind.

9. Luftfahrzeug nach Anspruch 8, dadurch gekennzeichnet, dass das Antriebselement (7) um die Rotationsachse (5) drehbar ist oder auf der Rotationsachse (5) drehbar gelagert ist.

10. Luftfahrzeug nach Anspruch 8 oder 9, dadurch gekennzeichnet, dass das Antriebselement (7) eine Lagerachse (8) oder Hohlachse aufweist.

11. Luftfahrzeug nach einem der Ansprüche 8 bis 10, dadurch gekennzeichnet, dass das Antriebselement (7) als Antriebsscheibe, Antriebskreisscheibe oder Antriebsring ausgebildet ist.

12. Luftfahrzeug nach einem der Ansprüche 8 bis 11, dadurch gekennzeichnet, dass die Schwenkachsen (4) kreisförmig am Rand des Antriebselements (7) oder der Antriebsscheibe oder der Antriebskreisscheibe oder am Rand des Antriebsrings angeordnet sind.

13. Luftfahrzeug nach einem der Ansprüche 8 bis 12, dadurch gekennzeichnet, dass das Antriebselement (7) Vertiefungen oder Durchgänge (9) zur Lagerung der Schwenkachsen (4) der Flügelblätter aufweist.

14. Luftfahrzeug nach einem der Ansprüche 8 bis 13, dadurch gekennzeichnet, dass das Antriebselement (7) Vertiefungen oder Durchgänge (10) für die Steuerachsen (6) der Flügelblätter (3) aufweist.

15. Luftfahrzeug nach Anspruch 14, dadurch gekennzeichnet, dass die Vertiefungen oder Durchgänge (10) für die Steuerachsen (6) der Flügelblätter (3) als vorzugsweise gekrümmte Langlöcher ausgebildet sind.

16. Luftfahrzeug nach einem der Ansprüche 8 bis 15, dadurch gekennzeichnet, dass das Antriebselement (7) Vertiefungen, Ausnehmungen oder Durchgänge (11) aufweist.

17. Luftfahrzeug nach einem der Ansprüche 8 bis 16, dadurch gekennzeichnet, dass das Antriebselement (7) zum Verschwenken der Flügelblätter (3) um ihre Schwenkachse (4) mit einem Steuerelement (12) zusammenwirkt.

18. Luftfahrzeug nach Anspruch 17, dadurch gekennzeichnet, dass das Steuerelement (12) von der Drehung der Flügelblätter (3) und/oder des Antriebselements (7) entkoppelt ist.

19. Luftfahrzeug nach Anspruch 17 oder 18, dadurch gekennzeichnet, dass das Steuerelement (12) auf der Rotationsachse (5) gelagert ist.

20. Luftfahrzeug nach einem der Ansprüche 17 bis 19, dadurch gekennzeichnet, dass das Steuerelement (12) eine Zykloidsteuerung aufweist.

21. Luftfahrzeug nach einem der Ansprüche 17 bis 20, dadurch gekennzeichnet, dass das Steuerelement (12) relativ zur Rotationsachse (5) in einer Führung verschiebbar ist.

22. Luftfahrzeug nach Anspruch 21, dadurch gekennzeichnet, dass die Führung zwei senkrecht zueinander angeordnete Linearführungen im Sinne einer Kreuztischführung aufweist.

23. Luftfahrzeug nach Anspruch 21, dadurch gekennzeichnet, dass die Führung eine Drehführung in Verbindung mit einer Linearführung im Sinne einer verlängerbaren Drehhebelführung aufweist.

24. Luftfahrzeug nach Anspruch 21, dadurch gekennzeichnet, dass die Führung zwei Drehführungen im Sinne einer doppelten Exzenterscheibenführung (13) aufweist.

25. Luftfahrzeug nach Anspruch 24, dadurch gekennzeichnet, dass zwei Exzenterscheiben der Exzenterscheibenführung (13) jeweils ein Stellmotor zugeordnet ist.

26. Luftfahrzeug nach einem der Ansprüche 17 bis 25, dadurch gekennzeichnet, dass das Steuerelement (12) eine Ringnut (14) oder Kreisnut zur Aufnahme der Steuerachsen (6) der Flügelblätter (3) aufweist.

27. Luftfahrzeug nach einem der Ansprüche 17 bis 26, dadurch gekennzeichnet, dass das Steuerelement (12) als Steuerring oder Steuerscheibe ausgebildet ist.

28. Luftfahrzeug nach Anspruch 26 oder 27, dadurch gekennzeichnet, dass die Ringnut (14) oder der Steuerring eine von der Kreisform abweichende Gestaltung aufweist.

29. Luftfahrzeug nach Anspruch 28, dadurch gekennzeichnet, dass die abweichende Gestaltung eine drehwinkelabhängige Anstellwinkelfunktion oder überlagerte Anstellwinkelfunktionen liefert.

30. Luftfahrzeug nach Anspruch 29, dadurch gekennzeichnet, dass die Anstellwinkelfunktion dem Ausdruck $a \cdot \cos(x)^w$ proportional ist, wobei a der Anstellwinkel der Flügelblätter (3) in Grad ist und w vorzugsweise eine ganze Zahl – vorzugsweise 11 – ist.

31. Luftfahrzeug nach einem der Ansprüche 17 bis 30, dadurch gekennzeichnet, dass die Lagerachse (8) oder Hohlachse des Antriebselements (7) vorzugsweise zentrisch durch das Steuerelement (12) hindurch verlaufend angeordnet ist.

32. Luftfahrzeug nach einem der Ansprüche 17 bis 31, dadurch gekennzeichnet, dass das Antriebselement (7) und das Steuerelement (12) parallel zueinander angeordnet sind.

33. Luftfahrzeug nach einem der Ansprüche 1 bis 32, dadurch gekennzeichnet, dass die Antriebseinrichtung (2) mindestens zwei Anordnungen aus um jeweils eine Rotationsachse (5) drehbaren Flügelblättern (3) aufweist.

34. Luftfahrzeug nach einem der Ansprüche 1 bis 33, dadurch gekennzeichnet, dass die Rotationsachse (5) oder Rotationsachsen (5) in einer im Wesentlichen horizontalen Ebene angeordnet sind.

35. Luftfahrzeug nach einem der Ansprüche 1 bis 34, dadurch gekennzeichnet, dass die Rotationsachse (5) oder Rotationsachsen (5) parallel zu einer in Vorwärts-Flugrichtung verlaufenden Längsachse des Rumpfs (1) angeordnet sind.

36. Luftfahrzeug nach einem der Ansprüche 1 bis 34, dadurch gekennzeichnet, dass die Rotationsachse (5) oder Rotationsachsen (5) senkrecht zu einer in Vorwärts-Flugrichtung verlaufenden Längsachse des Rumpfs (1) angeordnet sind.

37. Luftfahrzeug nach einem der Ansprüche 1 bis 36, dadurch gekennzeichnet, dass mehrere Flügelblätter (3) eine um jeweils eine der Rotationsachsen (5) rotierbare Walze (15) bilden und dass die Antriebseinrichtung (2) mindestens zwei derartige Walzen (15) aufweist.

38. Luftfahrzeug nach Anspruch 37, dadurch gekennzeichnet, dass die Walzen (15) in Richtung der Längsachse gegeneinander versetzt sind.

39. Luftfahrzeug nach Anspruch 37 oder 38, dadurch gekennzeichnet, dass auf jeder Längsseite des Rumpfs (1) mindestens eine Walze (15) angeordnet ist.

40. Luftfahrzeug nach einem der Ansprüche 37 bis 39, dadurch gekennzeichnet, dass zumindest zwei Walzen (15) gegensinnig drehbar sind.

41. Luftfahrzeug nach einem der Ansprüche 37 bis 40, dadurch gekennzeichnet, dass auf jeder Längsseite des Rumpfs (1) mindestens zwei Walzen (15) angeordnet sind und dass die Rotationsachsen (5) sich gegenüberliegender Walzen (15) fluchten.

42. Luftfahrzeug nach einem der Ansprüche 37 bis 41, dadurch gekennzeichnet, dass jede Walze (15) separat steuerbar ist.

43. Luftfahrzeug nach einem der Ansprüche 37 bis 42, dadurch gekennzeichnet, dass mehrere Walzen (15) zusammen in gleichem Sinn steuerbar sind.

44. Luftfahrzeug nach einem der Ansprüche 8 bis 43, dadurch gekennzeichnet, dass die Flügelblätter (3) an ihrem anderen, dem Antriebselement (7) abgewandten Ende an oder in einem Führungselement (16) mittels jeweils einer Schwenkachse (4) schwenkbar gelagert sind.

45. Luftfahrzeug nach Anspruch 44, dadurch gekennzeichnet, dass das Führungselement (16) im Wesentlichen wie das Antriebselement (7) - vorzugsweise scheibenförmig - ausgebildet ist.

46. Luftfahrzeug nach Anspruch 44 oder 45, dadurch gekennzeichnet, dass das Führungselement (16) mit dem Antriebselement (7) mitdrehbar angeordnet ist.

47. Luftfahrzeug nach einem der Ansprüche 44 bis 46, dadurch gekennzeichnet, dass das Führungselement (16) und das Antriebselement (7) mittels einer Achse oder der Rotationsachse (5) gekoppelt sind.

48. Luftfahrzeug nach einem der Ansprüche 44 bis 47, dadurch gekennzeichnet, dass dem Führungselement (16) ein Führungsrotor (17) aus mehreren Rotorblättern (18) zugeordnet ist.

49. Luftfahrzeug nach Anspruch 48, dadurch gekennzeichnet, dass die Rotorblätter (18) an dem Führungselement (16) angelenkt sind.

50. Luftfahrzeug nach Anspruch 48 oder 49, dadurch gekennzeichnet, dass der Führungsrotor (17) über ein durch die Rotationsachse (5) verlaufendes Gestänge angetrieben ist.

51. Luftfahrzeug nach einem der Ansprüche 1 bis 50, dadurch gekennzeichnet, dass neben- oder hintereinander angeordnete Anordnungen von Flügelblättern (3) oder Walzen (15) quasi gespiegelt angeordnet sind.

52. Luftfahrzeug nach einem der Ansprüche 17 bis 51, dadurch gekennzeichnet, dass an beiden Enden der Flügelblätter (3) jeweils ein vom jeweils anderen Steuerelement (12) unabhängig betätigbares Steuerelement (12) angeordnet ist.

53. Luftfahrzeug nach einem der Ansprüche 37 bis 52, dadurch gekennzeichnet, dass mindestens eine Antriebsturbine im Rumpf (1) des Luftfahrzeugs angeordnet ist.

54. Luftfahrzeug nach Anspruch 53, dadurch gekennzeichnet, dass Abgase der Antriebsturbine seitlich aus dem Rumpf (1) heraus direkt an die Rotorwalze (15) oder über die Rotorwalze (15) geleitet sind.

55. Luftfahrzeug nach einem der Ansprüche 37 bis 54, dadurch gekennzeichnet, dass sowohl vor als auch hinter einer Rotorwalze (15) jeweils ein Verstellpropeller oder Propeller (21, 22) angeordnet ist.

56. Luftfahrzeug nach Anspruch 55, dadurch gekennzeichnet, dass zwischen den Verstellpropellern oder Propellern (21, 22) zwei oder mehrere hintereinander angeordnete Rotorwalzen (15) angeordnet sind.

57. Luftfahrzeug nach einem der Ansprüche 37 bis 56, dadurch gekennzeichnet, dass am Rumpf (1) mindestens eine Hilfstragfläche oder Tragfläche (24) angeordnet ist, an der oder denen die Rotorwalze (15) oder Rotorwalzen (15) angeordnet oder aufgehängt sind.

58. Luftfahrzeug nach einem der Ansprüche 1 bis 57, dadurch gekennzeichnet, dass dem Rumpf (1) eine Andockeinrichtung (19) zur Zuführung oder Entladung von Transportgut und/oder zum Ein- oder Ausstieg von Personen zugeordnet ist.

59. Luftfahrzeug nach Anspruch 58, dadurch gekennzeichnet, dass die Andockeinrichtung (19) einen Tunnel, eine Brücke oder einen Korb aufweist.

60. Luftfahrzeug nach Anspruch 58 oder 59, dadurch gekennzeichnet, dass die Andockeinrichtung (19) am vorderen Ende des Rumpfs (1) angeordnet ist.

61. Luftfahrzeug nach einem der Ansprüche 58 bis 60, dadurch gekennzeichnet, dass der Andockeinrichtung (19) eine vorzugsweise trichterförmige Aufnahme für die Andockeinrichtung (19) zugeordnet ist.

62. Luftfahrzeug nach einem der Ansprüche 58 bis 61, dadurch gekennzeichnet, dass die Andockeinrichtung (19) eine Verriegelungseinrichtung zum Ankoppeln an ein Gebäude oder an die Aufnahme aufweist.

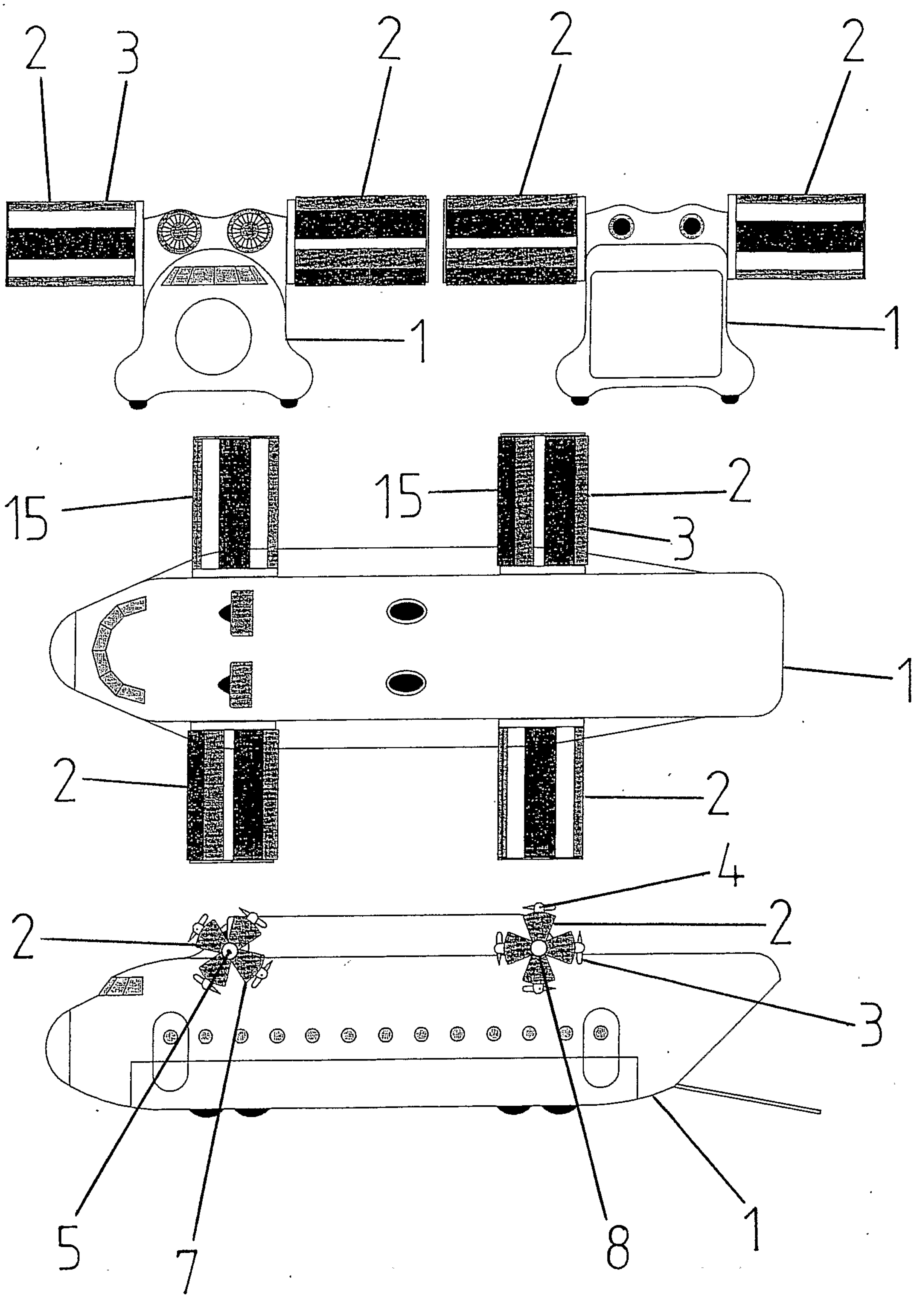


Fig. 1

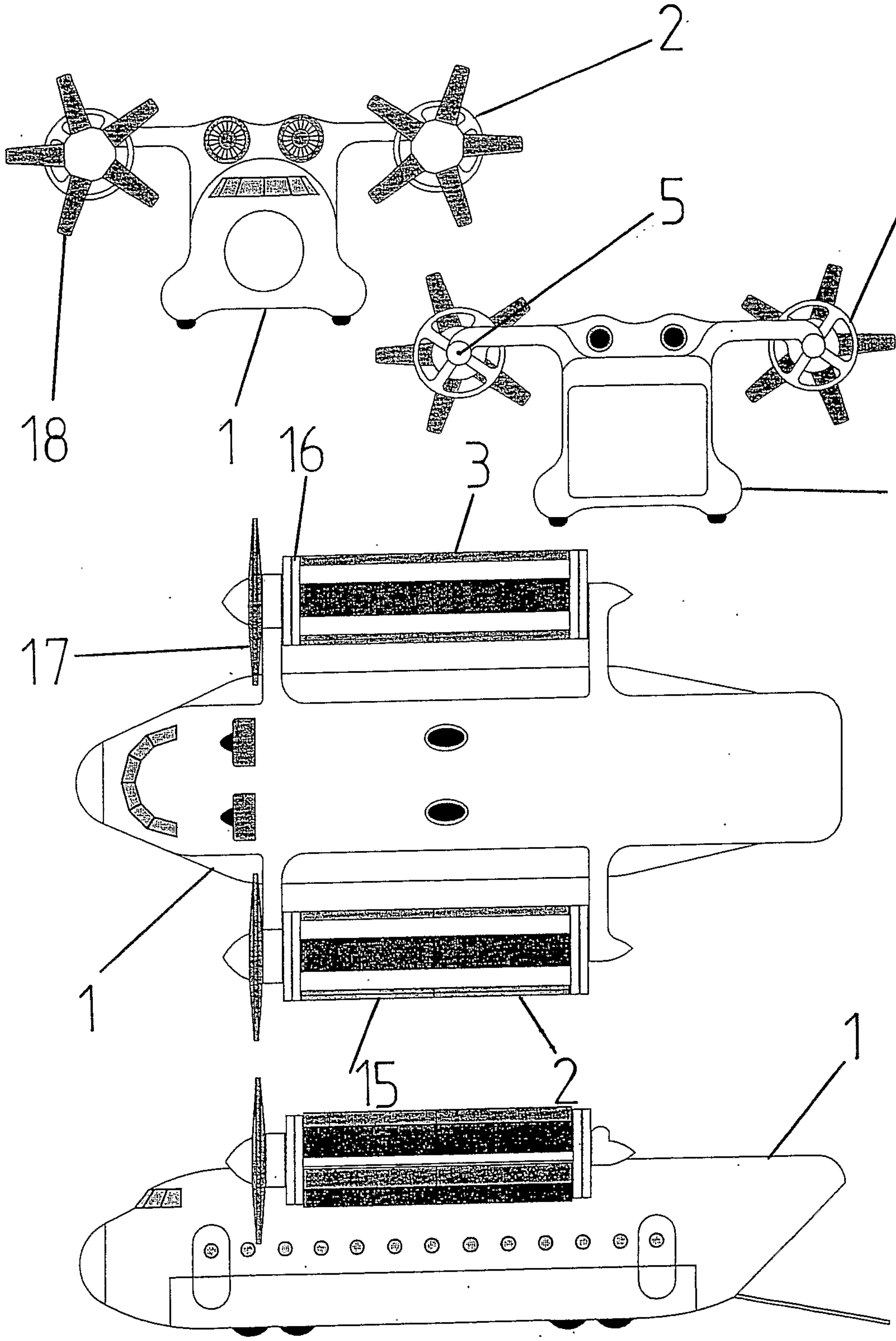


Fig. 2

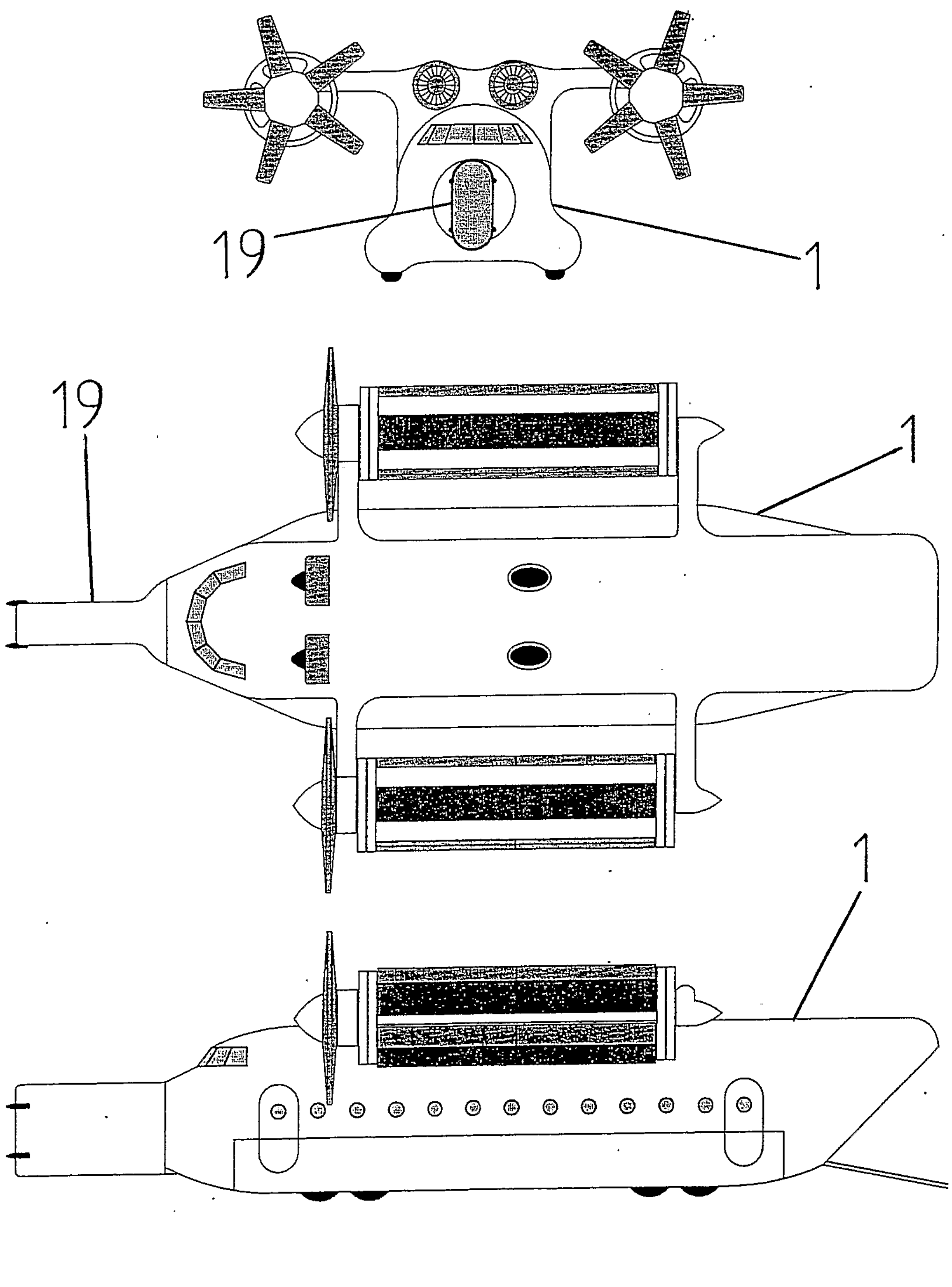


Fig. 3

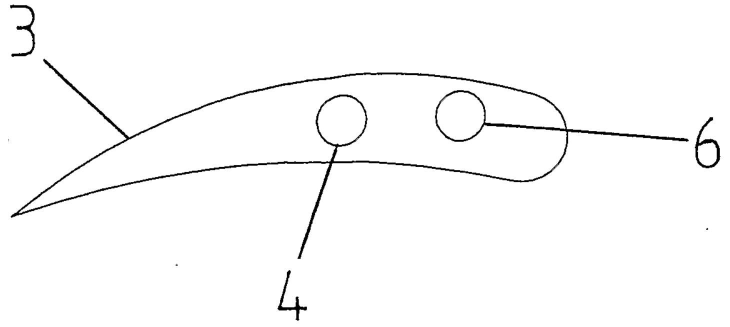


Fig. 4

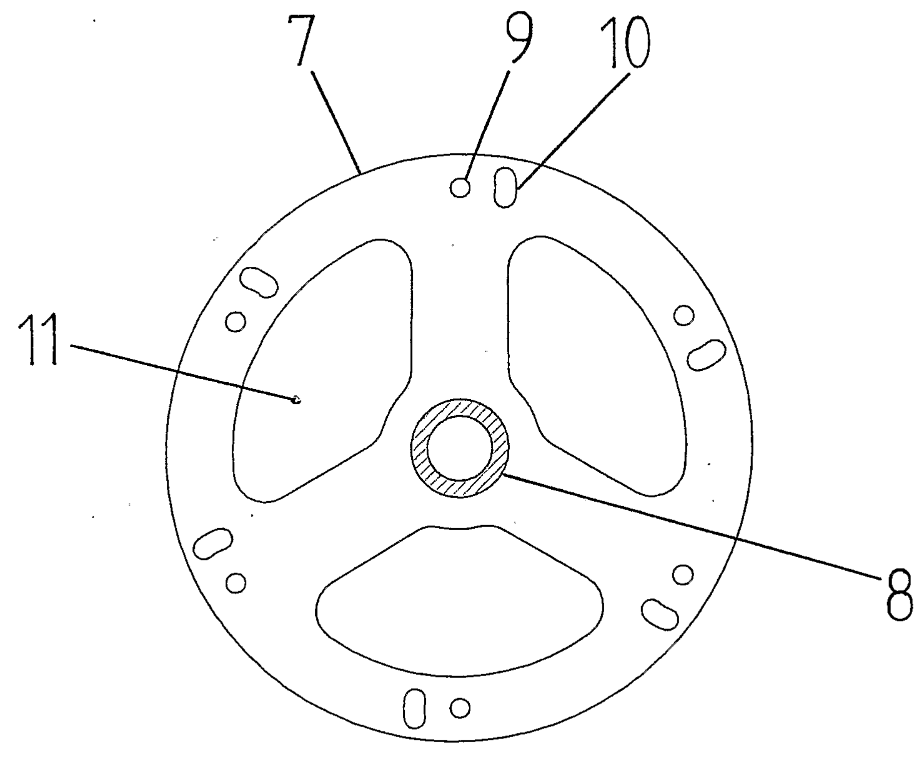


Fig. 5

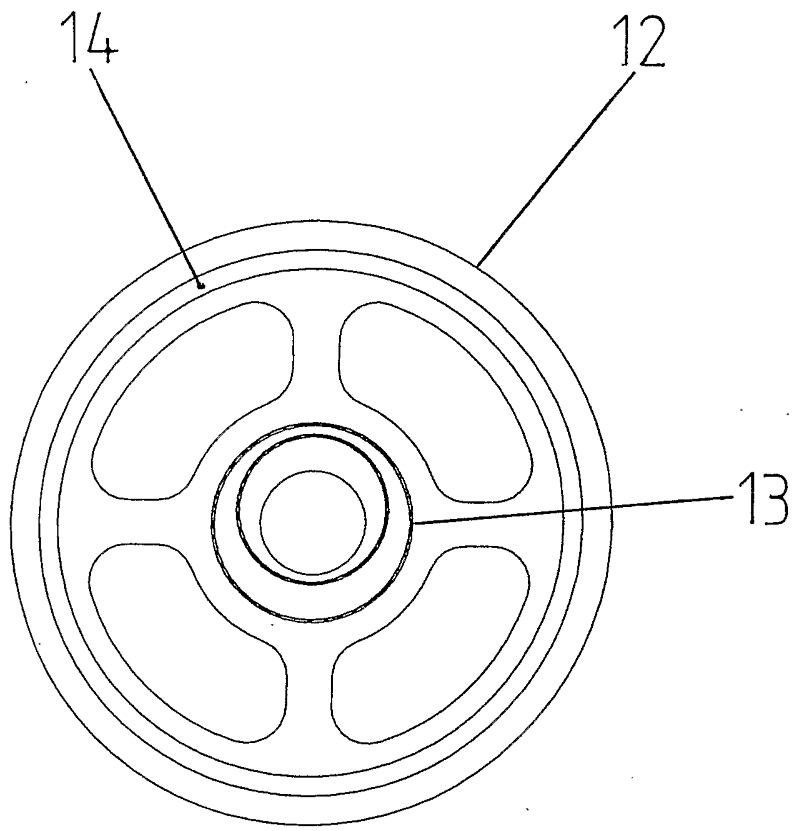


Fig. 6

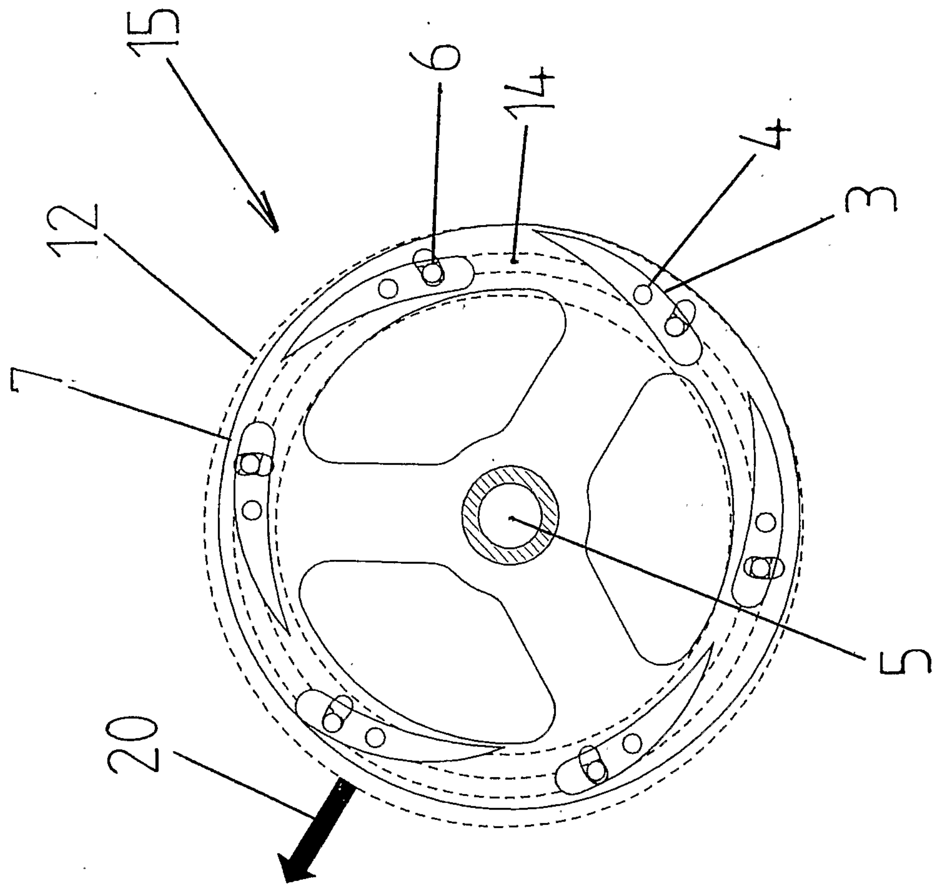


Fig. 8

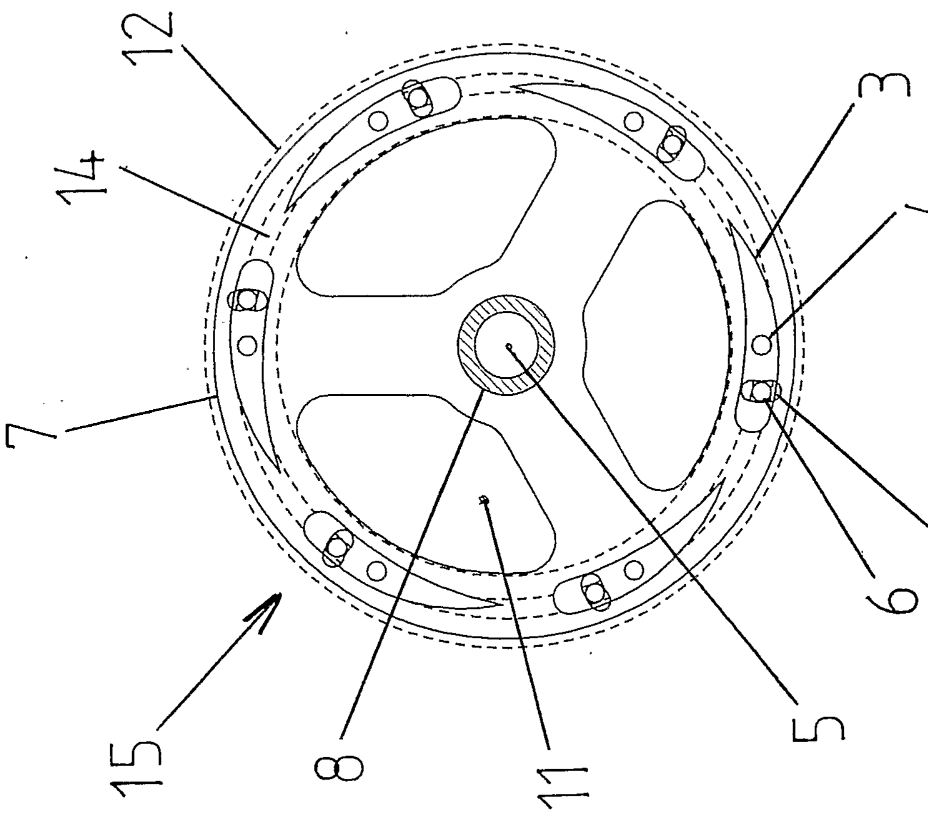


Fig. 7

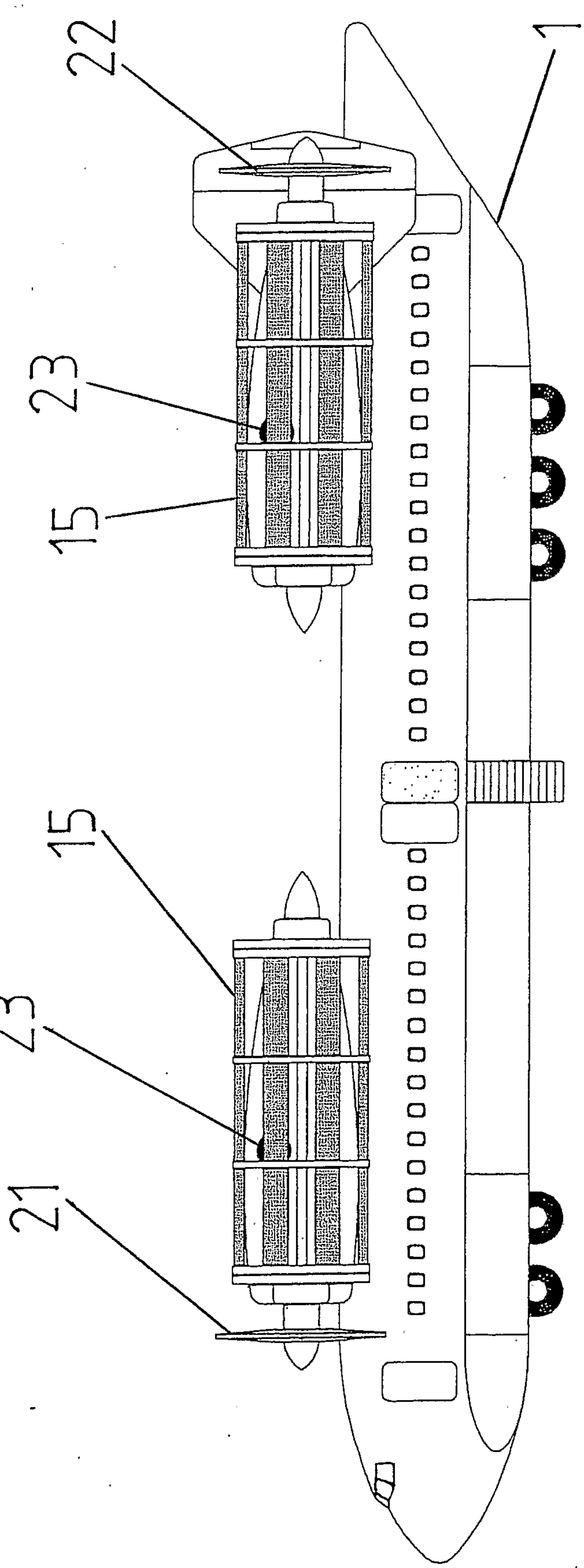
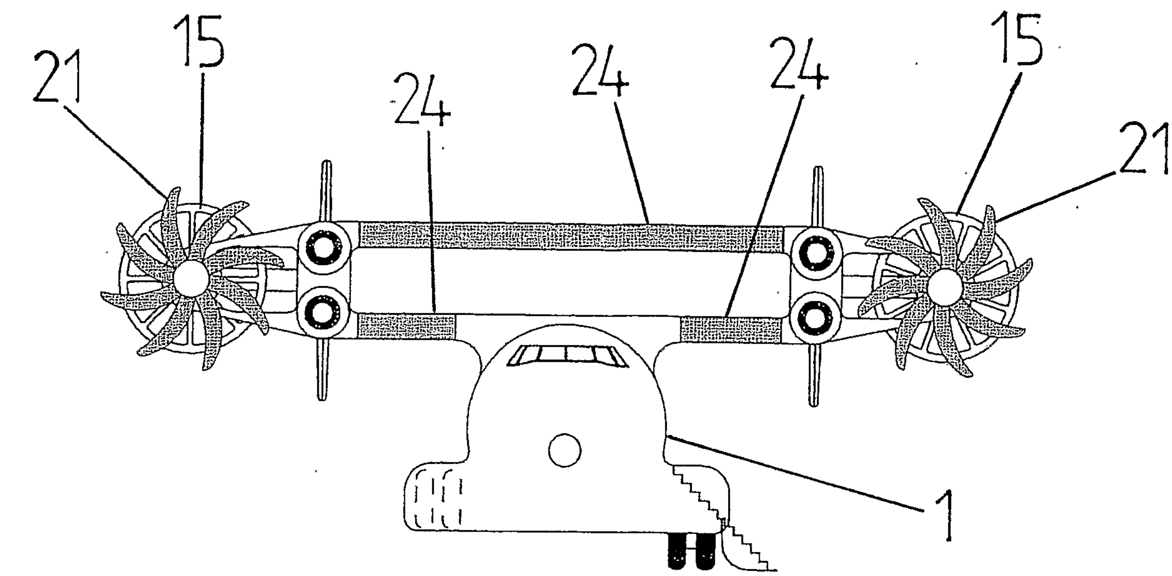


Fig. 9



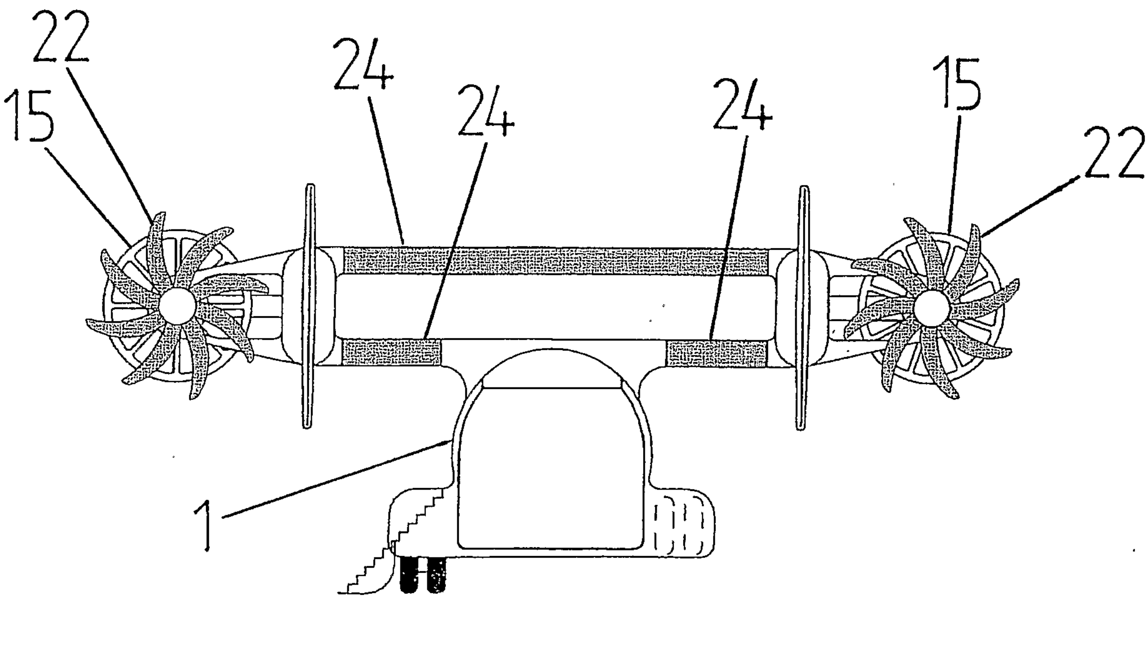


Fig. 10

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Altmikus et al.

(54) HELICOPTER WITH CYCLOIDAL ROTOR SYSTEM

(75) Inventors: **Andree Altmikus**, Hoehenkirchen-Siegertsbrunn (DE); **Marius Bebesel**, Munich (DE)

(73) Assignee: **EUROCOPTER DEUTSCHLAND GMBH**, Donauworth (DE)

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(52) **U.S. Cl.** **244/17.21**

(57) **ABSTRACT**

The invention is related to a helicopter (**10**) comprising a main rotor (**12**), a cycloidal rotor (**14**) and a rotating cylinder (**18**). The rotating cylinder (**18**) extends along a longitudinal axis of a tail boom (**13**). The cycloidal rotor (**14**) extends at least partly along said same tail boom (**13**) and rotates outside the rotating cylinder (**18**).

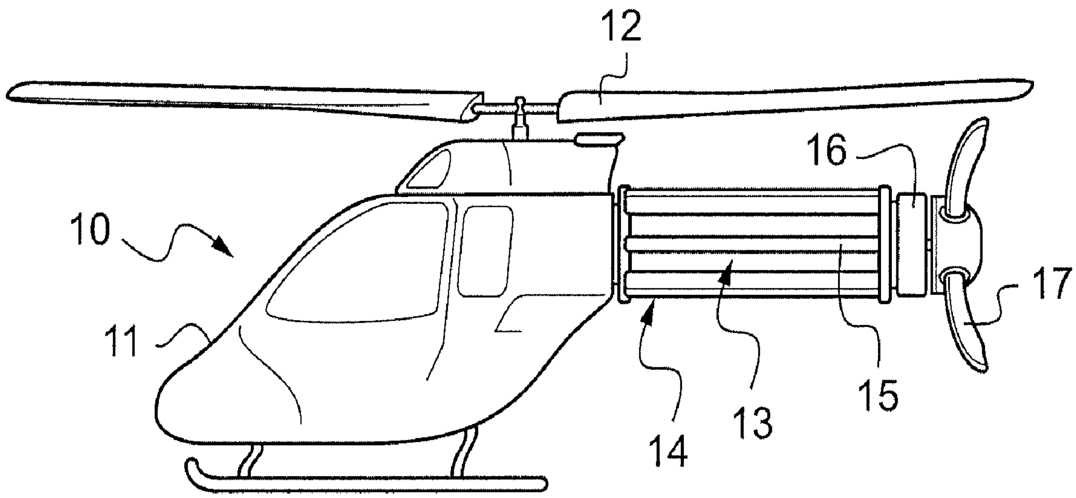


Fig.1

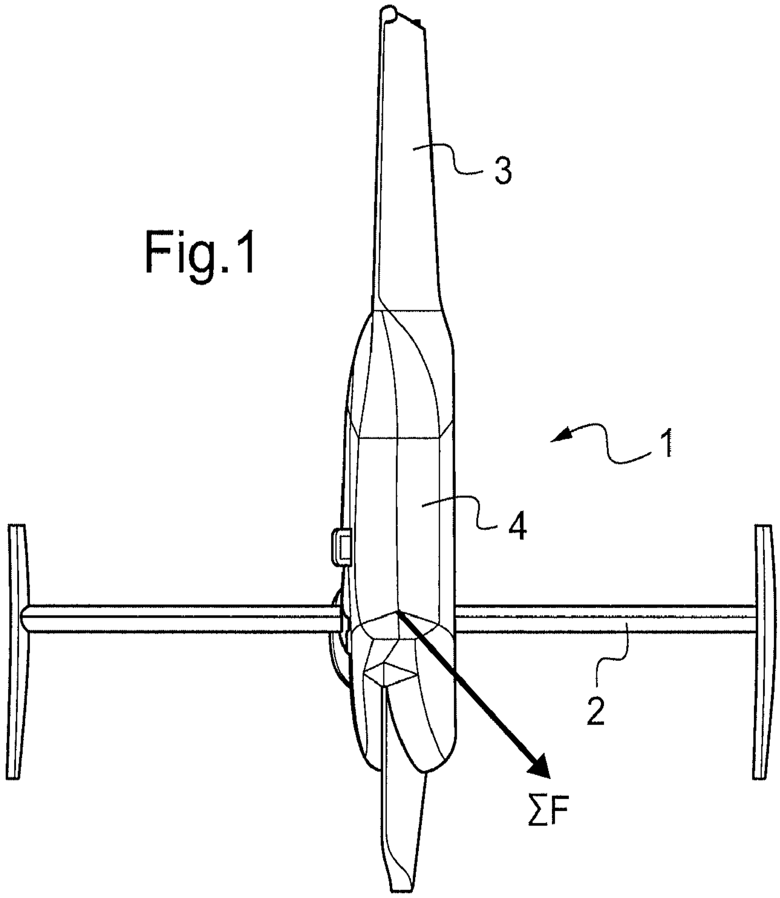


Fig.2

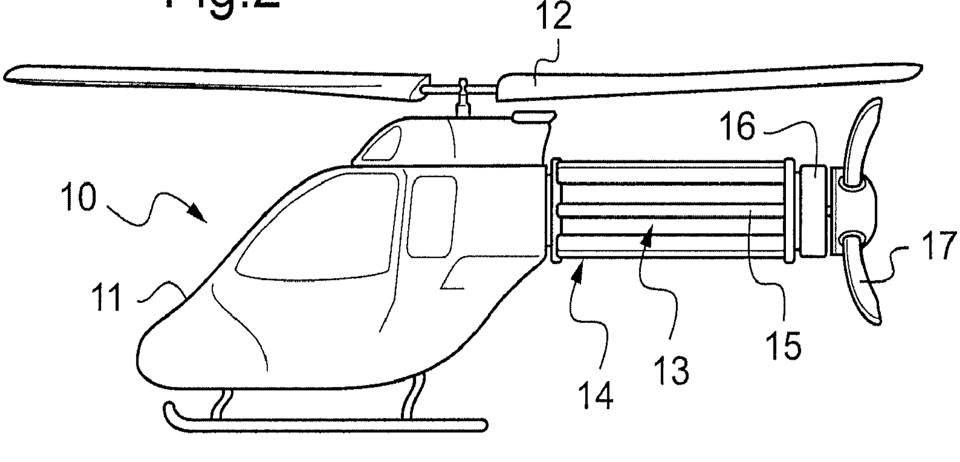


Fig.3

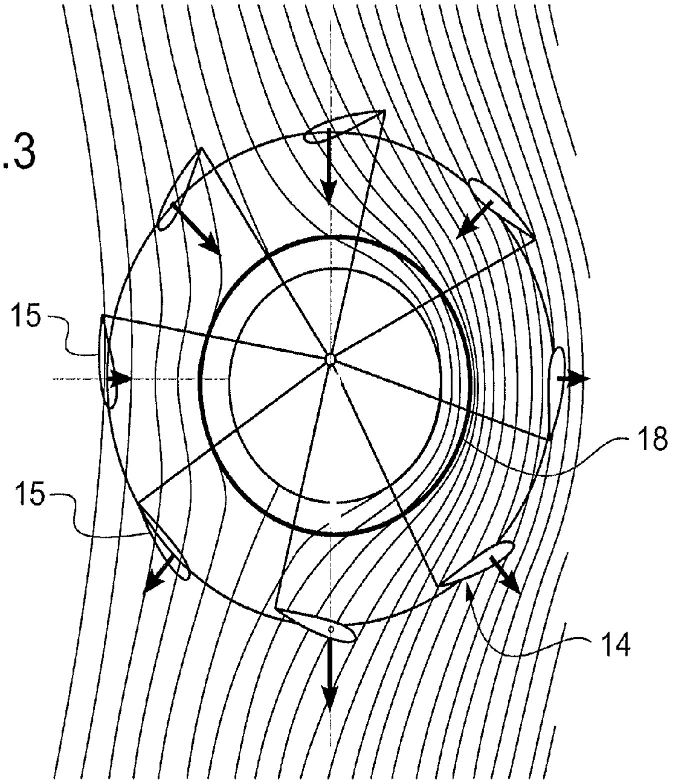


Fig.4

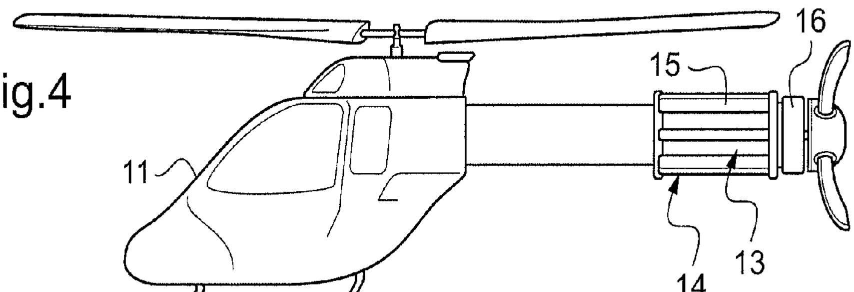
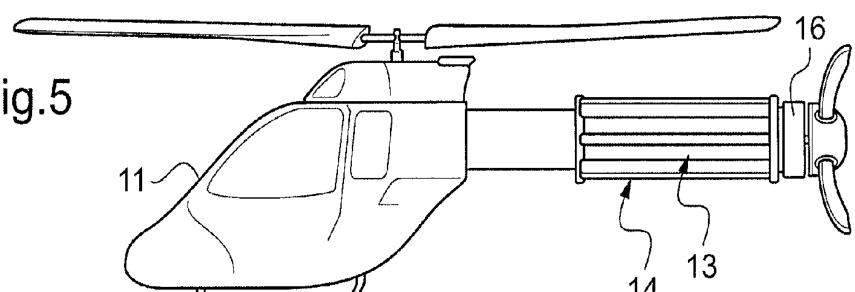


Fig.5



HELICOPTER WITH CYCLOIDAL ROTOR SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to European patent application serial no. EP 11 400027.6 filed Apr. 11, 2011, the disclosure of which is incorporated in its entirety by reference herein.

BACKGROUND OF THE INVENTION

[0002] (1) Field of the Invention

[0003] The invention is related to a helicopter with a cycloidal rotor system with blades disposed at a tail boom with the features of the preamble of the claim **1**.

[0004] (2) Background Art

[0005] An empennage of a classical helicopter configuration features 1. a fixed horizontal stabilizer, 2. a fixed vertical fin and 3. a tail rotor.

[0006] 1.: The horizontal stabilizer provides static pitch attitude stability, by generating a negative lift and provides via the tail boom lever a velocity dependent positive pitch, in order to keep the fuselage in a more or less horizontal position minimizing the configuration drag but at the cost of positive lift. A first problem of this classical configuration is: Since the horizontal stabilizer incidence angle is fixed, its negative lift cannot be fully adjusted to the flight condition, keeping the fuselage in its minimum drag position. Finally, due to this problem the pilot is lacking one degree of control freedom to fully control fuselage and aircraft attitude.

[0007] 2.: The vertical fin provides yaw stability and generates in forward flight part or all of the antitorque for the main rotor. Again the vertical fin incidence is built in and thus fixed, resulting in a side force that cannot be freely adjusted and that is dependent on the forward flight speed of the helicopter.

[0008] 3.: The possibility to freely adjust said side force is provided by the tail rotor, providing all of the antitorque force in hover condition and almost no additional force in cruise. The side forces and the lift act in a vertical plane with a normal vector parallel to the tail boom. A second problem is the helicopter's limited maximum horizontal speed, since the main rotor has to provide the propulsive force. This propulsive force is naturally limited, since it depends on the rotor specific limitations in tilting the tip path plane forward.

[0009] The document U.S. Pat. No. 2,580,428 A discloses an aircraft with cycloidal propulsion units including respectively airfoil blades pivotally mounted along an essentially horizontal blade axis parallel to the hub axis and perpendicular to a longitudinal axis of the aircraft.

[0010] The document WO 2007106137 A1 discloses a cycloidal propulsion unit for controlling a thrust vector including a hub that rotates about a hub axis. Further, the unit includes an airfoil blade pivotally mounted on the hub along a blade axis parallel to the hub axis and perpendicular to a longitudinal axis of the aircraft. As a result, the blade may pivot about the blade axis while travelling along a blade path during rotation of the hub. The unit further includes a ring that rotates around a ring axis parallel to the hub axis. The ring is interconnected with the blade via a control rod. Also, a device is engaged with the ring to selectively position the ring axis relative to the hub axis. As a result of these structures, selective positioning of the ring axis provides control of the rotation of the blade about the blade axis as the blade travels along the blade path.

[0011] The document WO 2009109918 A2 discloses a cycloidal rotor system having airfoil blades travelling along a generally non-circular, elongated and, in most embodiments, dynamically variable orbit. Such non-circular orbit provides a greater period in each revolution and an optimized relative wind along the trajectory for each blade to efficiently maximize lift when orbits are elongated horizontally, or thrust/propulsion when orbits are vertically elongated. Most embodiments, in addition to having the computer system controlled actuators to dynamically vary the blade trajectory and the angle of attack, can also have the computer system controlled actuators for dynamically varying the spatial orientation of the blades; enabling their slanting motion upward/downward and/or back sweep/forward sweep positioning to produce and precisely control a variety of aerodynamic effects suited for providing optimum performance for various operating regimes, counter wind gusts and enable the craft to move sideways and to allow roll and yaw control of the aircraft. Thus a rotor is provided, which when used in a VTOL rotorcraft, will require lower engine power to match or exceed the operating performance of VTOL rotorcrafts equipped with prior art rotors, this rotor also offers increased efficiency and decreased required power when used for generating the propulsive force for various vehicles or used as a fan.

[0012] The document JP 2009051381 A discloses a cycloidal blade capable of generating an advancing force during forward flying and accelerating forward speed, said cycloidal blade being disposed at the rear end of a tail boom of a helicopter to generate a propulsive force F in one direction. The blade includes a rotating shaft which extends along a vertical shaft of the helicopter, a plurality of blades which extend along the vertical shaft of the helicopter and rotate together with the rotating shaft, and a pitch angle change mechanism which decreases a pitch angle of the blade passing the opposite side to the one direction by moving in a direction opposite to the one direction, and increases the pitch angle of the blade passing on the same side with the one direction.

[0013] The document DE 102007009951 B3 discloses an aircraft with a closed cylinder drivable around a transverse axis of the aircraft with a controllable number of revolutions for generation of lift and/or propulsion after the Magnus effect. A radial blower having adjustable driving power is assigned to each of the cylinders for generating air flow that flows transversely against the cylinder. A wing profile of the radial blower has rotor blades that are pivotable around an aligned axis parallel to a rotation axis where a rotor of the radial blower concentrically surrounds the cylinder with a distance.

[0014] The document U.S. Pat. No. 1,761,053 discloses an airplane with a semi-cylindrical housing open upward and with a rotatable plane operable in the housing.

[0015] The document DE102008015073 A1 discloses a helicopter with a main rotor arranged on a cabin, on which a rear rotor is fixed over a rear bracket at a distance from the cabin for torque balancing. The rear bracket is provided with units for aerodynamic support for torque balancing. The devices for aerodynamic support for the torque balancing comprise a high-lift flap on the side turned away from the main rotor rotating direction extending along the rear bracket for accelerating the flow of the discharged air passing through the area of main rotor.

[0016] The document U.S. Pat. No. 4,948,068 A discloses a no tail rotor system for a helicopter. The addition of vortex generators in the longitudinal slots or nozzles, which produce the circulation control portion of the system which combines with a jet thruster and fluid resource, replaces the tail rotor.

[0017] The common disadvantage of all of said rotor systems of the state of the art is a low lift to drag ratio, limiting the efficiency of the generation of a propulsive force.

BRIEF SUMMARY OF THE INVENTION

[0018] It is an object of the present invention to provide a helicopter without the disadvantages of the state of the art.

[0019] A solution is provided with a helicopter with a cycloidal rotor system with the features of claim **1**. Preferred embodiments of the invention are presented in the subclaims.

[0020] According to the invention a helicopter is provided with at least one main rotor with an essentially vertical axis of rotation, a tail boom extending along a longitudinal axis essentially perpendicular with regard to said vertical axis of rotation and at least one anti-torque device. At least one cycloidal rotor is provided extending along said longitudinal axis of the tail boom said at least one cycloidal rotor having airfoil blades being rotated for anti-torque around said longitudinal axis of the helicopter the speed of said rotation being variable. The airfoil blades of said at least one cycloidal rotor are inclined relative to said longitudinal axis of the helicopter. Rotation creates aerodynamic effects at each of the airfoil blades that sum up to a lateral force resulting approximately in the middle of said at least one cycloidal rotor with some distance from the hub of the main rotor. The direction of rotation of said at least one cycloidal rotor and the inclination of each of the airfoil blades are tuned to create a lateral force with a suitable direction at said distance from the hub of the main rotor to provide anti torque to counter the operational torque of the main rotor. By varying the rotational speed of said at least one cycloidal rotor the lateral force is adapted to balance the operational torque of the main rotor for a controllable flight of the helicopter allowing for example at high forward speed of the helicopter to reduce the rotational speed of the cycloidal rotor as more anti torque may be contributed by a vertical tail thus allowing economy with regard to energy consumption of the inventive helicopter.

[0021] According to a preferred embodiment of the invention the inclination of each of the airfoil blades may be controlled relative to the longitudinal axis of the inventive helicopter to vary the direction of the force generated by the cycloidal rotor to allow as well yaw and pitch stabilization by means of said at least one cycloidal rotor allowing to replace the effect of any horizontal tail and thus allowing a more simple helicopter, said force being particularly directed to counteract the main rotor torque. The inventive helicopter with the cycloidal rotor allows for replacement of a classical tail rotor, any horizontal stabilizer and any vertical tail at the rear end of the tail boom of a helicopter and thus the inventive concept allows the provision of an improved helicopter with less structural elements.

[0022] Preferably said helicopter comprises as a second type of anti-torque means a rotating cylinder which extends inside said cycloidal rotor along said longitudinal axis of the tail boom and which is driven to produce a Magnus effect side force. The rotating cylinder extends from the fuselage towards a rear end of the tail boom of the inventive helicopter. According to a further advantage of the invention the rotating cylinder creates a force due to the down wash of the main rotor in a transversal direction to the tail boom. With a suitable rotational direction of the rotating cylinder relative to the rotational direction of the main rotor—mainly in hover flight—said force can principally be directed to counteract the effect of the main rotor torque to the inventive helicopter.

[0023] According to a preferred embodiment of the invention a three actuator combination drives the cycloidal rotor by means of a translational control plate with two translational degrees of freedom in a plane perpendicular to said longitudinal axis allowing said cycloidal rotor a thrust vector in any direction of a plane vertical to the longitudinal axis of the tail boom.

[0024] According to a further preferred embodiment of the invention a tail propeller is provided with a rotational axis in line with the tail boom to provide efficient thrust compounding for higher horizontal speed of the helicopter.

[0025] According to a further preferred embodiment of the invention said tail propeller is coupled to the tail boom by means of a gear box to adjust for different rotational speeds of cycloidal rotor and tail propeller.

[0026] According to a further preferred embodiment of the invention a periphery of the closed cylinder is provided with dimples and/or increased surface roughness for reduced drag in the downwash of the main rotor.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0027] Preferred embodiments of the invention are presented in more detail with regard to the following description and reference to the attached drawings:

[0028] FIG. **1** shows a force diagram of a tail boom of a helicopter of the state of the art,

[0029] FIG. **2** shows a schematic view of a helicopter according to the invention,

[0030] FIG. **3** shows a force diagram for a cycloidal rotor and a rotational cylinder of the helicopter according to the invention,

[0031] FIGS. **4** and **5** each show a schematic view of a preferred embodiment of the helicopter according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0032] According to FIG. **1** an empennage **1** of a classical helicopter (not shown) comprises a fixed horizontal stabilizer **2**, a fixed vertical fin **3** and a tail rotor **4**. The horizontal stabilizer **2** generates a negative lift, the vertical fin **3** provides yaw stability and generates in forward flight part or all of the antitorque for the main rotor while the tail rotor **4** provides all of the antitorque force in hover condition and almost no additional force in cruise. □F indicates direction and amplitude of the resulting force at the empennage **1** said resulting force being principally directed vertical to a tail boom of said helicopter.

[0033] According to FIG. **2** the helicopter **10** has a fuselage **11** and is equipped with a main rotor **12**. A tail boom **13** with a longitudinal axis is fixed to the fuselage **11**. A cycloidal rotor **14** of individual blades **15** surrounds the tail boom **13** between the fuselage and its rear end **16**, said blades **15** being essentially parallel to the longitudinal axis of the tail boom **13**. The radius of the main rotor **12** extends beyond the entire length of any of the blades **15**. Consequently the blades **15** are within the downwash of the main rotor **12** in operation.

[0034] A three actuator combination (not shown) drives the cycloidal rotor **14** by means of a translational control plate (not shown) with two translational degrees of freedom in a plane perpendicular to said longitudinal axis. Said drive comprises an electric motor arranged at the periphery of the tail boom **13** and being drivingly connected to the cycloidal rotor **14**.

[0035] A tail propeller **17** is rotatable fixed to the tail boom **13**, said tail propeller **17** being coaxial with the cycloidal rotor **14** and having the same rotational speed. A gear box (not shown) is provided between cycloidal rotor **14** and tail propeller **17** to adjust for different rotational speeds of cycloidal rotor **14** and tail propeller **17**.

[0036] According to FIG. **3** corresponding features are referred to with the references of FIG. **1**, **2**. The tail boom **13** is surrounded by a closed rotating cylinder **18** being driven in a range of 1000-2000 rpm. The rotating cylinder **18** has a diameter range of 300-800 mm. The cycloidal rotor **14** is eccentrically arranged with respect to the rotating cylinder **18**. The cycloidal rotor **14** is driven to rotate in the same or a direction contrary to the rotational direction of the rotating cylinder **18**. The diameter of the cycloidal rotor **14** is always more than that of the rotating cylinder **18** and is in the range of 600-1600 mm. The cycloidal rotor **14** has five to fifteen blades **15**. Any force vector resulting from the blades **15** of the cycloidal rotor **14** is freely controllable by changing respectively the inclinations of the blades **15** with regard to their trajectories. The periphery of the rotating cylinder **18** is provided with dimples and/or increased surface roughness. The rotating cylinder **18** is driven by the electric motor arranged at the periphery of the tail boom **13**.

[0037] According to FIGS. **4** and **5** the cycloidal rotor **14** extends from the rear end **16** of the tail boom **13** towards the fuselage **11** covering approximately ⅓ to ⅔ of the length of the tail boom **13** with the radius of the main rotor **12** essentially extending along the entire length of the blades **15**.

What is claimed is:

1. A helicopter comprising

at least one main rotor, and

a tail boom extending along a longitudinal axis, said tail boom being provided with at least one anti-torque device,

wherein at least one cycloidal rotor with individual airfoil blades is provided, said at least one cycloidal rotor extending along said longitudinal axis of the tail boom and being driven to rotate for anti-torque around said longitudinal axis with a controllable rotational speed.

2. The helicopter according to claim **1**, wherein each of the airfoil blades is pivotable relative to said longitudinal axis for yaw and pitch stabilization.

3. The helicopter according to claim **1**, wherein at least one rotating cylinder is provided, said rotating cylinder extending at least partly along said same tail boom and rotating inside the cycloidal rotor.

4. The helicopter according to claim **1**, wherein a control is provided said control allowing the cycloidal rotor to give a controllable thrust vector in any direction of a plane vertical to the longitudinal axis of the tail boom.

5. The helicopter according to claim **1**, wherein a three actuator combination is provided to drive the cycloidal rotor by means of a translational control plate.

6. The helicopter according to claim **1**, wherein a tail propeller is provided with a rotational axis in line with the axis of the cycloidal rotor.

7. The helicopter according to claim **6**, wherein the tail propeller is coupled to the tail boom by means of a gear box.

8. The helicopter according to claim **3**, wherein a periphery of the rotating cylinder is provided with dimples and/or increased surface roughness.

* * * * *

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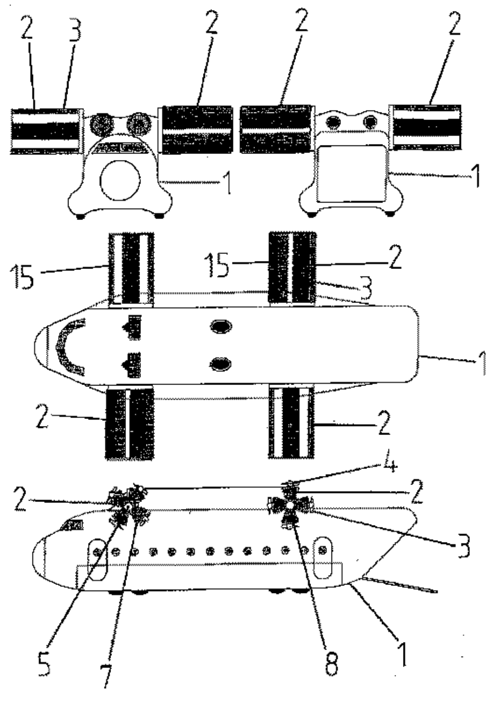
(71)出願人　502059179
アイピーツーエイチ　アーゲー
ＩＰ２Ｈ　ＡＧ
スイス国　ベルン　３０１３　ホフヴェグ　１１
Ｈｏｆｗｅｇ　１１，３０１３，Ｂｅｒｎ，　Ｓｗｉｔｚｅｒｌａｎｄ
(74)代理人　100111372
弁理士　津野　孝
(74)代理人　100119921
弁理士　三宅　正之
(72)発明者　アーノルド、ヨルグ
スイス国　ツェーハー－３０１３　ベルン、ホフヴェク　１１

最終頁に続く

(54)【発明の名称】航空機

(57)【要約】
【課題】単純な構造で実現される航空機を提供すること。
【解決手段】胴体（１）と設定可能な揚力の発生のための推進装置（２）を有して、該推進装置（２）が旋回軸（４）の周りに所定の羽根角まで回転可能な複数の回転羽根（３）を備えている航空機。この回転羽根（３）は回転軸（５）の周りを回転するよう取り付けられており、回転羽根角を該回転羽根角の回転時に変えて揚力を発生させることができる。この回転羽根（３）のそれぞれの旋回軸（４）が回転軸（５）に略平行に走っている。
【選択図】図１



【特許請求の範囲】
【請求項1】
　胴体（１）と、設定可能な揚力の発生のため該胴体（１）と連結された推進装置（２）とを備えて、該推進装置（２）が複数の回転羽根（３）から構成され、前記回転羽根（３）が旋回軸（４）の周りを所定の回転羽根角まで旋回可能である航空機において、
　前記回転羽根（３）が回転軸（５）の周りで回転するために取り付けられ、回転羽根角を変えることができると同時に揚力を発生させるため前記回転羽根（３）が回転し、前記回転羽根（３）のそれぞれの旋回軸（４）が、前記回転軸（５）に略平行に配置されていることを特徴とする航空機。
【請求項2】
　前記回転羽根（３）のそれぞれの旋回軸（４）が、互いに略等距離で配置されていることを特徴とする請求項１に記載の航空機。
【請求項3】
　前記回転羽根（３）の旋回軸（４）が、前記回転軸（５）まで略同じ距離に配置されていることを特徴とする請求項１又は請求項２に記載の航空機。
【請求項4】
　前記回転羽根（３）の旋回軸（４）が、互いに略平行に配置されていることを特徴とする請求項１ないし請求項３のいずれか１項に記載の航空機。
【請求項5】
　各回転羽根（３）のそれぞれの旋回軸（４）が、該回転羽根（３）の重心を通過するように配置されていることを特徴とする請求項１ないし請求項４のいずれか１項に記載の航空機。
【請求項6】
　前記回転羽根（３）の断面形状が、前記回転軸（５）の方へ凹状に湾曲していることを特徴とする請求項１ないし請求項５のいずれか１項に記載の航空機。
【請求項7】
　前記回転羽根（３）が、前記旋回軸（４）の周りに回転羽根（３）を回転させるために接触点として機能する少なくとも一端に制御シャフト（６）を備えることを特徴とする請求項１ないし請求項６のいずれか１項に記載の航空機。
【請求項8】
　前記回転羽根（３）が、駆動構成部品（７）に隣接するか、あるいは、駆動構成部品（７）の内部の一端に回転可能に取り付けられていることを特徴とする請求項１ないし請求項７のいずれか１項に記載の航空機。
【請求項9】
　前記駆動構成部品（７）が、前記回転軸（５）の周りを回転可能であり、あるいは前記回転軸（５）に取り付けられていることを特徴とする請求項８に記載の航空機。
【請求項10】
　前記駆動構成部品（７）が、ベアリングシャフト（８）、あるいは、中空シャフトを備えていることを特徴とする、請求項８又は請求項９に記載の航空機。
【請求項11】
　前記駆動構成部品（７）が、駆動プーリー、駆動ディスク、あるいは、駆動リングであることを特徴とする請求項８ないし請求項１０のいずれか１項に記載の航空機。
【請求項12】
　前記旋回軸（４）が、前記駆動構成部品（７）、あるいは、前記駆動プーリーあるいは前記駆動ディスクの端部、あるいは、前記駆動リングの端部に円形で配置されていることを特徴とする請求項８ないし請求項１１のいずれか１項に記載の航空機。
【請求項13】
　前記駆動構成部品（７）が、前記回転羽根（３）の旋回軸（４）を収容するための窪みあるいは通路（９）を備えていることを特徴とする請求項８ないし請求項１２のいずれか

１項に記載の航空機。
【請求項14】
　前記駆動構成部品（７）が、前記回転羽根（３）の制御シャフト（６）用の窪みあるいは通路（１０）を備えていることを特徴とする請求項８ないし請求項１３のいずれか１項に記載の航空機。
【請求項15】
　前記回転羽根（３）の制御シャフト（６）用の窪みあるいは通路（１０）が、長い好適には湾曲した孔として構成されていることを特徴とする請求項１４に記載の航空機。
【請求項16】
　前記駆動構成部品（７）が、溝、切欠きあるいは通路（１１）を備えていることを特徴とする請求項８ないし請求項１５のいずれか１項に記載の航空機。
【請求項17】
　前記駆動構成部品（７）が、制御部材（１２）と共に作動して、旋回軸（４）の周りに回転羽根（３）を調整することを特徴とする請求項８ないし請求項１６のいずれか１項に記載の航空機。
【請求項18】
　前記制御部材（１２）が、前記回転羽根（３）及び／又は駆動構成部品（７）の回転によって係合解除されることを特徴とする請求項１７に記載の航空機。
【請求項19】
　前記制御部材（１２）が、回転軸（５）に取り付けられていることを特徴とする請求項１７又は請求項１８に記載の航空機。
【請求項20】
　前記制御部材（１２）が、周期的ギアを備えていることを特徴とする請求項１７ないし請求項１９のいずれか１項に記載の航空機。
【請求項21】
　前記制御部材（１２）が、前記回転軸（５）に対してガイド内で移動可能であることを特徴とする請求項１７ないし請求項２０のいずれか１項に記載の航空機。
【請求項22】
　前記ガイドが、クロステーブル案内の形態で２つの垂直配置直線ガイドを備えていることを特徴とする請求項２１に記載の航空機。
【請求項23】
　前記ガイドが、直線ガイドに接続されている回転ガイドを張出し可能で旋回可能なガイドの形態で備えていることを特徴とする請求項２１に記載の航空機。
【請求項24】
　前記ガイドが、二重偏心ディスク制御部材（１３）の形態で２つの回転制御部を備えていることを特徴とする請求項２１に記載の航空機。
【請求項25】
　前記二重偏心ディスク制御部材（１３）の２つの偏心ディスクの各々が、互いにアクチュエーターとそれぞれ連携していることを特徴とする請求項２４に記載の航空機。
【請求項26】
　前記制御部材（１２）が、前記回転羽根（３）の制御シャフト（６）を収容するための環状溝（１４）あるいは円形溝を備えていることを特徴とする請求項１７ないし請求項２５のいずれか１項に記載の航空機。
【請求項27】
　前記制御部材（１２）が、制御リングあるいは制御ディスクであることを特徴とする請求項１７ないし請求項２６のいずれか１項に記載の航空機。
【請求項28】
　前記環状溝（１４）又は制御リングが、非円形部を備えていることを特徴とする請求項２６又は請求項２７に記載の航空機。
【請求項29】

前記非円形部が、回転角に依存する入射角関数を提供し、あるいは、重ね合わせ入射角関数を提供することを特徴とする請求項２８に記載の航空機。
【請求項30】
前記入射角関数が、式ａ－ｃｏｓ（ｘ）^{w}、この式で「ａ」は回転羽根（３）の入射角度であり、「ｗ」は好適には全体数、好適には１１である該式に比例していることを特徴とする請求項２９に記載の航空機。
【請求項31】
前記駆動構成部品（７）のベアリングシャフト（８）あるいは中空シャフトが、前記制御部材（１２）を中心で作動するよう好適に構成されていることを特徴とする請求項１７ないし請求項３０のいずれか１項に記載の航空機。
【請求項32】
前記駆動構成部品（７）及び制御部材（１２）が、互いに平行に配置されていることを特徴とする請求項１７ないし請求項３１のいずれか１項に記載の航空機。
【請求項33】
前記駆動装置（２）が、１つの回転軸（５）の周りを回転可能な回転羽根（３）の少なくとも２つの配置を備えていることを特徴とする請求項1ないし請求項３２のいずれか１項に記載の航空機。
【請求項34】
１つの前記回転軸（５）又は複数の回転軸（５）が、略平行面に配置されていることを特徴とする請求項1ないし請求項３３のいずれか１項に記載の航空機。
【請求項35】
１つの前記回転軸（５）又は複数の回転軸（５）が、胴体（１）の前進飛行方向の長手方向軸に平行に配置されていることを特徴とする請求項1ないし請求項３４のいずれか1項に記載の航空機。
【請求項36】
１つの前記回転軸（５）又は複数の回転軸（５）が、胴体（１）の前進飛行方向の長手方向軸に垂直に配置されていることを特徴とする請求項1ないし請求項３４のいずれか1項に記載の航空機。
【請求項37】
複数の前記回転羽根（３）が、前記複数の回転軸（５）のそれぞれ１つの軸の周りに回転可能なローター（１５）を形成し、それにより前記推進装置（２）が少なくとも２つのそのようなローター（１５）を備えていることを特徴とする請求項1ないし請求項３６のいずれか１項に記載の航空機。
【請求項38】
複数の前記ローター（１５）が、長手方向軸に並行して交互配置されていることを特徴とする請求項３７に記載の航空機。
【請求項39】
少なくとも１つの前記ローター（１５）が、各々の胴体（１）長手方向側面に配置されていることを特徴とする請求項３７又は請求項３８に記載の航空機。
【請求項40】
少なくとも２つの前記ローター（１５）が、互いに逆方向に回転することを特徴とする請求項３７ないし請求項３９のいずれか１項に記載の航空機。
【請求項41】
少なくとも２つの前記ローター（１５）が、前記胴体（１）の各々長手方向側面に配置されており、前記航空機のそれぞれ長手方向側面の対応するローター（１５）の回転軸（５）が整合していることを特徴とする請求項３７ないし請求項４０のいずれか１項に記載の航空機。
【請求項42】
各前記ローター（１５）が、個別に制御可能であることを特徴とする請求項３７ないし請求項４１のいずれか１項に記載の航空機。

【請求項43】
　複数の前記ローター（１５）が、同じ方法で一緒に制御可能であることを特徴とする請求項３７ないし請求項４２のいずれか１項に記載の航空機。
【請求項44】
　複数の前記回転羽根（３）が、１つの旋回軸（４）によって、前記駆動構成部品（７）から離れた該回転羽根（３）の端部に誘導装置（１６）で、あるいは、該誘導装置（１６）の内部でフェザリング可能（featherably）に取り付けられていることを特徴とする請求項８ないし請求項４３のいずれか１項に記載の航空機。
【請求項45】
　前記誘導装置（１６）が、ディスク状の駆動構成部品（７）と略同じ形態であることを特徴とする請求項４４に記載の航空機。
【請求項46】
　前記誘導装置（１６）が、前記駆動構成部品（７）で回転するように配置されていることを特徴とする請求項４４又は請求項４５に記載の航空機。
【請求項47】
　前記誘導装置（１６）及び駆動構成部品（７）が、軸又は回転軸（５）によって連結されていることを特徴とする請求項４４ないし請求項４６のいずれか１項に記載の航空機。
【請求項48】
　前記誘導装置（１６）が、複数のローター羽根（１８）から成る誘導ローター（１７）と関連していることを特徴とする請求項４４ないし請求項４７のいずれか１項に記載の航空機。
【請求項49】
　前記複数のローター羽根（１８）が、前記誘導装置（１６）に連動していることを特徴とする請求項４８に記載の航空機。
【請求項50】
　前記誘導ローター（１７）が、前記回転軸（５）を通る連結装置の周りで推進されることを特徴とする請求項４８又は請求項４９に記載の航空機。
【請求項51】
　互いに隣接してあるいは前後に配置される複数の前記回転羽根（３）又はローター（１５）が、ミラー配置で配置されることを特徴とする請求項１ないし請求項５０のいずれか１項に記載の航空機。
【請求項52】
　各前記制御部材（１２）が、前記回転羽根（３）の両端で、他の前記制御部材（１２）の各々から独立して作動可能であることを特徴とする請求項１７ないし請求項５１のいずれか１項に記載の航空機。
【請求項53】
　前記航空機の胴体（１）に、少なくとも１つの駆動タービンが配置されていることを特徴とする請求項３７ないし請求項５２のいずれか１項に記載の航空機。
【請求項54】
　タービン排気ガスが、前記胴体（１）から直接ローター（１５）の方へあるいはその上方へ、横に向けられることを特徴とする、請求項５３に記載の航空機。
【請求項55】
　前記ローター組立品（１５）の前と、前記ローター組立品（１５）の後方の双方に、可変ピッチプロペラ又はプロペラ（２１，２２）が配置されていることを特徴とする請求項３７ないし請求項５４のいずれか１項に記載の航空機。
【請求項56】
　前記可変ピッチプロペラ間又はプロペラ（２１，２２）間に２つ以上のローター組立品（１５）が，前後に配置されていることを特徴とする請求項５５に記載の航空機。
【請求項57】
　前記胴体（１）に、翼又は補助翼が隣接して取り付けられ、１つの前記ローター組立品

（１５）又は複数のローター組立品（１５）が、翼又は補助翼に取り付けられているか、それら翼から下げられていることを特徴とする請求項３７ないし請求項５６のいずれか１項に記載の航空機。
【請求項58】
前記胴体（１）には、ドッキング用組立品（１９）が装備され、該ドッキング用組立品（１９）から輸送物資が積込まれ、あるいは、積降ろされ、及び／又は人が該航空機に出入りすることを特徴とする請求項１ないし請求項５７のいずれか１項に記載の航空機。
【請求項59】
前記ドッキング用組立品（１９）が、トンネル、橋、あるいは、バスケットになることを特徴とする請求項５８に記載の航空機。
【請求項60】
前記ドッキング用組立品（１９）が、前記胴体（１）の先端に配置されることを特徴とする請求項５８又は請求項５９に記載の航空機。
【請求項61】
前記ドッキング用組立品（１９）に、略漏斗状入口通路が設けられていることを特徴とする請求項５８ないし請求項６０のいずれか１項に記載の航空機。
【請求項62】
前記ドッキング用組立品（１９）が、ビルに、あるいは、入口通路に連結するためのロック機構を備えていることを特徴とする請求項５８ないし請求項６１のいずれか１項に記載の航空機。

【発明の詳細な説明】
【技術分野】
【0001】
本発明の種々の実施形態は、胴体と、設定可能な推力発生のためのこの胴体と連結した推進装置とを備え、該推進装置が回転羽根を有し、該回転羽根を所定の羽根角で軸の周りを回転できる航空機に関する。
【背景技術】
【0002】
このような先行技術の航空機は、種々の形態とサイズで存在している。
特に、略垂直シャフト周囲の１つあるいは２つ以上のローターの回転により、力（推力）を発生するヘリコプターが周知である。
この力の垂直成分が、ヘリコプターの揚力を供給する。
ローター推力は、回転羽根の位置決めを制御することで垂直シャフトから得ることができ、この回転羽根は、ローター推力の水平成分を作り出す。
このローター推力の水平成分が、ヘリコプターを横方向あるいは後方に移動させるように機能できる推進力として機能する。
この回転羽根を軸の周りに所定の角度まで回転してフェザリング効果を生むことができる。
ヘリコプターの複数のローターが、それらの回転軸に対して、通常、半径方向に配置されている。
【0003】
このような先行技術の航空機は、２つ以上の半径方向に配置されたローター又は回転羽根を各々備えた１つ又は２つ以上のローターを有し、そのローターのそれぞれが一端で回転軸及び／又はローターハブに固定されている。
複数ローターの複数の羽根が円形領域上を回っており、このローターの回転軸（該円形領域に垂直である）が、ヘリコプターの胴体の長手方向、あるいは、横方向軸に沿った共通の垂直軸に平行及び／又は同軸である。
このローターの羽根は、該垂直軸から数度回転が行われるだけである。
この基本的な構造原理が、公知ヘリコプターで種々のフライト静的及びフライト動的な欠点を招いている。

【0004】
　先行技術のヘリコプターの欠点の１つは、これらのヘリコプターの胴体が前方、後方あるいは横方向への操縦だけが可能であり、この運動が胴体のピッチ動作又は横揺れ動作に結びついていることである。
　従って、胴体を垂直方向に維持しながら（すなわち、胴体を傾けること無く）、胴体を全方向に操縦することが不可能である。
　ヘリコプターが操縦されているとき、少なくとも２つの胴体の状態軸が傾斜する。
　これに対し、衛星は、該衛星の全ての３つの状態軸が平行ままである運動操縦を実現できる。
　そのような「シフト操縦」が、先行技術のヘリコプターでは可能でない。
【0005】
　先行技術のヘリコプターの他の欠点は、ヘリコプターが、回転羽根と該回転羽根が走行する円形領域とがヘリコプターの前方及び両側以上に十分に行き亘る上記所謂「オーバーヘッドキャリングローター」を有することである。
　その結果、これらのヘリコプターは障害物から十分な距離を維持する必要があり、従って、(例えば、ヘリコプターに人あるいは物資を乗せるため)対象物とドッキングすることができない。
　ヘリコプターに人あるいは物資を乗せることはヘリコプター胴体の下から行えるに過ぎない。
　これにより、救助・サルベージ操縦に機能するヘリコプターの能力に限界がある。
【0006】
　また、多くの先行技術のヘリコプターは、１つだけのオーベーヘッドローターを使用している。これが結果として、ヘリコプターの羽根に対する空気抵抗により生じる相対力によるトルクとなる。このトルクが、ヘリコプターを胴体の垂直軸の周りに回転させようとする。
　第２ローター（例えば、後部ローター）は、このトルクを補うために通常使用されている。
　そのような後部ローターは、故障し易く、ヘリコプター墜落や事故着陸の原因となることが多い。
【0007】
　先行技術のヘリコプターは、飛行中にヘリコプターの数本の羽根が飛行流に対抗して動き、一方、残りのヘリコプターの羽根が飛行流と共に動き、それにより、空気がヘリコプターの種々の羽根に対して様々に通過する。
　従って、方向性飛行時に、対気速度の変化がヘリコプターの飛行力学を変える。
　ヘリコプターが非常に高速飛行で使用されているときに、回転羽根の飛行流に対する動きにより、空気流が回転羽根の前方端から開始する場合である。
　空気中での回転羽根の運動速度は、回転羽根の円形通路速度と飛行流の速度の組み合わせである。
【0008】
　このことにより、ヘリコプターの速度と搬送能力との恐らく適用可能な組み合わせと、羽根回転数と回転羽根の先端が超音速範囲にまだなっていないため、衝撃波で損傷を受けることがない範囲までの対気速度との適用可能な組み合わせが制限される。
　飛行流への動きを伴う羽根がローターサークルの内部、特に、回転羽根の後方端部から先頭に向けて流される。
　これは、飛行流に対する円形通路速度割合が飛行流それ自体の流速より小さい回転羽根の全ての部分に当てはまる。
　対気速度の増大と共に、これらの羽根がヘリコプターの揚力に益々寄与が小さくなり、ヘリコプター飛行セルに対する及び／又は胴体に対する対気速度依存横揺れモーメントを生み出し、このモーメントがヘリコプターの性能に影響を与える原因となっていることに相違ない。

【0009】
この問題は、先行技術のヘリコプターの最大速度の限界を約４００ｋｍ／時間にすることにつながる。
その問題は、またヘリコプターの対気速度が増大するにつれ、エネルギー消費の増大も招き、これはヘリコプターの対気速度又は搬送能力に好ましくない。
従って、今日のヘリコプターは、その飛行性能で非常にエネルギー非効率であり、従って、通常、約１０００ｋｍの飛行範囲を有するに過ぎない。
ヘリコプターは、回転羽根の入射角を調整することで、また、幾つかの実験的ヘリコプターは、ヘリコプターのローター軸（例えば、回転軸）を傾斜させることで制御される。
回転羽根は、周期的にも集約的にも調整する必要があるため、複雑な斜板制御と複雑なローターヘッド構造が必要である。
この複雑な構造により、８本以上の羽根あるいは６０トン以上の荷重搬送能力を有するローターヘッドを現在は装備することができない。
【0010】
典型的なヘリコプターは、胴体がローターヘッドから下がり、その下で振動する原則として振子である。
胴体の飛行姿勢は、動的飛行条件（例えば、ヘリコプターが前進飛行か、後退飛行か、横向き飛行か、空中停止飛行かどうか）に依存している。
この胴体の飛行姿勢は、該動的飛行条件から独立して設定できず、例えば、ヘリコプターがくの字形に折れ曲がることは不可能である。
しかし、傾斜できるローターヘッドを有するヘリコプターで実験する試みがあった。
しかしこれらの試みは、更に脆弱で複雑な駆動構造とする結果に終わった。
【発明の開示】
【発明が解決しようとする課題】
【0011】
従って、本発明の目的は、上記問題の少なくとも１つが除去され、単純な構造により実現される航空機を提供することである。
【課題を解決するための手段】
【0012】
本発明によれば、議論中の課題が請求項１に記載の航空機で解決される。
これらの特性を備えた航空機は、回転羽根が回転軸の周りを回転できる方法で位置するように装備され、開発されている。
回転羽根が回っている間、その回転羽根角も揚力を作り出すために調整可能である。
この回転羽根のそれぞれの旋回軸も回転軸に略平行に配置されている。
【0013】
発明の方法では、上記参照した航空機のタイプは、オーバーヘッド搬送ローターを装備し、回転羽根、そのため回転羽根の旋回軸もヘリコプターの回転軸の周りに略半径方向に配置されているヘリコプターである必要がないことが認識された。
さらに、回転羽根が回転軸の周りを回転でき、それにより回転羽根のそれぞれの旋回軸が回転軸に略平行に配置されているように位置しているため、推進装置の特に単純な構造が実現可能である。
言い換えれば、それぞれの旋回軸と回転軸は、回転羽根が回っている間、この同じ回転軸の周りを平行に動くように配置されている。
羽根角は変えることができ、一方、回転羽根は、該回転軸の周りを回っており、制御揚力を作り出す。
推力の力と方向は、回転羽根角の設定によって決まる。
【0014】
航空機の発明実施形態によれば、通常、航空機の胴体以上に延びて胴体への近づき易さをより困難にして建物近くでの胴体ドッキングの可能性を妨げるオーバーヘッドローターの使用が特に必要ではない。

複数回転羽根のそれぞれの旋回軸を互いに略等距離に配置することができる。
これにより、回転軸の周りに回転羽根が一様にバランスよい動きの進路を有することが可能である。
そして、その同じ進路に沿って、複数回転羽根の旋回軸を、各々回転軸に等距離になるように配置することができる。
回転羽根の旋回軸は、回転軸に略平行であり、互いに略平行に配置できる。
従って、回転軸周囲の全体的に均一で略対称の回転羽根装置の１つの実施形態が実施可能である。
【0015】
この回転羽根の角度の単純で安全な調整のために、回転羽根の旋回軸を回転羽根の重心に基づいて配置することができる。
この旋回軸は、回転羽根の断面の重心を正確に走行してもよい。
回転羽根が回転軸の周りでの回転時に推力又は空気の方向転換を生じない回転羽根の中立位置を、該回転軸に対する回転羽根の断面の凹状曲線で作り出すことができる。
この羽根の断面形状は、架空円形円筒の円筒壁内に殆ど完全に入ることができる。
そのような回転円形円筒は、推力も空気の方向転換も生じさせないだろう。
各羽根の旋回軸は、回転羽根の断面から垂直に立ち、該回転羽根の長手方向軸に略平行にあるいは同軸上に延びることができる。
【0016】
旋回軸の周りで回転羽根を安全に制御し、旋回させるために、回転羽根は、少なくとも一端で制御シャフトを有することができる。
これらの制御シャフトは、各々、旋回軸の周りに回転羽根を旋回させるために接触点として機能するだろう。
制御シャフトは、回転羽根断面から垂直に延在でき、回転軸の周りの回転羽根の回転方向から見えるように、旋回軸の前方又は後方に配置することもできる。
該回転羽根は、連結されてもよく、また、それぞれ回転羽根の攻撃角（又は羽根角）を制御シャフトで調整することができる。
正又は負の羽根角度を回転羽根の中立位置に対して使用することができる。
上記のように、回転羽根の中立位置は、該回転羽根が回転軸の周りを回転するときに、定常空気が回転羽根から流れていないことを意味している。
これは、むしろ、回転羽根が空気を単に突っ切っていることを意味している。
制御シャフトと旋回軸との間の距離が、回転羽根角としての転換比を調整することを規定している。
【0017】
回転羽根の特に安全な保管と運動のために、回転羽根を一端で駆動構成部品に回転可能に取り付けたり、駆動構成部品内に回転可能に装着したりすることができる。
従って、駆動構成部品は、回転軸の周りで構造的に単純に回転でき、あるいは、回転軸に回転可能に配置することができる。
そこで、駆動構成部品は、回転羽根の外側と整合できるベアリングシャフト又は中空シャフトを有することができる。
比較的単純な実施形態では、回転羽根を旋回可能に取り付ける駆動ディスク又は駆動リングとして駆動構成部品を構成することができる。
【0018】
旋回軸又は回転羽根を、駆動構成部品、駆動プーリー、駆動ディスク又は駆動リングに垂直に配置することができる。
そして、回転羽根又は旋回軸をベアリングシャフトの対向側に配置してもよい。
更に、旋回軸を、駆動構成部品、駆動プーリー、駆動ディスク又は駆動リングに沿って円形に配置することができる。
この旋回軸は、等距離に離間するように配置することが好ましい。
平行羽根の配置は、それにより、円筒ローター組立品を構成することができる。

【0019】
原則として、駆動構成部品の直径と回転羽根の幅に依存して該駆動構成部品にあるいは円筒ローター組立品に所定通り配置されるように多くの羽根がある。
各回転羽根は、その旋回軸が駆動構成部品に垂直になるように、また、回転羽根がその旋回軸の周りを旋回するように配置することができる。
該駆動構成部品のベアリングシャフト又は中空シャフトが、駆動構成部品からあるいは駆動プーリー及び／又は駆動ディスクの表面から垂直に延在することができる。
該駆動構成部品が安全に作動するのを確実にするため、該駆動構成部品を歯付きベルト、チェーン又は円形歯付きギアと連結することができる。
このため、該駆動構成部品が、その部品の円周又は円形縁に隣接して、あるいはベアリングシャフトに円形歯装置を備えることができる。
従って、ベアリングシャフトを駆動シャフトの形態に構成することができる。
【0020】
回転羽根を駆動構成部品に安全に連結するため、駆動構成部品が、回転羽根の旋回軸の収容のための窪み又は通路を備えてもよい。
その代わりに、あるいは更に、該駆動構成部品が回転羽根の制御シャフト用窪み又は通路を備えることができる。
制御シャフトは、該動構成部品の窪み又は通路を介して延在する寸法とすることができる。
この窪み又は通路は、切欠き、孔又はスロットとして構成してもよい。
特に、該回転羽根の制御シャフト用窪み又は通路は、長く、好ましくは、湾曲した孔として構成することができる。
【0021】
駆動構成部品の重量を制限するため、この駆動構成部品は、駆動構成部品が星形、円形、あるいはスポーク状外観を有するように、複数のスロット、通路、切欠き、孔又はスライバーを備えることができる。
回転羽根の角度を安全に調整するため、駆動構成部品が制御部材と共に作用して旋回軸の周りで回転羽根を調整してもよい。
この制御部材は、制御シャフトの動きによって回転羽根角度の姿勢に対して役割を担うことができる。
この制御部材は、それにより、回転羽根及び／又は駆動構成部品の回転運動から切り離される。
言い換えれば、制御部材は、回転羽根の回転軸の周りでの回転と共に回転しない。
比較的単純な実施形態では、制御部材を回転軸の周りに取り付けることができる。
【0022】
旋回シャフトを安全に制御するため、制御部材は、円筒ギアを有することができる。
原則として、制御部材は、回転羽根の角度の安全な設定あるいは予め調節された設定を達成するために、回転軸に対しガイドで調整可能にすることができる。
制御部材も、回転軸に垂直な全ての方向に、ある程度の距離又は振幅だけずらすことができるように取り付け及び／又は向けることができる。
特に、単純な実施形態では、そのようなクロステーブル案内の目的で、ガイドが垂直に配置された２つの直線ガイドを備えることができる。
同様に、単純な実施形態では、ガイドが、直線ガイド部材に接続されている回転ガイド部材を備えることができる(例えば、張り出し可能で旋回可能なガイドの形態で)。
【0023】
他の好ましい実施形態として、制御組立品が二重の偏心ディスク制御部材の形態で２つの回転制御部を有してもよい。
上記明記された制御部材の複数要素を制御ディスクとして説明してもよい。
該偏心ディスク制御部材は、該部材を駆動構成部品のベアリングシャフト又は中空シャフト上に直接配置し、あるいはそれらで支持することができる利点がある。

該偏心ディスク制御部材の複数の偏心ディスクを別個に、安全に制御し動かすために、各偏心ディスクをアクチュエーターと対応させることができる。
特に、該偏心ディスク制御部材の２つの偏心ディスクをそれぞれアクチュエーターに対応させることができる。
【0024】
偏心ディスク制御部材は、２つの偏心ディスク、すなわち、駆動構成部品のベアリングシャフトのベアリングを介して取り付けられた偏心カムを有する内部偏心ディスクと、この内部偏心ディスクの外側周囲のあるいはそれに隣接するベアリングに取り付けることができる外部偏心ディスクとを有することができる。
この外部偏心ディスクの偏心カム孔が内部偏心ディスクを有してもよい。
この制御部材を該外部偏心ディスクのベアリングに取り付け(走らせ)てもよく、及び／又は該外部偏心ディスクに対して中央に配置してもよい。
そのような配置では、双方の偏心ディスクが互いの周りを及び／互いの内部で自由に回ることができる。
偏心ディスクが振れた場合、制御部材がその問題に対処するよう携わる。
偏心ディスクの偏心率が、偏心ディスクの相対角度姿勢のために、外部偏心ディスクの支点が駆動構成部品のベアリングシャフトの支点に対応するように選択される。
この相対角度姿勢の偏心ディスクが、駆動構成部品のベアリングシャフトの周りを回りながら互いに滑らかに動作すれば、制御部材の状態が何も変化を起こさず、解放された方位のままである。
【0025】
該偏心ディスク制御部材は、制御効果を生むように、以下のように使用することができる。
制御部材が複数偏心ディスクの相互角度の向きにより係合解除されると、互いに係合しないで、偏心ディスクを回転させてローター組立品の羽根の所定の偏向方向に対応する特定角度になる。
その後、双方の偏心ディスクを、外部偏心ディスクが、内部偏心ディスクの回る角度の２倍回転するように、互いを回転させる。
従って、外部偏心ディスクは、内部偏心ディスクの２倍早く回転する。
そのため、偏向が、回転の偏心ディスク角度、すなわち、方位角に比例する所定の方向に作られる。
従って、この二重偏心ディスク制御は、先ず、偏向角が設定され、次に、その偏向角の量が設定されるベクトル制御である。
各制御指令及び／又は各所定の制御位置、すなわち、「操縦桿位置」を割り当てることができる（偏向及び／又は偏向の方向の角度）。
【0026】
この制御は、順次別個の制御位置に分割するように行われてもよい。
割り当てられた偏向角が次の割り当て偏向角に移行し、偏向量の割り当て角度が次の割り当て偏向量に移行するため、１つの制御位置から続いて次の制御位置まで段階的な切換えがある。
選択された独立の故障がより高精度であればある程、利用できる制御は、より高精度であり及び／又は同時に行なわれる。
それにより、偏心ディスクを２つのアクチェーター、例えば、２つのステッパーモーターで調整することができる。
１つのアクチュエーターが内部偏心ディスクを保持すると同時に回転させ、そして１つのアクチュエーターが外部偏心ディスクを保持すると同時に回転させる。
さらに、各偏心ディスクには、アクチュエーターがピニオンに係合するギアリムを設けてもよい。
回転羽根が制御手順の外側で回転している間、この偏心ディスクは動かない。
【0027】

制御シャフトを安全に取り付け及び／又はガイドするため、制御部材が、回転羽根の制御シャフトを収容するための環状溝あるいは円形溝を有することができる。
回転羽根が回転軸の周りで回転すると同時に、制御シャフトが該環状溝又は円形溝内で回転する。
別の単純な実施形態では、制御部材を制御リング、又は、制御ディスクとして構成してもよい。
この実施形態については、環状溝あるいは円形溝を該制御リング、又は、制御ディスクの外部領域に形成することができる。
【0028】
ここで、駆動構成部品の回転中に制御部材をガイドすることで制御部材を特定方向に動かすと、回転羽根の制御シャフト（環状又は円形溝内で回転できる）が、この偏向を循環的に追従する。
これにより、周期的な羽根調整がもたらされる。
１回転で、回転羽根の制御シャフトが、その中立位置から出て、１度最大の正の位置まで移動し、そして、１度最大の負の位置まで移動する。
これらの最端の偏向間で、回転羽根の制御シャフトが、その中立位置を２度通過する。
制御部材の環状溝の通路上の互いに両端にある２つの中立位置では、定常空気が回転羽根から流されない。
回転羽根の運動方向が円形通路に沿って逆転するため、定常空気が２つの最端位置で同じ方向に最大で流される。
【0029】
回転羽根の最端位置が、シフト軸の所定位置にあるか、制御部材の運動方向にある。
その結果、中立位置がそれぞれ９０度ずれた位置になる。
回転羽根の制御シャフトが回転羽根の旋回軸の前に配置されていると（回転羽根の回転方向から見て）、制御部材のシフト方向が空気流により予め決められた推力方向と同じである。
回転羽根の制御シャフトが旋回軸後方に配置されると、逆の効果が得られる。
【0030】
推進装置の効率を上げるために、環状溝あるいは制御リングを円形配置からずらすことができる。
従って、環状溝あるいは制御リングが円形配置を有することが必須条件ではない。
例えば、回転角に依存する入射角関数あるいは重ね合わされた複数の入射角関数を他の配置に備えることができる。
そのような技術が、推進装置の効率を変えるために使用される。
更に、入射角関数が、式ａ－ｃｏｓ（ｘ）^{w}、この式で「ａ」は、回転羽根の入射角度及び「ｗ」は、好適には全体数、好ましくは１１である該式に比例する。
【0031】
言い換えれば、回転軸の周りを回転する回転羽根の効率あるいは円筒ローター組立品の効率を上げるために、制御リング又は環状溝の形態を更に最適化することができる。
このため、回転依存入射角関数、ａ－ｃｏｓ（ｘ）^{w}を与える別の実施態様を提供することができる。
これを円形環状溝の代わり、あるいは、円形制御リングの代わりに使用してもよい。
回転軸の周りを回転する回転羽根あるいは円筒ローター組立品の効率を最適化することが、この機能の唯一の実施例である。
実際には環状溝形態がより適切である。
それらの形態は、重ね合わされた入射角関数を与え、それから、円筒ローター組立品の効率あるいは回転軸の周りを回転する回転羽根の効率を、最大円筒ローター組立品あるいは羽根の推力を落とさずに最適化する。
【0032】
そのような環状溝形態あるいは制御リング形態又は羽根の軌跡を、円上に２つあるいは

４つの周期的で対称的な「突起部」を備えた円、すなわち、基準円のオーバーレイから作ることができる。
　これは、該基準円の可能な共通関数の曲線を内接でき、正方形を外接できるように行われる。
　従って、多数の曲線が存在している。
　非公式的近似では、円の周りに正方形を考えることが予想されよう。
【0033】
　そのような重複曲線の単純な実施例は、以下の通りである。
　すなわち、２つの突き出た(凸状)楕円の場合、４つの凸状外サイクロイド及び星形あるいはコーナーが丸みを帯びた単純な正方形又は矩形の場合である。
　円形形態から非常に外れた非円形制御リング又は環状溝を使用する場合、回転羽根の制御又は円筒ローター組立品を代える必要がある。
　それにより、互いの次のあるいは前方の２つの制御部材の使用あるいは円筒ローター組立品の一端あるいは両端で使用される同じ又は僅かに異なった形態のスロットリングの使用が可能であろう。
　羽根旋回駆動軸、すなわち、回転羽根駆動軸が、駆動ディスク及び／又はガイドディスクに隣接してあり、ディスクに対し固定されている溝リング内部周囲で作動する。
　他のスロットリング、すなわち、制御リングの内部では、回転羽根制御シャフト又は羽根連結シャフトが作動している。
　このスロットリングを駆動ディスク又はガイドディスクに対して更に回転させ、ずらすことができる。
【0034】
　回転羽根旋回シャフト取り付け用ドリル孔の代わりに、駆動ディスクとガイドディスクに、回転羽根ドラッグ旋回シャフトが半径方向に摺動可能な半径方向スロットあるいは長い孔が備えられている。
　それで、この駆動ディスクとガイドディスクは、駆動／取付け部品ディスクの特性を有している。
　複数対の制御部材及び／又はスロットリングを有するこの実施形態では、回転羽根旋回シャフト及び、回転羽根制御シャフトの双方を半径方向に制御し動かすことができる。
　そのため、円形円筒ローター組立品又は羽根装置の代わりに、回転羽根が、例えば、楕円、周転円、星形、又はコーナーが丸い正方形あるいはコーナーが丸い矩形でよい円筒ローター組立品上で移動できることが明らかである。
【0035】
　簡単な実施形態では、駆動構成部品のベアリングシャフト又は中空シャフトを、制御部材を介して中心で作動するよう好適に構成することができる。
　そして、制御部材を駆動構成部品の後方又は下方で中心的に配置することができる。
　駆動シャフトとして同時に機能できる駆動構成部品のベアリングシャフトを制御部材に通してもよい。
　従って、駆動構成部品と制御部材を互いに平行に配置することができる。
　駆動ディスクとしての駆動構成部品及び制御リングとしての制御部材の１つの実施形態では、駆動ディスクの円形領域を、制御リングがある平面に平行か、あるいは、その同一平面に配置することができる。
【0036】
　駆動ディスクが回転しているときに、複数回転羽根の制御シャフトの複数端部が、制御部材の環状溝又は円形溝内で遊び無しで作動できる。
　この実施形態では、制御シャフトが、駆動構成部品又は駆動ディスクに挿入される。
　この遊びを無くすことは、例えば、制御シャフトの端部が配置されている適切なプーリー支持体によって達成できる。
　最も簡単な実施形態では、このプーリー支持体を、制御シャフトの端部に配置されている、２つの半径方向に容易に移行された減摩ベアリング（転がり軸受）によって作製でき

る。
　１つの減摩ベアリングは、環状溝の内壁の１つと加圧接触を保持し、そして、他方の減摩ベアリングが、環状溝の他方のあるいは反対側の内壁と加圧接触を保持している。
【0037】
　回転羽根の周期的調整は、舶用推進技術－例えば、シュナイダー－ボイス駆動装置に由来するパドル駆動装置の公知の周期的ギアにより、作製することができる。
　しかし、これらの公知構造原理は、高速回転ローター組立品には殆ど適していない。
　それは、パドル制御機械工が、周期的加速が高い反力と振動を招く高い慣性質量を制御するからである。
　しかし、本発明は、回転羽根が、その長手方向軸の周りで周期的に加速するに過ぎず、他の制御機構を周期的に加速する必要がないため、最小のグランド加速を確保する。
【0038】
　安定した飛行特性のために、推進装置が、回転軸の周りに回転可能な回転羽根の少なくとも２つの装置を有することができる。
　それにより、航空機の垂直軸の周りの不要なトルクを回避することができる。
　安全な揚力を生み出すため、１つの回転軸あるいは複数の回転軸を略水平面に配置することができる。
　これにより、垂直方向への最大推力変換が可能となる。
　狭い構造の航空機では、その回転軸を、前方飛行方向に沿った胴体の長手方向軸に平行に配置してもよい。
　他の実施形態では、この回転軸を、前方飛行方向に沿った胴体の長手方向軸に垂直に配置してもよい。
　原則として、上記のような回転軸の配置が航空機の安定性に好ましい。
【0039】
　簡単な実施形態では、回転羽根が、それぞれ１つの回転軸の周りで回転可能なローターを形成し、それにより、推進装置が少なくとも２つのそのようなローターを有することができる。
　安定した飛行姿勢を作るため、複数ローターを長手方向軸に沿って交互ジグザグ配置としてもよい。
　少なくとも１つのそのようなローターを胴体の各長手方向側に配置できる。
　しかし、また、複数のローターが各長手方向側にあってもよいと考えられる。
　複数のローターを備えた実施形態では、強力な揚力を発生させ、それにより重い搭載量を航空機で輸送することができるだろう。
【0040】
　不要なトルクを避けるため、少なくとも２つのローターを反対方向に回してもよい。
　簡単な実施形態では、少なくとも２つのローターを胴体の各長手方向側に配置でき、各ローターを隔てて複数回転軸が自身の向きを調節できる。
　従って、最終的には、ローターの配置を、前方飛行方向の胴体の長手方向軸に垂直である回転軸で実現される。
　万能で独立した航空機の制御のために、各ローターが別個に制御可能とすることができる。
　単純化制御の場合には、複数ローターを同様に共に制御してもよい。
【0041】
　回転軸の周りで羽根を回転させて作動するローターの動作原理のために、揚力及び／又は推進力が、ローター及び／又は回転軸の長手方向軸に垂直な方向に発生する。
　従って、複数ローター（駆動装置として）及び／又はそれらの回転軸を、航空機の横軸に平行に及び／又は同軸で胴体に配置できる。
　しかし、静的に好ましい飛行条件を達成するため、特に、安定なシステムを達成するため、少なくとも２つのローターを使用する必要がある。
　この複数ローターは、胴体の長手方向軸の方向に、胴体の各サイドに１つ用いて、ジグ

ザグ状に配置しなければならない。
　不要なトルクを避けるため、２つのローター組立品を逆向きに回転させてもよい。
　長手方向軸の同じ高さに配置された２つのローター組立品を、航空機の重心に配置できる。
　このローター組立品が、同じ方向か、あるいは逆方向に回転するかにより、胴体の横軸の回りあるいは垂直軸の周りにトルクを発生させることができる。
　そのような場合、飛行姿勢の必要な静的安定性が提供されよう。
【0042】
　１つのローター組立品の使用を逸する可能性を考えると、４つのローター組立品の使用が、本発明の特に安全な実施形態に含まれる。
　２つのローター組立品を、胴体の両側に互いに向かい合って設けることができ、及び／又は該ローター組立品が、共通のローター組立品の長手方向軸及び／又は回転軸を形成できる。
　そのような１対のローター組立品は、胴体の前方部分及び後方部分に対してイメージできる。
【0043】
　胴体の長手方向軸の方向で２つ及び／又は４つのローター組立品を使用することで、航空機が縦揺れ無しに前方、後方の方向転換操縦を行うことができる。
　この目的のため、前方及び後方の複数ローター又は複数ローター対の推力発生を一様に制御する必要があろう。
　他方、前向き及び／又は後ろ向きの方向転換操縦を、前方駆動装置又は後方駆動装置からの種々の推力で実施できる。
　それで、この操縦が、胴体の横軸周りのトルク、従って、周知の縦揺れ運動を再度もたらし、これにより、力のベクトル分析の下で、二次ベクトルが前向きあるいは後ろ向きの複数成分を有する。
【0044】
　前述した前向き及び後ろ向きの方向転換操縦と同じことが、横向き方向転換操縦にも言える。
　横への方向転換操縦は、左あるいは右ローター組立品及び／又は左あるいは右駆動装置の推力を変えることで行うことができる。
　従って、トルクが胴体の長手方向軸の周りに生じ、その後の横揺れ運動から、横向き推力ベクトルが発生する。
【0045】
　他の実施形態では、航空機の横向き運動を、横揺れ運動を生じることなく行うことができる。
　このため、駆動構成部品から離れた該羽根端部に、誘導装置で、あるいは誘導装置内で、回転羽根を旋回シャフトによりフェザリング可能に取り付けられる。
　そのような誘導装置は、周期空気流と回転の遠心エネルギーとから生じる回転羽根の曲げモーメントを吸収できる。
　回転羽根あるいは円筒ローター組立品の装置は、誘導装置を用いて実質的に高い回転数で回転できる。
　この誘導装置は、多くの推力反力を吸収し、多くの前進推力及び揚力推力を生み出す。
【0046】
　誘導装置は、ディスク形状の駆動構成部品のように、構成できる。
　こうすることで、誘導装置がガイドディスクの形態とすることができる。
　この誘導装置は、駆動構成部品と該誘導装置間の中央支持シャフトあるいは中空シャフトで支持でき、駆動構成部品に連結できる。
　従って、誘導装置を、該駆動構成部品で回転するように構成できる。
　該誘導装置と駆動構成部品は、シャフトあるいは回転軸によって結合できる。
　支持シャフトの長手方向軸、中空シャフト、軸あるいは回転軸が駆動構成部品の中心と

誘導装置に通っており、支持シャフトの長手方向軸あるいは中空シャフトがローター組立品長手方向軸及び／又は回転軸に一致する。

【0047】

該誘導装置の支持シャフトあるいはガイドディスクは、駆動構成部品あるいは駆動ディスクのベアリングシャフトに対応する。

該支持シャフトを該駆動構成部品のベアリングシャフトの誘導装置の横延長部と見なすことができる。

この支持シャフトあるいは中空シャフトが該誘導装置を搬送し、及び／又は推進するため、該シャフトが誘導装置用の駆動シャフトとしても機能する。

【0048】

横揺れ運動を生じること無く航空機の簡単な横運動を発生させるため、誘導装置には、ローター羽根を有する誘導ローターを設けることができる。

このローター羽根は、構造的に単純な方法で該誘導装置と連動できる。

また、このローター羽根を、誘導装置のハブと誘導装置のエッジとの間に半径方向に配置してもよい。

このため、誘導装置は、適切な通路及び／又はベアリングシートを有することができる。　そのような誘導ローターは、従来のヘリコプターの尾部ローターに相当し、原則として構造が類似していてもよい。

【0049】

この誘導ローターは、回転軸を介してリンク装置の周りを前進させることができる。

そのようなリンク装置は、支持シャフトや駆動構成部品のベアリングシャフトにより誘導される連結ロッドを備えてもよい。

この誘導ローターは、連結ロッドにより、またベルクランクによって取り付けることができる。

ローター組立品の誘導ローターにより、航空機が横揺れ運動を生じること無く横運動を行うことが可能となる。

更に、誘導ローターの全てを、それらの推力に対し同様に制御してもよい。

胴体の垂直軸周りの航空機の回転操縦が、ローター組立品か誘導ローターの不均一推力によって達成できる。

更に、推力は、向かい合わせにあるか同じ対のローター組立品に属しない２つのローター組立品又は誘導ローターから発生しさえすれば良いであろう。

【0050】

航空機を上昇させたり、下降させたりするため、前方及び後方駆動装置の揚力推力を一様に制御することができる。

上昇推力の増加は、回転羽根の増加及び／又はローター組立品の回転数の増加で達成できる。

ここにおいて、本発明と従来のヘリコプターとの大きな違いが明らかになる。

従来のヘリコプターは、回転羽根角度の集約的増加及び／又はローターの回転数の増加に対して上昇推力を生む。

しかし、本発明については、上昇推力が周期的羽根制御によって達成される。

胴体飛行姿勢及び／又はトリムを制御するため、前方あるいは後方及び／又は横の駆動装置の推力を別々に制御できる。

本発明は、航空機の動的飛行条件の様々な飛行姿勢の微調整を別個に維持できる。

【0051】

本発明の一実施態様が、集約的羽根制御を使用せずに、従来のヘリコプターと同じ飛行動的状態を達成できる。

従って、本発明は、かなり単純な構造を伴っている。

更に、本発明の実施態様は、完全に分離された動作及び／又は純粋な並進動作で操縦を行うことができ、縦揺れ及び／又は横揺れ動作無しで操縦をシフトできる。

そのような操縦あるいは動作は、従来のヘリコプターには可能でない。

更に、胴体の飛行姿勢を微調整できる。
ヘリコプターは、胴体の横軸の周りに全３６０度内で全ての姿勢を安全に取ることができる。
本発明の一実施形態である航空機が、各ローター組立品に対して任意数の回転羽根を備えた２つあるいは４つのローター組立品を有するため、高い揚力推力を達成でき、従来のヘリコプターで可能な有効搭載量より高い有効搭載量を輸送できる。
【0052】
ローター組立品の長手方向軸及び／又は回転軸が、胴体の横軸に平行及び／又は同軸である一実施形態では、明らかな欠点、すなわち、飛行流に対して動いている回転羽根、及び回転速度及び対気速度に応じて非効率的で変化する方法で飛行流に向かって動いている回転羽根に対する気流打撃がある。
更に、この構造に関して対気速度が回転羽根の経路速度に付加されて、最大対気速度が非常に制限されたままの欠点がある。
これらの欠点を以下の本発明の実施形態で対処可能である。
このため、ローター組立品の長手方向軸及び／又は回転軸は、胴体横軸に平行に及び／又は同軸に配置されない。
その代わり、それらの軸が、胴体長手方向軸に平行に及び／又は同軸に配置される。
１つの推進装置は、互いに前後に共用ローター組立品の長手方向軸及び／又は回転軸を備えた少なくとも２つのローター組立品を使用して、必要な操縦トルクを生むことができる。
２つのローター組立品だけを使用すると、胴体上で２つのローターを互いに前後にそして頭上に配置できる。
４つのローター組立品を使用すると、４つのローターを、胴体の各サイドで２つのローターが互いに前後した状態で横に配置してもよい。
互いに前後し、互いに隣接し、及び／又は互いに交差して配置される各対のローター組立品が逆向きに回転して不要なトルクを無くすことができる。
【0053】
本発明の実施形態では、互いに隣接あるいは前後して配置される複数の羽根、あるいは、ローターを擬似ミラー配置に配置できる。
ここでは、双方のローター組立品が連結して反転された「互いに前後の」配置と言うことができる。
この実施形態の場合、唯一の誘導要素が、双方のローター組立品に必要である。
そして、該ローター組立品を共通の誘導装置に対し連結でき、及び／又は相互支持軸を互いに堅固に連結できるため、１つの駆動構成部品を駆動することだけで十分である。
しかし、唯一の駆動装置を有するこの実施形態では、操縦トルクを、周期的羽根調整により双方のローターに対して達成できるに過ぎないが、回転数を制御することによっては達成できない。
それとは別に、ローター羽根に対する空気抵抗から生じるトルクは、ローター組立品の個別の、反対の推進回転で補うことができない。
【0054】
本発明の実施形態に係る航空機のさらなる大幅な単純化は、回転羽根の両端で、各制御部材が他の制御部材の各々からそれぞれ別個に作動できることによって達成できる。
例えば、唯一のローター組立品を使用できるが、そのローター組立品が２つの制御部材又は制御リングを備えている。
そして、複数の羽根を、それらの端部の各々で駆動構成部品にあるいは制御装置に取り付けることができ、制御部材又は環状溝内で誘導されるそれら端部の各々を羽根が有することができる。
この用途では、ローター組立品長手方向軸に垂直に作動する操縦トルクを回転羽根の周期的振りで達成できる。
この振りは、互いに、２つの制御部材又は制御リングの相対的シフトにより行われる。

従って、回転羽根角度及び回転羽根の選択的推力が、該回転羽根の一端から他端まで絶えず変化する。
前述した航空機の実施形態では、操縦トルクが個々のローター組立品の異なった総推力ベクトルで生じる。
捩り制御を備えたローター組立品は、２つの別個の制御可能なローター組立品のように作動する。
【0055】
飛行操縦に対する推力発生の相互関係は、胴体の長手方向軸に平行及び／又は同軸のローター組立品の複数長手方向軸の整合で変化する。
横シフト操縦あるいは胴体の垂直軸の周りの回転操縦は、誘導ローターによって達成できないが、今ではそれら操縦は、ローター組立品の推力制御によってのみ行われる。
しかし、前向きシフト操縦は、ローター組立品によっては不可能で、誘導ローターによってのみ行うことができる。
連動縦揺れによる航空機推進を得る通常の方法を回避することができる。
代わりに、航空機推進を得る、よりエネルギー効率の良いやり方では、比較的弱い誘導ローター（真の並進運動に関連して）を強力な可変ピッチプロペラに代えられる。
【0056】
本発明の実施形態では、駆動構成部品を有する駆動列(ドライブトレイン)は、可変ピッチプロペラと；胴体取付け部品を備えたシャフト電源供給タービンと；往復運動タービンシャフトと；前方制御部材又は前方制御リングと；前方ローター組立品の駆動構成部品あるいは駆動ディスクと；前方平行羽根と；往復運動支持シャフトを備えた誘導装置あるいは誘導ディスクと；後方平行羽根と；後方ローター組立品の駆動構成部品あるいは駆動ディスクと；後方制御部材又は後方制御リングと；後方ローター組立品の駆動構成部品あるいは駆動ディスクの胴体取付け部品を備えた後方ベアリングシャフト取り入れ孔とから構成され、それにより可変ピッチプロペラが該タービンシャフトの前に置かれ、第１駆動構成部品又は第１駆動ディスクのベアリングシャフトがタービン後方で作動タービンシャフトと連結されている。
この駆動列内のタービンは、その他、なお必要なベアリングシャフト取り入れ孔に代わり、前方駆動構成部品又は後方駆動ディスク用胴体取付け部品に交換する。
【0057】
また、１つの駆動タービンあるいは複数の駆動タービンを胴体内にあるいは胴体に配置でき、そして伝動装置を介して駆動列を推進できる。
この代わりの実施形態では、１つの駆動タービンが２つの横駆動列を前進させることができ、あるいは、２つの駆動タービンを使用するときには、これらの駆動列を伝動装置に連結させて駆動タービンのロスを防止する。
本発明の実施形態において、少なくとも１つの駆動タービンを航空機の胴体に配置できる。
これにより、駆動タービンの保護配置が確保されよう。
【0058】
胴体内の１つの駆動タービンあるいは複数の駆動タービンの配置は、タービンの排気ガスは、胴体から直接ローターにあるいはローター上方に、横から向けられてもよい。
それにより、ローター上及びローターからの自己生成負圧が、タービン排気ガスの流入によって部分的に均衡が取れるようになる。
必要な自己誘導駆動出力が幾分駆動出力の費用を低下させる。
高温タービン排気ガスは、ローター組立品の可能性のある凍結を防止できると同時に、この高温タービン排気ガスは、そのように渦を巻き、他のタービンの全ての他のタービン入口に達することができず、他のタービンの故障を招くように下向きに流される。
【0059】
可変ピッチプロペラは、前向き及び後ろ向き推力双方がそのプロペラ羽根調整により達成できるように、配置する必要があろう。

誘導出力費用を更に下げるために、可変ピッチプロペラ又は単なるプロペラをローター組立品の前方及びその後方の双方に配置できる。
そして、前プロペラをドラフトプロペラとして配置して、後ろプロペラを圧力プロペラとして配置してもよい。
可変ピッチプロペラ又はプロペラ間、例えば、該ドラフトプロペラと圧力プロペラとの間で、２つ以上のローター組立品を互いに前後に配置できる。
【0060】
航空機のホバリング飛行では、２つのプロペラが互いに押し付け合うように該プロペラを上に作動してもよい。
双方のプロペラは、それらの推進効果がそれ自体を相互に補うようにホバリング飛行が調整できるが、ローター組立品、又は、それぞれのローター組立品の付加的空気質量がかかる。
【0061】
プロペラは、トルクを一部補うために使用可能である。ローター組立品の回転及び／又は反応性空気抵抗から生じる残りのトルクをプロペラが略補う。
概して補われないトルクは、例えば唯一の振り制御ローター組立品を使用する場合に生じる（上記参照）。
更に、プロペラ回転は、逆転装置機構によってローター組立品回転の逆方向に回転するように設定可能である。
このトルクの調和が、唯一の駆動列を有する本発明の実施形態に係る小さな航空機には特に関心を引く。
【0062】
本発明の他の実施形態では、ローター組立品を取り付けるか、あるいはローター組立品を吊るす、少なくとも１つのエアフォイル又は補助エアフォイルを胴体に有することができるだろう。
【0063】
発生し、あるいは補正されない空気抵抗から起きるトルクは、従来のヘリコプターに対して有するのと同じ、本発明の実施形態に係る航空機に対して有する重大な効果を有さない。
従来のヘリコプターでは、このトルクを、垂直軸の周りの胴体の連続回転を防止するため、通常、第２ローター、例えば尾部ローターにより、絶対的に補正する必要がある。
本発明の実施形態では、垂直軸の周りのそのようなトルクが発生しない。
対応する複数トルクが胴体の長手方向軸の周りだけで発生し、胴体の横への振り子ぶれを招く。
本発明の実施形態に係る航空機は、従来のヘリコプターより飛行静的に安定である。
【0064】
ローター組立品の長手方向軸が胴体の長手方向軸に対して平行及び／又は同軸向きのため、ヘリコプターの駆動速度の速度成分がヘリコプターの前進運動時にローター経路速度と共に消去される。
この理由は、双方の速度成分が互いに垂直であるためである。
【0065】
従って、本発明の一実施形態に係る航空機は、従来のヘリコプターより高い最大の対気速度を得ることができる。
ターボプロップエンジン航空機の最大対気速度が、本発明の実施形態に係る航空機でも可能である。
また、本発明に係る実施形態の航空機が、そのケースにはない更なる空気抵抗を生じる飛行機尾翼と飛行機主翼を備えていないため、本発明の実施形態に係る航空機が同じ駆動出力を有するターボプロップエンジン航空機より高速で飛行できる期待もある。
本発明に係る実施形態の航空機が、従来のヘリコプターと従来の飛行機の双方の飛行力学を有しており、そのため、ヘリコプター又は飛行機のように飛行することができる（飛

行力学の観点から）。
本発明の実施態様に係る航空機の飛行操作は、対気速度の増加と共に横揺れモーメントの増加が生じないため、従来のヘリコプターよりエネルギー効率が良い。
従って、本発明の実施態様に係る航空機が、序文に明記された従来のヘリコプターの全ての周知の欠点を回避している。
更に、胴体の長手方向軸に平行及び／又は同軸にローター組立品を配置できるため、２つ以上のローター組立品を互いに横に前後して、また、胴体に直ぐに隣接して横に配置できる。
従って、約２００トンの、あるいは２００人より多くの乗員の搭載能力を有する大型胴体構造が可能である。
【0066】
上記利点のため、張出した頭上の搬送用ローターが無いため、本発明の実施形態に係る航空機では、ドッキング操縦や困難な輸送、救助及びサルベージ操縦も可能である。
困難な輸送、救助及びサルベージ操縦のため、輸送品の積み降ろし用に、及び／又は人が航空機へあるいは航空機からの乗り降りを可能にするために、使用できるドッキング用組立品を胴体に備えることができる。
本発明の実施形態では、ドッキング用組立品は、トンネル、橋又はバスケットを備えることができる。
航空機のコックピットの容易観察ドッキング組立品に基づいて、ドッキング組立品を胴体の前方部に配置することができる。
【0067】
本発明に係る航空機には、救助された人、動物あるいは物資が航空機に入れるように使用できる救助管あるいはキャッチボックスを航空機の先端に装備することができよう。
そのことにより、ドッキング後に補助隊あるいは救助隊及び／又は補助物資あるいは救助物資の降下も容易にできる。
これは、例えば、高層ビルで補助隊あるいは救助隊が、安全の理由からエレベーターを使用できず、そのため必要なら階段を使用して多くのフロア間で機器の輸送が強制されるため、大きな利点である。
【0068】
例えば、ビルとの航空機の安全なドッキングに関し、ドッキング用組立品は好適には漏斗状ガイドを備えることができよう。
このタイプのガイドは、ビルに取り付け可能であり、航空機への入口通路としての用途のため航空機に連結するように構成できる。
このことにより、航空機の有利なドッキングを容易にすることができる。
航空機と、ビルやあるいは入口通路との安全な連結に関して、このドッキング用組立品は、ロック機構を備えることができよう。
そのようなロック機構は、例えば、ドッキング用組立品に雄ロック装置部材及び入口通路に雌ロック装置部材を備えることができる。
【0069】
言い換えれば、航空機が、ガイドあるいは入口通路に正確に嵌まるドッキング用組立品、あるいはこの目的のために意図されたロック装置を備えることができる。
これらのガイド、入口通路、あるいはロック装置を、例えば、高いビルの外側にある、例えば、脱出窓、非常ドア、脱出口あるいはその他の形態の非常出口に配置できる。
航空機は、これらの場所にそれ自体をドッキングし、固定し、適切な非常あるいは脱出出口を開け、人、動物あるいは物資を積み、人、動物あるいは物資を積み込んだ状態で出発できる。
【0070】
このドッキング用組立品は、ドッキング用先端を全体的に収容するようになっている漏斗状ガイドを備えることができる。
このドッキング用先端をその雄ロック部材と共に、該漏斗状ガイドにスライドさせると

、該ドッキング用先端が漏斗状ガイドの端部に見える雌ロック部材に誘導できる。
この雌ロック部材は、漏斗状ガイドの端部の入口開口の周囲に、例えば、対称３点配置あるいは４点配置とすることができる。
このロック機構のロック及び／ロック解除は、本発明の航空機により電気機械的に、あるいは連結ロッドを介して機械的に操作することができよう。
該ロック装置は、例えば、フックロック、普及ロック装置、チャンネルロック、ボルトロック、あるいは、例えばローラー、ピン、又はフォークロックの形態の横ロッドロックでよい。
【0071】
この漏斗状ガイドの入口通路は、外側から開けることができる、ハッチ、ドア、あるいは窓ガラスによって閉鎖することが可能である。
ビルの前面と共にビルの外側を拘束してロックし、従って視覚的に不快でないように、この漏斗状ガイドをビルの内側に移すことができよう。
高層ビルでは、そのようなガイドは、例えば、ビルの全側面に設置でき、例えば、所定のフロア数毎に設置できよう。
同様に、この漏斗状ガイドを固定あるいは回転可能なアームに取り付け可能である。
そのような装置の１つは、例えば、沖合掘削用プラットフォーム、採鉱プラットフォーム、製造プラントあるいは海上の大型船により好適であろう。
人あるいは物資の通常の輸送のために、これらのガイドは、高いビル又は空港ターミナルとしてのタワーでの利用に同様に供されよう。
【0072】
本発明に係る航空機の上記技術的利点は、従来の民間及び軍用飛行操作に関して、結果として経済的、論理学的及び戦略的利点となる。
本発明に係る航空機が、中間あるいは中距離あるいは長距離航空機と同じ飛行重量又は同じ乗員数を輸送し、比較的高い対気速度及び距離を示すため、本発明に係る航空機が中間距離及び長距離航空機飛行の領域で実際的な競合航空機として機能するはずであると同時に、環境に優しく、経済的で論理学的利点を提供する。
本発明に係る航空機は、実際の高さから垂直下降飛行により滑走路に着陸することができ、このように離陸もできる。
これにより、滑走路近隣で従来の飛行機の周知の騒音公害が回避される。
【0073】
本発明に係る航空機は、例えば、広大な飛行機滑走路を備えた飛行場のようなコストのかかるインフラを必要としない。
従って、本発明に係る航空機に関連するコストが低減され、都市に空港がなくとも、該航空機はいかなる所望の都市やその都市の中心までも直接飛行することができる。
航空路のネットワークを最小のインフラで作ることができる。
これは、従来の空港を含むインフラを作る手段を持たない田舎の経済的発展に、特に、好ましい。
【0074】
長距離飛行運行（例えば、海洋を渡って）では、本発明に係る航空機が、従来の飛行機と違い、メンテナンス、燃料補給のため、あるいは、緊急着陸のために海上の母船に着陸できる。
本発明の航空機は、水上又は陸上を低速で緊急着陸でき、水ベースの緊急着陸に関連する飛行機の通常の破壊、あるいは、陸への強制着陸に関連する飛行機の頻繁に生じる破壊を防止できる。
本発明の航空機は、従来の中距離及び長距離飛行機より安全である。
【0075】
本発明の航空機の高搭載量、操縦性及びドッキング性のために、従来のヘリコプターでは可能でないサルベージ及び救助活動を行うことができる。
本発明で、ニューヨークの世界貿易センターへの攻撃の犠牲者を当時近づけないビルの

フロアから救助できたであろう。
　本発明で、供給あるいは避難危機あるいは被災地を現在利用できる輸送手段より良好に高速で実施できる。
【0076】
　軍事用途において、本発明の航空機は、新規で効果的な作業及び戦略を可能にする。
　例えば、船及び／又は大きな飛行機及び／又は陸上輸送を使用する大きな材料あるいは軍隊移動を、本発明に係る航空機で軍事的目標領域への直接輸送により早く行うことができよう。
　本発明の航空機によって可能になった時間とお金の節約は、軍事戦略に非常に重要である。
　例えば、軍事活動の枠組みでは、飛行場の占有、確保が必要ではないだろう。
　公海上のどの地点でも、供給船を待ちあるいは該供給船とのクロスオーバーを開始する必要も無く、高い遠洋大型船を供給できる。
【0077】
　好ましい方法で本発明の教示を適用し、該教示について詳しく説明する様々な可能性がある。
　この目的のため、一方で特許請求の範囲と、他方で図面を考慮して本発明に係る航空機の以下の実施例の説明を参照する。
　本発明の航空機の好ましい実施形態の説明に関連して、一般的に好ましい実施形態とこの教示の他の態様を図面に関して説明する。
【発明を実施するための最良の形態】
【0078】
　図１は、本発明に係る航空機の第１の典型的な実施形態を概略正面図、裏面図、上面図及び側面図で示している。
　この航空機は、胴体１と、この胴体１に連結された設定可能な揚力を発生させるための推進装置２とを備えている。
　この推進装置２は、旋回軸４の周りに所定の羽根角に回転可能な複数の回転羽根３を備えている。
　この回転羽根３は、回転軸５の周りに回転させるために取り付けられており、回転羽根角が揚力発生のために回転時に変えることができる。
　更に、回転羽根３のそれぞれの旋回軸４が回転軸５に略平行に配置されている。
　この回転羽根３の旋回軸４は、互いに略平行に配置されている。
【0079】
　更に、旋回軸４は、互いに等距離に配置され、回転軸５から等距離に配置されている。
　複数の回転羽根３は、それらの旋回軸４を介して駆動構成部品７に一端で回転可能に取り付けられているか、この駆動構成部品７内に回転可能に装着されている。
　各回転羽根３は、該回転羽根３を旋回軸４の周りに回転させるためのアタック点として制御シャフト６を備えている。
　前記駆動構成部品７は、ベアリングシャフト８を備えている。
　ここに図示された典型的な実施形態では、回転羽根３が複数の回転軸５の１つの周りにそれぞれ回転可能なローター組立品１５を形成し、それにより推進装置２がそのような４つのローター組立品１５の合計で構成されている。
　２つのローター組立品１５が、胴体１の各長手方向側面に配置されている。
　それにより、回転軸５が、ローター組立品１５に対向して位置合わせされている。
【0080】
　図２は、本発明に係る航空機の第２の典型的実施形態の概略正面図、裏面図、上面図及び側面図を示している。
　この典型的な実施形態では、ローター組立品１５が、前進飛行方向に延びる胴体１の長手方向軸に平行に配置されている。
　複数のローター組立品１５の複数の回転羽根３は、振り制御され、制御シャフトを制御

するために両端に制御部材を備えている。

前進あるいは後退運動のために、誘導装置１６に隣接して誘導ローター１７が配置されている。

この誘導ローター１７は、ローター羽根１８から成っている。

ここに示した実施形態は、２つの波形実現駆動タービンが、頭上に配置されている。

【0081】

図３は、図２に示された航空機の典型的な実施形態の概略正面図、上面図及び側面図を示しており、この図では、ドッキング用組立品１９が荷物の積み込みあるいは積み降ろしのため又は人の乗り降りのために胴体１に取り付けられている。

このドッキング用組立品１９は、脱出管として設計されている。

図４は、回転羽根３の断面形の概略図を示している。

旋回軸４が片側に認められ、制御シャフト６が他方の側に認められる。

【0082】

図５は、ベアリングシャフト８を備える駆動ディスクとして設計された駆動構成部品７の概略平面図を示している。

駆動、回転羽根３の旋回軸４を収容するための通路９を備えている。

更に、この駆動構成部品７は、回転羽根３の制御シャフト６の通路１０を備えている。

通路１０が湾曲した細長い孔として設計されている。

駆動構成部品７は、重量節約のための通路１１を特徴とする。

【0083】

図６は、回転羽根３の制御シャフト６を制御するための制御リングの外側端部の領域内に走る環状溝１４を有する制御リングの形態にある制御部材１２の平面図である。

この制御部材１２は、偏心ディスクガイドの形態にあるガイド内で移動可能である。

これにより、回転軸５に対し制御部材１２の運動が容易となる。

１つの典型的な実施形態では、制御部材１２が駆動構成部品７に平行に配置され、回転羽根３の制御シャフト６が駆動構成部品７の通路１０を通して延び、制御部材１２の環状溝１４に達する。

【0084】

図７は、ローター組立品１５の後方に配置された該ローター組立品１５の制御部材１２と共に駆動構成部品７の配置の概略平面図を示している。

この制御部材１２は、破線でしかもその外側境界域でのみ示されているだけである。

図７の制御部材１２は、推力と空気流が回転羽根３で発生しないその中立位置にある。

回転羽根３の断面形状が回転軸５の方に凹状に湾曲している。

この回転羽根３は、回転羽根３の湾曲部で作られる架空の円形円筒内に基本的に配置されている。

【0085】

図８では、制御部材１２が、ガイドにより回転軸５に対してずらされている。

推力が推力方向２０に生じている。

制御部材１２によって、制御部材１２に対する駆動構成部品７の１回転時に、回転羽根３が該回転羽根の極端な偏り間でフェザリングする、図８の周期的羽根調整の原理を認めることができる。

この回転羽根３の２つの極端な偏り位置が、回転軸５を走る線上に実際には配置され、そして推力方向２０で規定される。

この位置が９０°動くと、回転羽根３が再度その中立位置になり、推力又は空気流を生じない。

図８に示された典型的な実施形態の回転羽根３の回転方向は、時計回りである。

【0086】

図９は、胴体１と共に、この発明に係る航空機の他の典型的な実施形態の概略側面図を示しており、この図では、ドラフトプロペラ２１がローター組立品１５の前に配置され、圧力プロペラ２２がローター組立品１５の後方に配置されている。

更に、タービン出口２３が、ローター組立品１５に隣接して配置されている。
【0087】
図１０は、図９からの典型的な実施形態の概略正面及び裏面図を示しており、翼２４又は補助翼２４が胴体１に隣接して配置されている。
ローター組立品１５が、翼２４に取り付けられあるいは該翼２４から下げられている。
このドラフトプロペラ２１は、ローター組立品１５の前に配置され、圧力プロペラ２２は、ローター組立品１５の後方に配置されている。
【0088】
この発明の航空機の典型的な実施形態に関して、一般的な説明部分の繰り返しを避けるため、特許請求の範囲を参照することができる。
最後に、本発明に係る航空機の実施例が請求装置の議論の目的にだけ使用される。
しかし、これらの実施例は限定するものとは見なすべきではない。
【図面の簡単な説明】
【0089】
【図1】本発明に係る航空機の第１実施形態の概略正面図、裏面図、上面図及び側面図。
【図2】本発明に係る航空機の第２実施形態の概略正面図、裏面図、上面図及び側面図。
【図3】胴体の前面部に配置されたドッキング用組立品を備えた図２の航空機の概略正面図、上面図及び側面図。
【図4】推進装置の回転羽根の概略断面。
【図5】該回転羽根用駆動ディスクの平面図。
【図6】円形環状溝及び偏心ディスクガイドを備えた制御リングの平面図。
【図7】中立位置に（破線で）示された該制御リングを備えた駆動ディスクの平面図。
【図8】推力が矢印方向にかかる作動位置に（破線で）示された該制御リングを備えた駆動ディスクの平面図。
【図9】本発明に係る航空機の他の典型的実施形態の概略側面図。
【図10】図９の典型的な実施形態の概略正面図及び裏面図。
【符号の説明】
【0090】
１　・・・　胴体
２　・・・　推進装置
３　・・・　回転羽根
４　・・・　旋回軸
５　・・・　回転軸
６　・・・　制御シャフト
７　・・・　駆動構成部品
８　・・・　ベアリングシャフト
９，１０，１１　・・・　通路
１２　・・・　制御部材
１３　・・・　二重偏心ディスク制御部材
１４　・・・　環状溝
１５　・・・　ローター、ローター組立品
１６　・・・　誘導装置
１７　・・・　誘導ローター
１８　・・・　ローター羽根
１９　・・・　ドッキング用組立品
２０　・・・　推力方向
２１　・・・　ドラフトプロペラ
２２　・・・　圧力プロペラ
２３　・・・　タービン出口
２４　・・・　翼

【図1】

【図2】

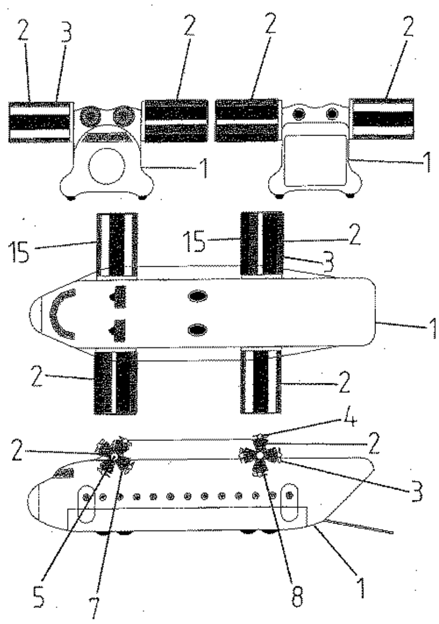


Fig. 1

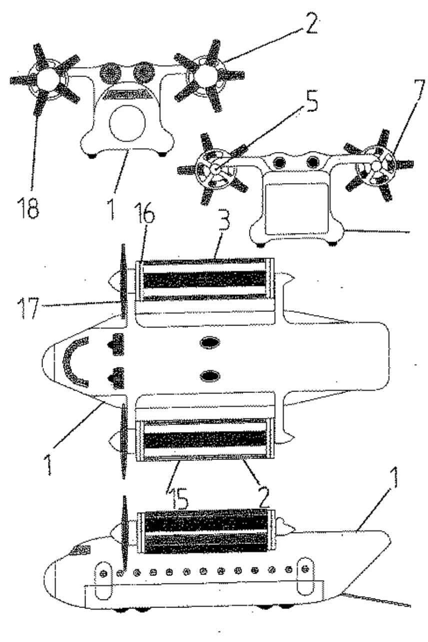


Fig. 2

【図3】

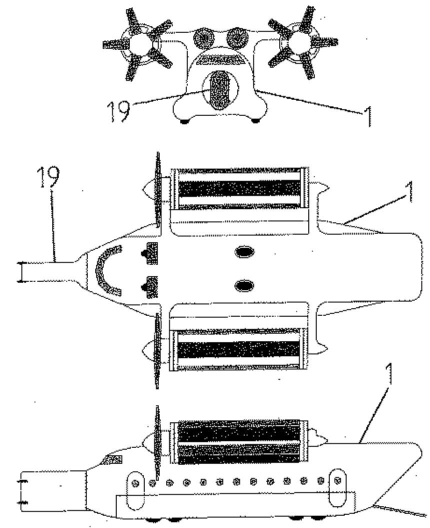


Fig. 3

【図4】

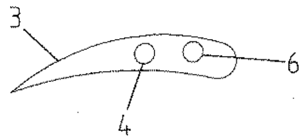


Fig. 4

【図5】

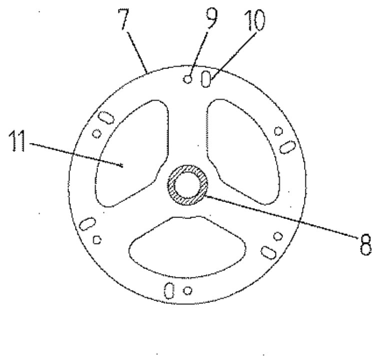


Fig. 5

【図6】

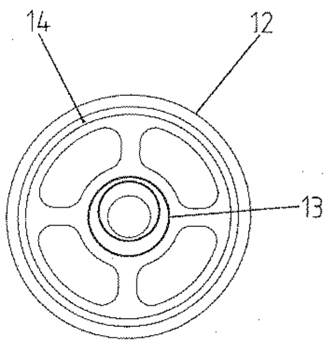


Fig. 6

【図7】

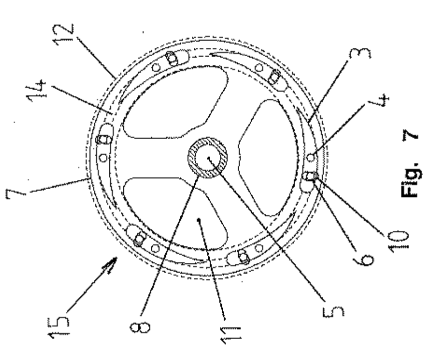


Fig. 7

【図8】

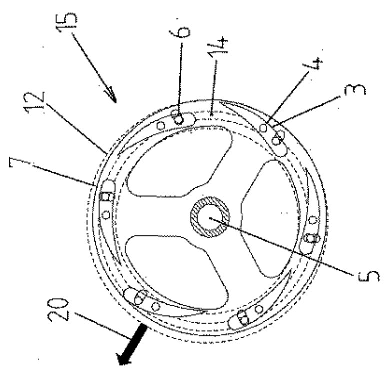


Fig. 8

【図9】

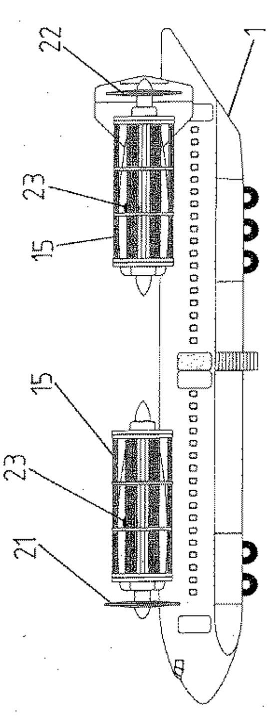


Fig. 9

【図10】

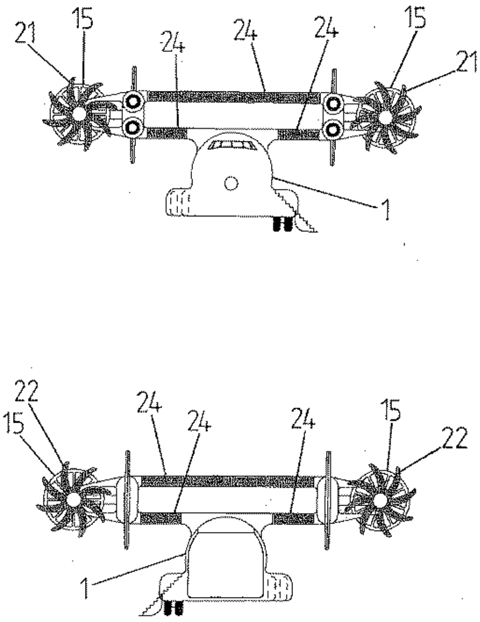


Fig. 10

【手続補正書】
【提出日】平成18年1月19日(2006.1.19)
【手続補正1】
【補正対象書類名】特許請求の範囲
【補正対象項目名】全文
【補正方法】変更
【補正の内容】
【特許請求の範囲】
【請求項1】
胴体（１）と、設定可能な揚力の発生のため該胴体（１）と連結された推進装置（２）とを備えて、該推進装置（２）が複数の回転羽根（３）から構成され、前記回転羽根（３）が旋回軸（４）の周りを所定の回転羽根角まで旋回可能なように且つ回転軸（５）の周りで回転可能なように取り付けられ、回転羽根角が揚力を発生させるための回転中に調整可能であり、該回転羽根（３）のそれぞれの旋回軸（４）が回転軸（５）に略平行に配置され、複数の前記回転羽根（３）が前記複数の回転軸（５）の１つの軸の周りに回転可能なローター組立品（１５）を形成し、それにより前記推進装置（２）が少なくとも２つのそのようなローター組立品（１５）を備えている航空機において、
前記ローター組立品（１５）の前方と該ローター組立品（１５）の後方の双方に、可変ピッチプロペラ又はプロペラ（２１，２２）が配置されていることを特徴とする航空機。
【請求項2】
前記回転羽根（３）のそれぞれの旋回軸（４）が、互いに略等距離で配置されていることを特徴とする請求項１に記載の航空機。
【請求項3】
前記回転羽根（３）の旋回軸（４）が、前記回転軸（５）まで略同じ距離に配置されていることを特徴とする請求項１又は請求項２に記載の航空機。

【請求項4】
前記回転羽根（３）の旋回軸（４）が互いに略平行に配置されていることを特徴とする請求項１ないし請求項３のいずれか１項に記載の航空機。
【請求項5】
前記それぞれの回転羽根（３）が、該回転羽根（３）の重心を通過するように配置されていることを特徴とする請求項１ないし請求項４のいずれか１項に記載の航空機。
【請求項6】
前記回転羽根（３）の断面形状が、前記回転軸（５）の方へ凹状に湾曲していることを特徴とする請求項１ないし請求項５のいずれか１項に記載の航空機。
【請求項7】
前記回転羽根（３）が、前記旋回軸（４）の周りに回転羽根（３）を回転させるために接触点として機能する少なくとも一端に制御シャフト（６）を備えることを特徴とする請求項１ないし請求項６のいずれか１項に記載の航空機。
【請求項8】
前記回転羽根（３）が、前記駆動構成部品（７）に隣接するか、あるいは、駆動構成部品（７）の内部の一端に回転可能に取り付けられていることを特徴とする請求項１ないし請求項７のいずれか１項に記載の航空機。
【請求項9】
前記駆動構成部品（７）が、前記回転軸（５）の周りを回転可能であり、あるいは、回転軸（５）に取り付けられていることを特徴とする請求項８に記載の航空機。
【請求項10】
前記駆動構成部品（７）が、ベアリングシャフト（８）あるいは中空シャフトを備えていることを特徴とする請求項８又は請求項９に記載の航空機。
【請求項11】
前記駆動構成部品（７）が駆動プーリー、駆動ディスクあるいは駆動リングであることを特徴とする請求項８ないし請求項１０のいずれか１項に記載の航空機。
【請求項12】
前記旋回軸（４）が、前記駆動構成部品（７）あるいは前記駆動プーリーあるいは前記駆動ディスクの端部にあるいは前記駆動リングの端部に円形で配置されていることを特徴とする請求項８ないし請求項１１のいずれか１項に記載の航空機。
【請求項13】
前記駆動構成部品（７）が、前記回転羽根（３）の旋回軸（４）を収容するための窪みあるいは通路（９）を備えていることを特徴とする請求項８ないし請求項１２のいずれか１項に記載の航空機。
【請求項14】
前記駆動構成部品（７）が、前記回転羽根（３）の制御シャフト（６）用の窪みあるいは通路（１０）を備えていることを特徴とする請求項８ないし請求項１３のいずれか１項に記載の航空機。
【請求項15】
前記回転羽根（３）の制御シャフト（６）用の窪みあるいは通路（１０）が、長い好適には湾曲した孔として構成されていることを特徴とする請求項１４に記載の航空機。
【請求項16】
前記駆動構成部品（７）が、溝、切欠きあるいは通路（１１）を備えていることを特徴とする請求項８ないし請求項１５のいずれか１項に記載の航空機。
【請求項17】
前記駆動構成部品（７）が、制御部材（１２）と共に作動して、旋回軸（４）の周りに前記回転羽根（３）を調整することを特徴とする請求項８ないし請求項１６のいずれか１項に記載の航空機。
【請求項18】
前記制御部材（１２）が、前記回転羽根（３）及び／又は駆動構成部品（７）の回転に

よって係合解除されることを特徴とする請求項１７に記載の航空機。
【請求項19】
前記制御部材（１２）が、回転軸（５）に取り付けられていることを特徴とする請求項１７又は請求項１８に記載の航空機。
【請求項20】
前記制御部材（１２）が、周期的ギアを備えていることを特徴とする請求項１７ないし請求項１９のいずれか１項に記載の航空機。
【請求項21】
前記制御部材（１２）が、前記回転軸（５）に対しガイド内で移動可能であることを特徴とする請求項１７ないし請求項２０のいずれか１項に記載の航空機。
【請求項22】
前記ガイドが、２つの垂直配置直線ガイドをクロステーブル案内の形態で備えていることを特徴とする請求項２１に記載の航空機。
【請求項23】
前記ガイドが、直線ガイドに接続されている回転ガイドを張出し可能で旋回可能なガイドの形態で備えていることを特徴とする請求項２１に記載の航空機。
【請求項24】
前記ガイドが、二重偏心ディスク制御部材（１３）の形態で２つの回転制御部を備えていることを特徴とする請求項２１に記載の航空機。
【請求項25】
前記二重偏心ディスク制御部材（１３）の２つの偏心ディスクの各々が、互いにアクチュエーターとそれぞれ連携することを特徴とする請求項２４に記載の航空機。
【請求項26】
前記制御部材（１２）が、前記回転羽根（３）の制御シャフト（６）を収容するための環状溝（１４）あるいは円形溝を備えていることを特徴とする請求項１７ないし請求項２５のいずれか１項に記載の航空機。
【請求項27】
前記制御部材（１２）が、制御リングあるいは制御ディスクであることを特徴とする請求項１７ないし請求項２６のいずれか１項に記載の航空機。
【請求項28】
前記環状溝（１４）又は前記制御リングが、非円形部を備えていることを特徴とする請求項２６又は請求項２７に記載の航空機。
【請求項29】
前記非円形部が、回転角に依存する入射角関数を提供し、あるいは重ね合わせ入射角関数を提供することを特徴とする請求項２８に記載の航空機。
【請求項30】
前記入射角関数が、式$a-\cos(x)^{w}$、この式で「ａ」は回転羽根（３）の入射角度であり、「ｗ」は好適には全体数、好適には１１である該式に比例していることを特徴とする請求項２９に記載の航空機。
【請求項31】
前記駆動構成部品（７）のベアリングシャフト（８）あるいは中空シャフトが、前記制御部材（１２）を中心で作動するように構成されていることを特徴とする請求項１７ないし請求項３０のいずれか１項に記載の航空機。
【請求項32】
前記駆動構成部品（７）及び前記制御部材（１２）が、互いに平行に配置されていることを特徴とする請求項１７ないし請求項３１のいずれか１項に記載の航空機。
【請求項33】
前記駆動装置（２）が、１つの回転軸（５）の周りを回転可能な回転羽根（３）の少なくとも２つの配置を備えていることを特徴とする請求項1ないし請求項３２のいずれか１項に記載の航空機。

【請求項34】
前記１つの回転軸（５）又は複数の回転軸（５）が、略平行面に配置されていることを特徴とする請求項１ないし請求項３３のいずれか１項に記載の航空機。
【請求項35】
前記１つの回転軸（５）又は複数の回転軸（５）が、胴体（１）の前進飛行方向の長手方向軸に平行に配置されていることを特徴とする請求項１ないし請求項３４のいずれか１項に記載の航空機。
【請求項36】
前記１つの回転軸（５）又は複数の回転軸（５）が、胴体（１）の前進飛行方向の長手方向軸に垂直に配置されていることを特徴とする請求項１ないし請求項３４のいずれか１項に記載の航空機。
【請求項37】
前記複数のローター（１５）が、長手方向軸に並行して交互配置されていることを特徴とする請求項３６に記載の航空機。
【請求項38】
前記少なくとも１つのローター（１５）が、各々の胴体（１）長手方向側面に配置されていることを特徴とする請求項１ないし請求項３７のいずれか１項に記載の航空機。
【請求項39】
前記少なくとも２つのローター（１５）が、互いに逆方向に回転することを特徴とする請求項１ないし請求項３８のいずれか１項に記載の航空機。
【請求項40】
前記少なくとも２つのローター（１５）が、前記胴体（１）の各々長手方向側面に配置されており、前記航空機のそれぞれ長手方向側面の対応するローター（１５）の回転軸（５）が整合していることを特徴とする請求項１ないし請求項３９のいずれか１項に記載の航空機。
【請求項41】
前記ローター（１５）が、個別に制御可能であることを特徴とする請求項１ないし請求項４０のいずれか１項に記載の航空機。
【請求項42】
前記複数のローター（１５）が、同じ方法で一緒に制御可能であることを特徴とする請求項１ないし請求項４１のいずれか１項に記載の航空機。
【請求項43】
前記複数の回転羽根（３）が、１つの旋回軸（４）によって、前記駆動構成部品（７）から離れた回転羽根（３）の端部に誘導装置（１６）であるいは誘導装置（１６）の内部でフェザリング可能に取り付けられていることを特徴とする請求項１ないし請求項４２のいずれか１項に記載の航空機。
【請求項44】
前記誘導装置（１６）が、ディスク状の駆動構成部品（７）と略同じ形態であることを特徴とする請求項４３に記載の航空機。
【請求項45】
前記誘導装置（１６）が、前記駆動構成部品（７）で回転するように配置されていることを特徴とする請求項４３又は請求項４４に記載の航空機。
【請求項46】
前記誘導装置（１６）及び駆動構成部品（７）が、軸又は回転軸（５）によって連結されていることを特徴とする請求項４３ないし請求項４５のいずれか１項に記載の航空機。
【請求項47】
前記誘導装置（１６）が、複数のローター羽根（１８）から成る誘導ローター（１７）と関連していることを特徴とする請求項４３ないし請求項４６のいずれか１項に記載の航空機。
【請求項48】

前記複数のローター羽根（１８）が、前記誘導装置（１６）に連動していることを特徴とする請求項４７に記載の航空機。
【請求項49】
前記誘導ローター（１７）が、前記回転軸（５）を通る連結装置の周りで推進されることを特徴とする請求項４７又は請求項４８に記載の航空機。
【請求項50】
互いに隣接してあるいは前後に配置される複数の回転羽根（３）又はローター（１５）が、実際にはミラー配置で配置されることを特徴とする請求項１ないし請求項４９のいずれか１項に記載の航空機。
【請求項51】
前記制御部材（１２）が、前記回転羽根（３）の両端で他の制御部材（１２）の各々から独立して作動可能であることを特徴とする請求項１７ないし請求項５０のいずれか１項に記載の航空機。
【請求項52】
前記航空機の胴体（１）に、少なくとも１つの駆動タービンが配置されていることを特徴とする請求項１ないし請求項５２のいずれか１項に記載の航空機。
【請求項53】
タービン排気ガスが、前記胴体（１）から直接ローター（１５）の方へあるいはその上方へ横に向けられることを特徴とする請求項５２に記載の航空機。
【請求項54】
前記可変ピッチプロペラ間又はプロペラ（２１，２２）間に２つ以上のローター組立品（１５）が、前後に配置されていることを特徴とする請求項１ないし請求項５３のいずれか１項に記載の航空機。
【請求項55】
前記胴体（１）に、翼又は補助翼が隣接して取り付けられ、１つのローター組立品（１５）又は複数のローター組立品（１５）が、前記翼又は補助翼に取り付けられているか、それら翼から下げられていることを特徴とする請求項１ないし請求項５４のいずれか１項に記載の航空機。

INTERNATIONAL SEARCH REPORT

International Application No
PCT/DE2004/002520

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B64C39/00 B64C1/22 B64D1/22 B64C11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B64C A62B B64D B64G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 007 021 A (TSEPENYUK ET AL) 28 December 1999 (1999-12-28) the whole document	1-57
Y	-----	58-60
X	US 2 037 377 A (GARDNER ALBERT B) 14 April 1936 (1936-04-14) the whole document	1-57
Y	-----	58-60
X	US 2 507 657 A (WIESSLER GASTON ANTOINE AUGUSTE) 16 May 1950 (1950-05-16) the whole document	1-57
Y	-----	58-60
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 August 2005	19. 10. 05

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Pedersen, K

INTERNATIONAL SEARCH REPORT

International Application No
PCT/DE2004/002520

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	GB 747 172 A (CHARLES FREDERICK BYRON POWLEY) 28 March 1956 (1956-03-28) the whole document	1-57 58-60
X	US 1 761 053 A (RYSTEDT INGEMAR K) 3 June 1930 (1930-06-03) the whole document	1-57
X Y	US 5 265 827 A (GERHARDT ET AL) 30 November 1993 (1993-11-30) the whole document	1-57 58-60
X Y	DE 101 07 515 A1 (HOYER, RALF) 5 September 2002 (2002-09-05) the whole document	1-57 58-60
X,P	EP 1 394 039 A (LOSI, BRUNO) 3 March 2004 (2004-03-03) the whole document	1-57
Y	US 4 588 148 A (KRAUCHICK ET AL) 13 May 1986 (1986-05-13) the whole document	58-60
Y	US 5 375 795 A (STRUNK ET AL) 27 December 1994 (1994-12-27) the whole document	58-60
A	US 4 860 975 A (SCHLIESING ET AL) 29 August 1989 (1989-08-29) the whole document	58-62
A	US 4 235 399 A (SHOREY, THOMAS H) 25 November 1980 (1980-11-25) the whole document	58-60
A	US 5 906 336 A (ECKSTEIN ET AL) 25 May 1999 (1999-05-25) the whole document	61

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DE2004/002520

Box I　Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II　Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See the Supplemental Sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest
☐ The additional search fees were accompanied by the applicant's protest.
☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DE2004/002520

Continuation of Box III

The International Searching Authority has found that the international application contains multiple (groups of) inventions, as follows:

1. Claims 1-57:

   an aircraft with a propulsion device consisting of wing blades which are mounted in such a way that they can rotate about an axis of rotation, the blade angle of each wing blade being displaceable about a pivotal axis that is substantially parallel to the axis of rotation (claim 1); arrangements and details of said propulsion device(s) (claims 2-57).

2. Claims 1 and 58-62:

   an aircraft with a propulsion device consisting of wing blades which are mounted in such a way that they can rotate about an axis of rotation, the blade angle of each wing blade being displaceable about a pivotal axis that is substantially parallel to the axis of rotation (claim 1); arrangement and details of a docking system for use in the transport of passengers or freight (claims 58-62).

INTERNATIONAL SEARCH REPORT
Information on patent family members

International Application No
PCT/DE2004/002520

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 6007021	A	28-12-1999	NONE		
US 2037377	A	14-04-1936	US	1975098 A	02-10-1934
US 2507657	A	16-05-1950	NONE		
GB 747172	A	28-03-1956	NONE		
US 1761053	A	03-06-1930	NONE		
US 5265827	A	30-11-1993	NONE		
DE 10107515	A1	05-09-2002	NONE		
EP 1394039	A	03-03-2004	EP	1394039 A1	03-03-2004
US 4588148	A	13-05-1986	NONE		
US 5375795	A	27-12-1994	NONE		
US 4860975	A	29-08-1989	NONE		
US 4235399	A	25-11-1980	NONE		
US 5906336	A	25-05-1999	NONE		

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/DE2004/002520

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
IPK 7 B64C39/00 B64C1/22 B64D1/22 B64C11/00

Nach der Internationalen Patentklassifikation (IPK) oder nach der nationalen Klassifikation und der IPK

B. RECHERCHIERTE GEBIETE
Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
IPK 7 B64C A62B B64D B64G

Recherchierte aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

Während der internationalen Recherche konsultierte elektronische Datenbank (Name der Datenbank und evtl. verwendete Suchbegriffe)

EPO-Internal

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie°	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	US 6 007 021 A (TSEPENYUK ET AL) 28. Dezember 1999 (1999-12-28) das ganze Dokument	1-57
Y		58-60
X	US 2 037 377 A (GARDNER ALBERT B) 14. April 1936 (1936-04-14) das ganze Dokument	1-57
Y		58-60
X	US 2 507 657 A (WIESSLER GASTON ANTOINE AUGUSTE) 16. Mai 1950 (1950-05-16) das ganze Dokument	1-57
Y		58-60

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[X] Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen

[X] Siehe Anhang Patentfamilie

° Besondere Kategorien von angegebenen Veröffentlichungen :
"A" Veröffentlichung, die den allgemeinen Stand der Technik definiert, aber nicht als besonders bedeutsam anzusehen ist
"E" älteres Dokument, das jedoch erst am oder nach dem internationalen Anmeldedatum veröffentlicht worden ist
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"O" Veröffentlichung, die sich auf eine mündliche Offenbarung, eine Benutzung, eine Ausstellung oder andere Maßnahmen bezieht
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"X" Veröffentlichung von besonderer Bedeutung; die beanspruchte Erfindung kann allein aufgrund dieser Veröffentlichung nicht als neu oder auf erfinderischer Tätigkeit beruhend betrachtet werden
"Y" Veröffentlichung von besonderer Bedeutung; die beanspruchte Erfindung kann nicht als auf erfinderischer Tätigkeit beruhend betrachtet werden, wenn die Veröffentlichung mit einer oder mehreren anderen Veröffentlichungen dieser Kategorie in Verbindung gebracht wird und diese Verbindung für einen Fachmann naheliegend ist
"&" Veröffentlichung, die Mitglied derselben Patentfamilie ist

Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
29. August 2005	19. 10. 05
Name und Postanschrift der Internationalen Recherchenbehörde	**Bevollmächtigter Bediensteter**
Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Pedersen, K

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/DE2004/002520

C.(Fortsetzung) ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie°	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	GB 747 172 A (CHARLES FREDERICK BYRON POWLEY) 28. März 1956 (1956-03-28) das ganze Dokument	1-57
Y		58-60
X	US 1 761 053 A (RYSTEDT INGEMAR K) 3. Juni 1930 (1930-06-03) das ganze Dokument	1-57
X	US 5 265 827 A (GERHARDT ET AL) 30. November 1993 (1993-11-30) das ganze Dokument	1-57
Y		58-60
X	DE 101 07 515 A1 (HOYER, RALF) 5. September 2002 (2002-09-05) das ganze Dokument	1-57
Y		58-60
X,P	EP 1 394 039 A (LOSI, BRUNO) 3. März 2004 (2004-03-03) das ganze Dokument	1-57
Y	US 4 588 148 A (KRAUCHICK ET AL) 13. Mai 1986 (1986-05-13) das ganze Dokument	58-60
Y	US 5 375 795 A (STRUNK ET AL) 27. Dezember 1994 (1994-12-27) das ganze Dokument	58-60
A	US 4 860 975 A (SCHLIESING ET AL) 29. August 1989 (1989-08-29) das ganze Dokument	58-62
A	US 4 235 399 A (SHOREY, THOMAS H) 25. November 1980 (1980-11-25) das ganze Dokument	58-60
A	US 5 906 336 A (ECKSTEIN ET AL) 25. Mai 1999 (1999-05-25) das ganze Dokument	61

INTERNATIONALER RECHERCHENBERICHT

nationales Aktenzeichen
PCT/DE2004/002520

Feld II Bemerkungen zu den Ansprüchen, die sich als nicht recherchierbar erwiesen haben (Fortsetzung von Punkt 2 auf Blatt 1)

Gemäß Artikel 17(2)a) wurde aus folgenden Gründen für bestimmte Ansprüche kein Recherchenbericht erstellt:

1. [ ] Ansprüche Nr.
weil sie sich auf Gegenstände beziehen, zu deren Recherche die Behörde nicht verpflichtet ist, nämlich

2. [ ] Ansprüche Nr.
weil sie sich auf Teile der internationalen Anmeldung beziehen, die den vorgeschriebenen Anforderungen so wenig entsprechen, daß eine sinnvolle internationale Recherche nicht durchgeführt werden kann, nämlich

3. [ ] Ansprüche Nr.
weil es sich dabei um abhängige Ansprüche handelt, die nicht entsprechend Satz 2 und 3 der Regel 6.4 a) abgefaßt sind.

Feld III Bemerkungen bei mangelnder Einheitlichkeit der Erfindung (Fortsetzung von Punkt 3 auf Blatt 1)

Die Internationale Recherchenbehörde hat festgestellt, daß diese internationale Anmeldung mehrere Erfindungen enthält:

siehe Zusatzblatt

1. [X] Da der Anmelder alle erforderlichen zusätzlichen Recherchengebühren rechtzeitig entrichtet hat, erstreckt sich dieser internationale Recherchenbericht auf alle recherchierbaren Ansprüche.

2. [ ] Da für alle recherchierbaren Ansprüche die Recherche ohne einen Arbeitsaufwand durchgeführt werden konnte, der eine zusätzliche Recherchengebühr gerechtfertigt hätte, hat die Behörde nicht zur Zahlung einer solchen Gebühr aufgefordert.

3. [ ] Da der Anmelder nur einige der erforderlichen zusätzlichen Recherchengebühren rechtzeitig entrichtet hat, erstreckt sich dieser internationale Recherchenbericht nur auf die Ansprüche, für die Gebühren entrichtet worden sind, nämlich auf die Ansprüche Nr.

4. [ ] Der Anmelder hat die erforderlichen zusätzlichen Recherchengebühren nicht rechtzeitig entrichtet. Der internationale Recherchenbericht beschränkt sich daher auf die in den Ansprüchen zuerst erwähnte Erfindung; diese ist in folgenden Ansprüchen erfaßt:

Bemerkungen hinsichtlich eines Widerspruchs

[ ] Die zusätzlichen Gebühren wurden vom Anmelder unter Widerspruch gezahlt.

[X] Die Zahlung zusätzlicher Recherchengebühren erfolgte ohne Widerspruch.

Internationales Aktenzeichen PCT/ DE2004/ 002520

WEITERE ANGABEN PCT/ISA/ 210

Die internationale Recherchenbehörde hat festgestellt, dass diese internationale Anmeldung mehrere (Gruppen von) Erfindungen enthält, nämlich:

1. Ansprüche: 1-57

   Luftfahrzeug mit einer Antriebseinrichtung bestehend aus Flügelblätter, die um eine Rotationsachse drehbar gelagert sind, wobei deren jeweiliger Blattwinkel um eine Schwenkachse verstellbar ist, die zur Rotationsachse ist (Anspruch 1). Anordnungen und Details der Antriebseinrichtun(en) (Ansprüche 2-57)

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2. Ansprüche: 1, 58-62

   Luftfahrzeug mit einer Antriebseinrichtung bestehend aus Flügelblätter, die um eine Rotationsachse drehbar gelagert sind, wobei deren jeweiliger Blattwinkel um eine Schwenkachse verstellbar ist, die zur Rotationsachse ist (Anspruch 1). Anordnung und Details von einer Andockeinrichtung für Passagiere und Transport (Ansprüche 58-62)

INTERNATIONALER RECHERCHENBERICHT

Angaben zu Veröffentlichungen, die zur selben Patentfamilie gehören

Internationales Aktenzeichen
PCT/DE2004/002520

Im Recherchenbericht angeführtes Patentdokument	Datum der Veröffentlichung	Mitglied(er) der Patentfamilie	Datum der Veröffentlichung
US 6007021 A	28-12-1999	KEINE	
US 2037377 A	14-04-1936	US 1975098 A	02-10-1934
US 2507657 A	16-05-1950	KEINE	
GB 747172 A	28-03-1956	KEINE	
US 1761053 A	03-06-1930	KEINE	
US 5265827 A	30-11-1993	KEINE	
DE 10107515 A1	05-09-2002	KEINE	
EP 1394039 A	03-03-2004	EP 1394039 A1	03-03-2004
US 4588148 A	13-05-1986	KEINE	
US 5375795 A	27-12-1994	KEINE	
US 4860975 A	29-08-1989	KEINE	
US 4235399 A	25-11-1980	KEINE	
US 5906336 A	25-05-1999	KEINE	

(81)指定国　AP(BW,GH,GM,KE,LS,MW,MZ,NA,SD,SL,SZ,TZ,UG,ZM,ZW),EA(AM,AZ,BY,KG,KZ,MD,RU,TJ,TM),EP(AT,BE,BG,CH,CY,CZ,DE,DK,EE,ES,FI,FR,GB,GR,HU,IE,IS,IT,LU,MC,NL,PL,PT,RO,SE,SI,SK,TR),OA(BF,BJ,CF,CG,CI,CM,GA,GN,GQ,GW,ML,MR,NE,SN,TD,TG),AE,AG,AL,AM,AT,AU,AZ,BA,BB,BG,BR,BW,BY,BZ,CA,CH,CN,CO,CR,CU,CZ,DK,DM,DZ,EC,EE,EG,ES,FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KP,KR,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MN,MW,MX,MZ,NA,NI,NO,NZ,OM,PG,PH,PL,PT,RO,RU,SC,SD,SE,SG,SK,SL,SY,TJ,TM,TN,TR,TT,TZ,UA,UG,US,UZ,VC,VN,YU,ZA,ZM,ZW

US006352219B1

(12) United States Patent
Zelic

(10) Patent No.: US 6,352,219 B1
(45) Date of Patent: Mar. 5, 2002

(54) **FLYING VEHICLE WITH LIFT GENERATORS**

(76) Inventor: **Safedin Zelic**, Evlijo Celebija BB. 2, 71000 Sarajevo (BA)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/485,340**

(22) PCT Filed: **Apr. 16, 1998**

(86) PCT No.: **PCT/BA98/00001**

§ 371 Date: **Apr. 6, 2000**

§ 102(e) Date: **Apr. 6, 2000**

(87) PCT Pub. No.: **WO99/07601**

PCT Pub. Date: **Feb. 18, 1999**

(30) **Foreign Application Priority Data**

Aug. 8, 1997 (BA) 97244A

(51) **Int. Cl.**[7] **B64C 29/00**
(52) **U.S. Cl.** **244/12.1**
(58) **Field of Search** .... 244/12.1, 12.2, 244/12.3, 12.4, 12.5, 23 R, 23 C, 73 R, 73 B, 73 C, 20, 70, 19, 48; 416/179

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,360,182 A * 11/1920 Cortes 416/179
1,487,228 A * 3/1924 Garcia 244/48
1,820,919 A * 9/1931 Massey 244/19
2,037,377 A * 4/1936 Gardner 244/20
2,092,052 A * 8/1937 Kirsten 244/20
2,736,514 A * 2/1956 Ross .... 244/23 C
2,777,649 A * 1/1957 Williams .... 244/23 C
3,801,047 A * 4/1974 Dell'aquila 244/19
3,938,759 A * 2/1976 Bastide 244/20
5,100,080 A * 3/1992 Servanty 244/70
6,007,021 A * 12/1999 Tsepenyuk 244/9

FOREIGN PATENT DOCUMENTS

CA 750805 * 1/1967 .... 244/12.2
GB 747172 * 3/1956 .... 244/20

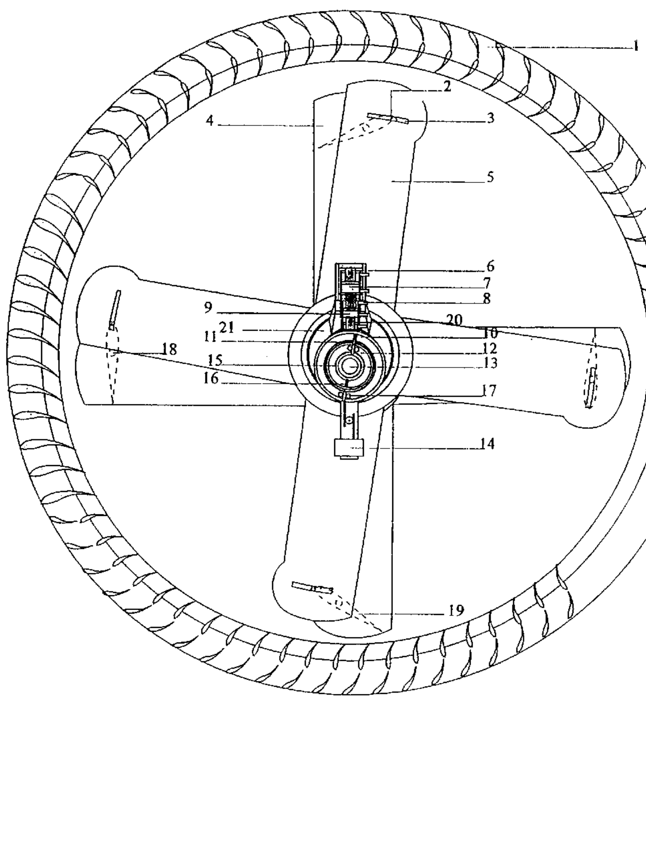
* cited by examiner

Primary Examiner—Galen L. Barefoot
(74) *Attorney, Agent, or Firm*—Rothwell, Figg, Ernst & Manbeck

(57) **ABSTRACT**

An aircraft is provided including a fuselage with a drive shaft in the fuselage, in which the drive shaft drives an aerodynamic generator consisting of an aerodynamic rotor which is attached to the shaft and an aerodynamic stator which is attached to the fuselage over the rotor. A control device which is responsive to control commands is attached to the fuselage and has an actuator for controlling the aerodynamic generator. The aerodynamic generator produces an aerodynamic force in response to the commands whose intensity, direction and sense of direction can be controlled through the control device, in which vertical lifting and landing are achieved by orienting the direction and sense of direction of the aerodynamic force vertically with respect to the horizon plane.

2 Claims, 23 Drawing Sheets



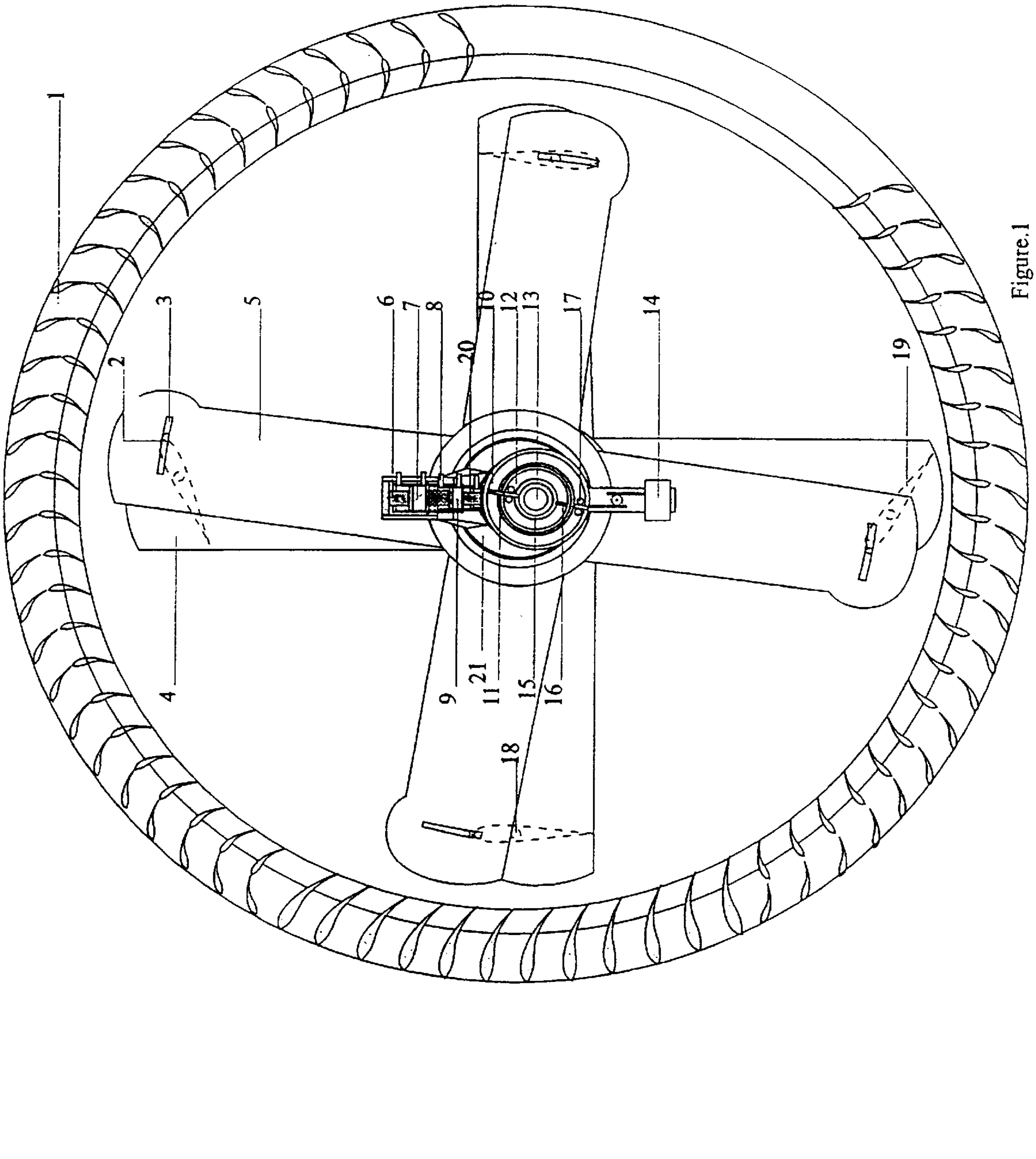


Figure.1

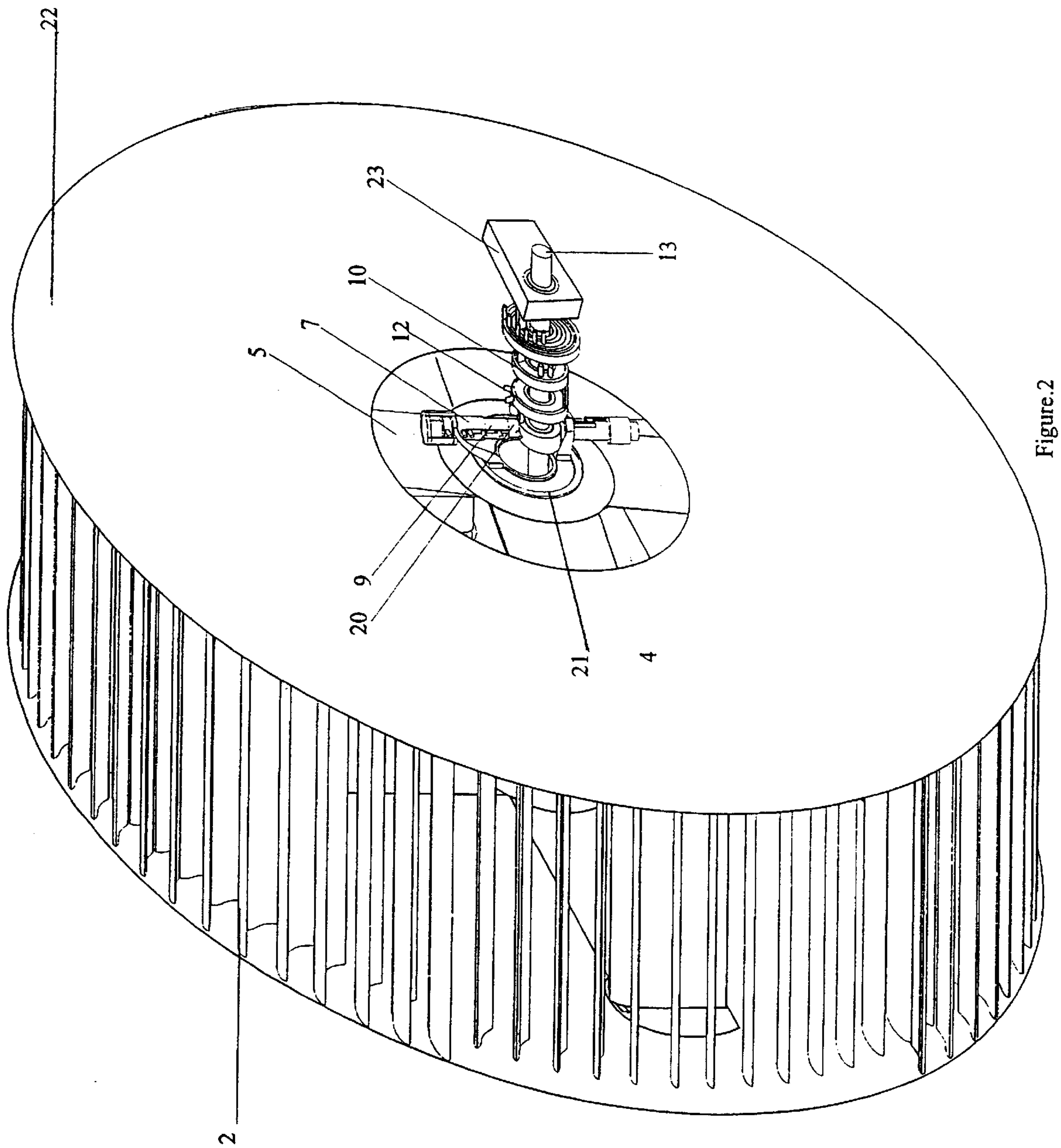


Figure.2

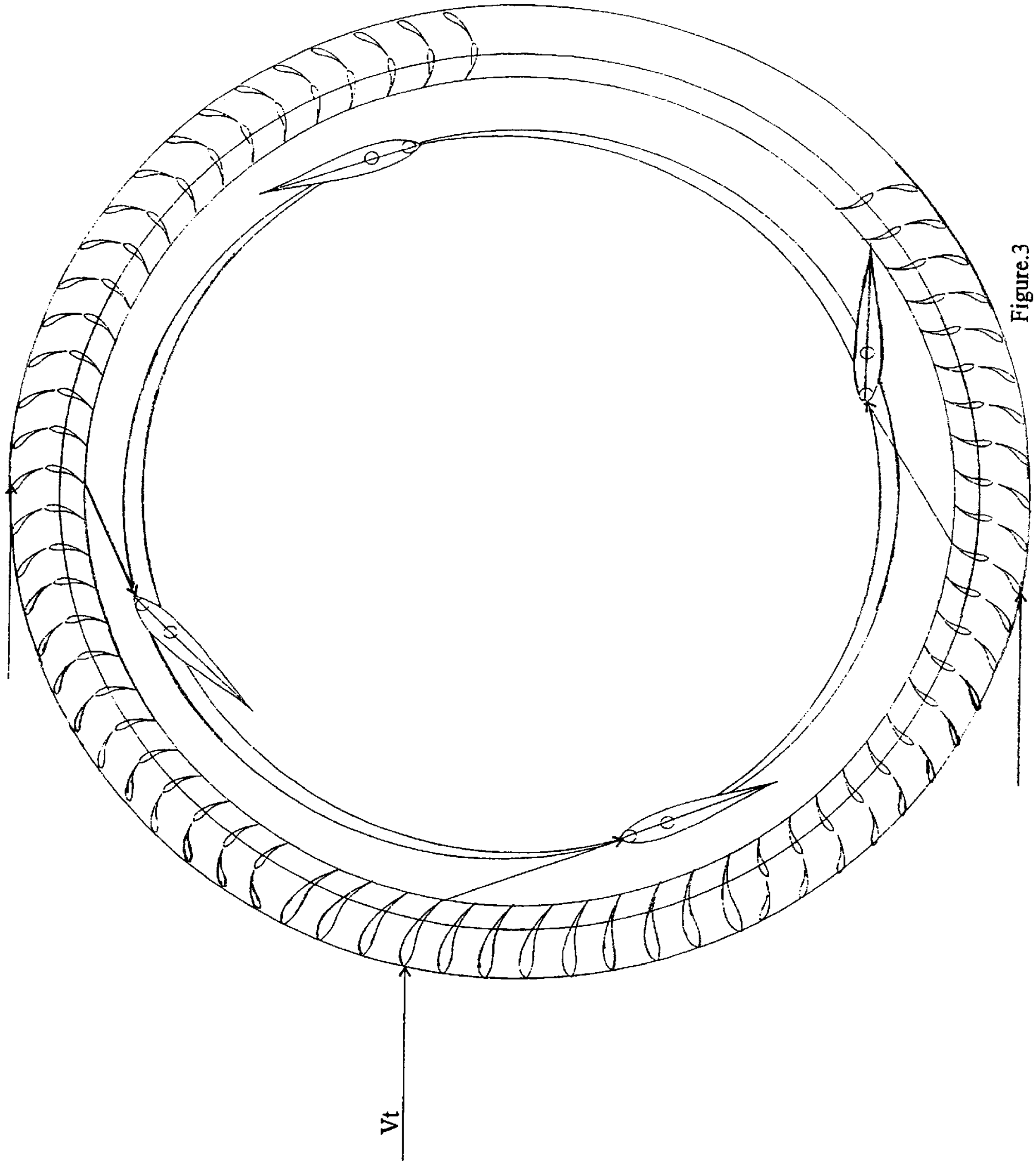
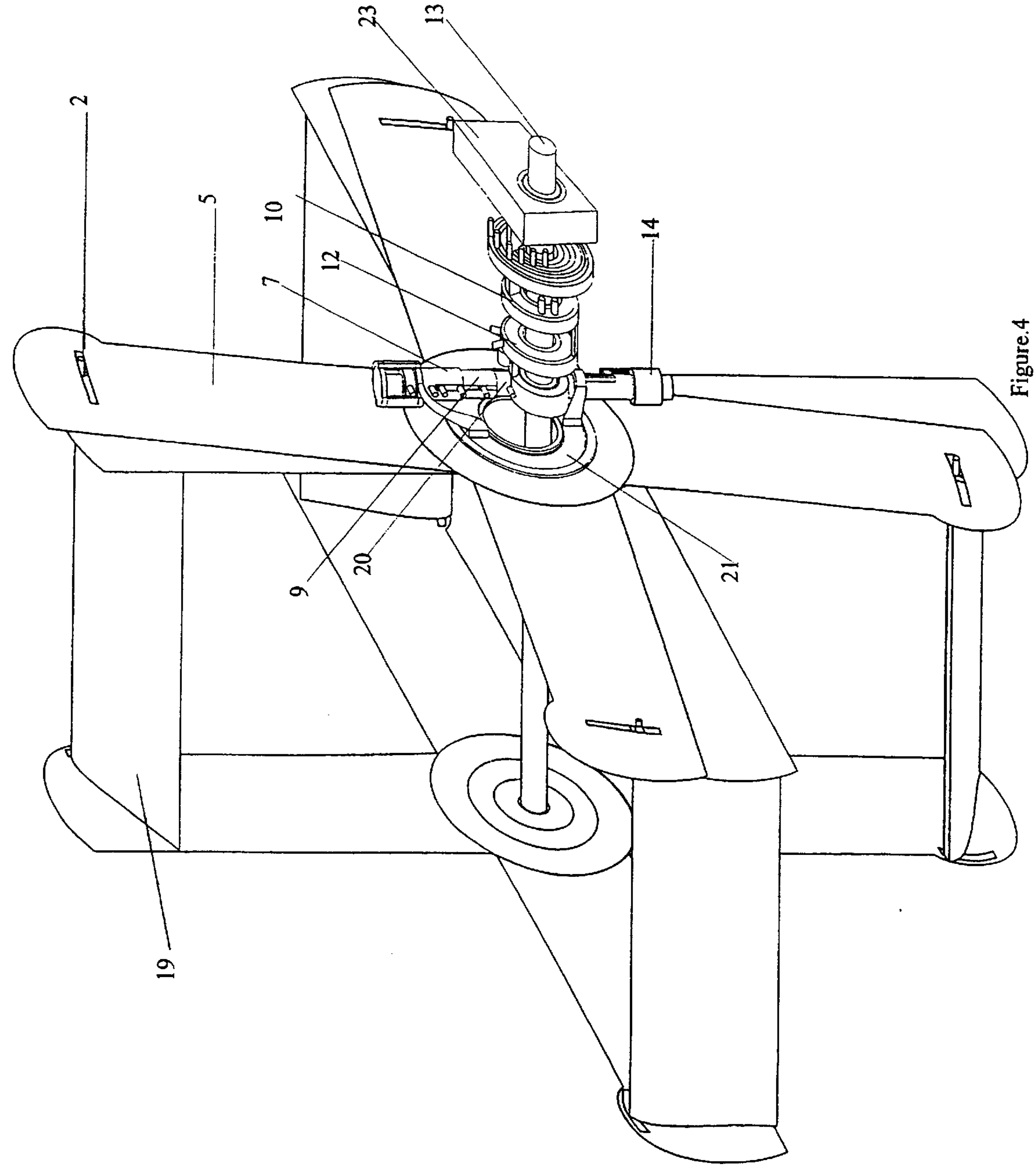


Figure.3



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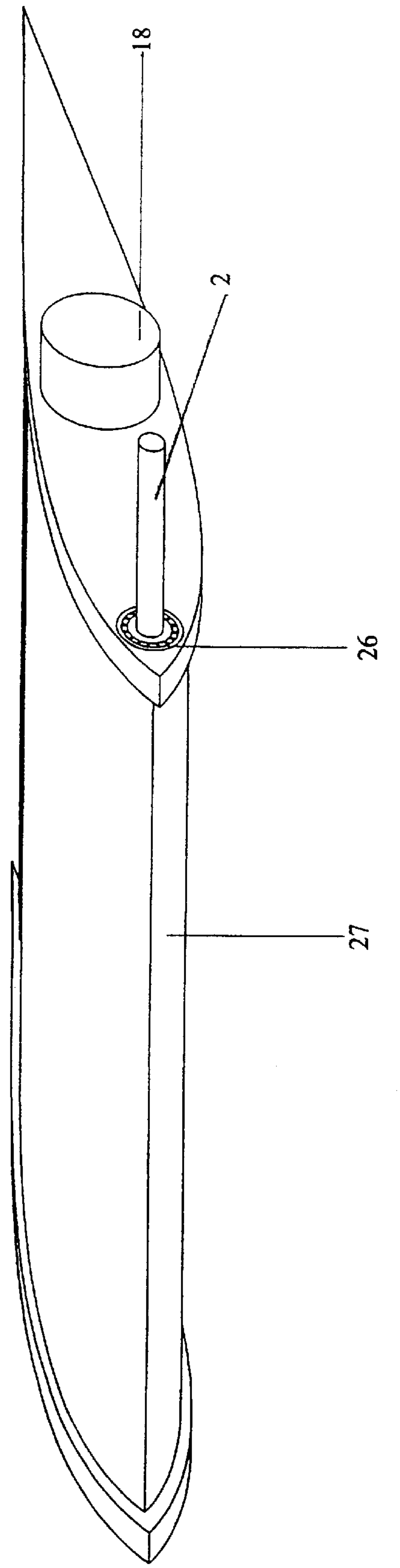

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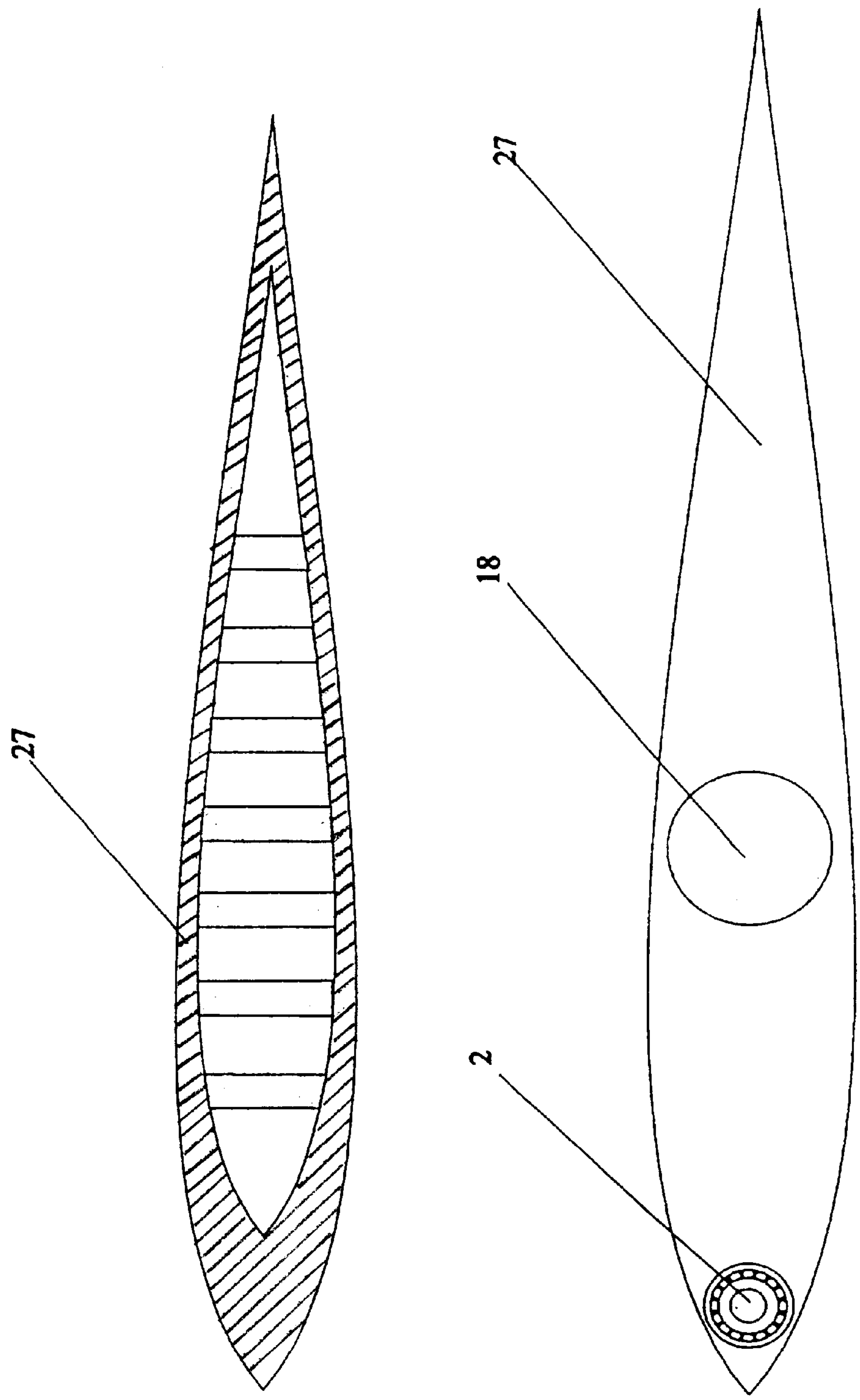

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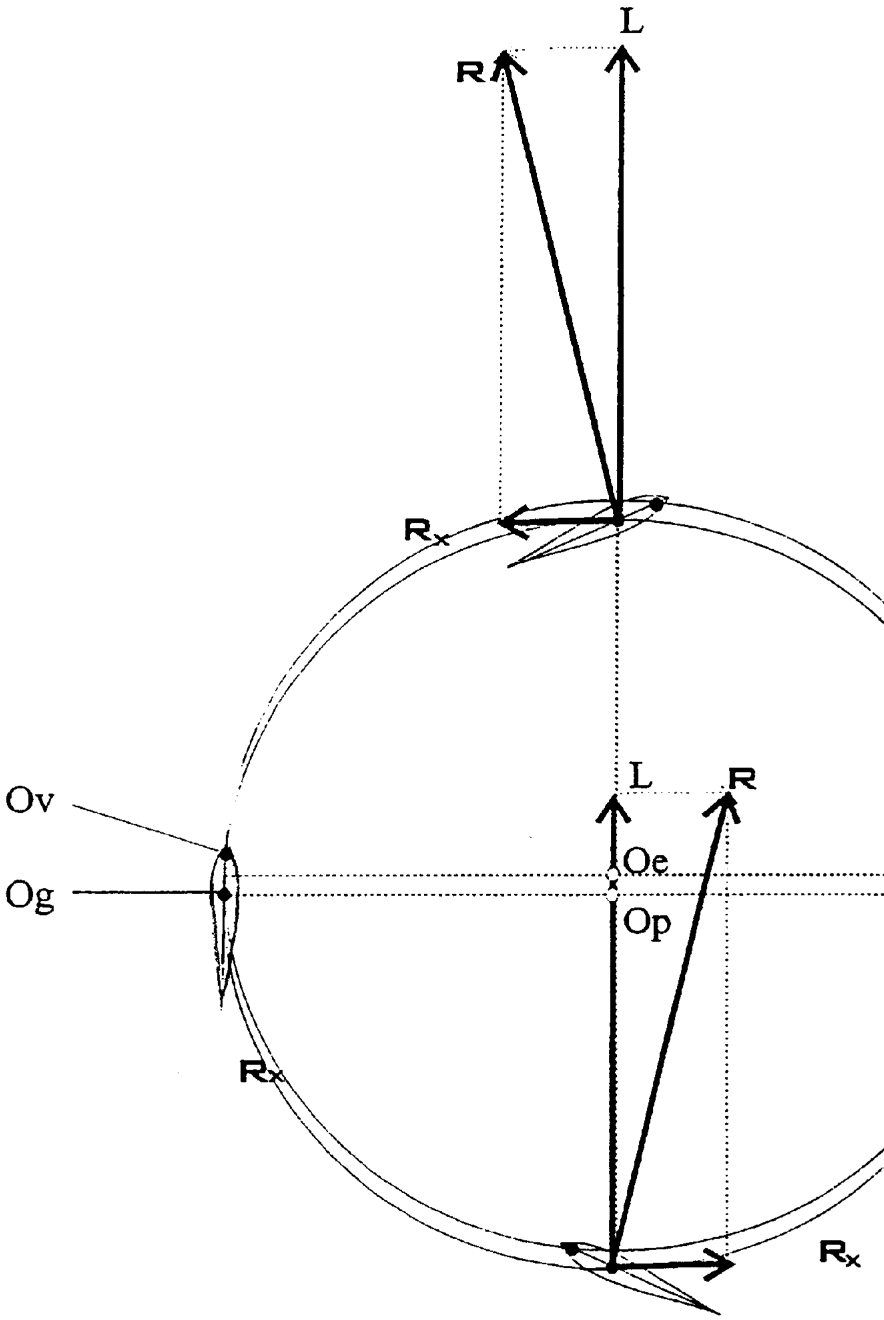

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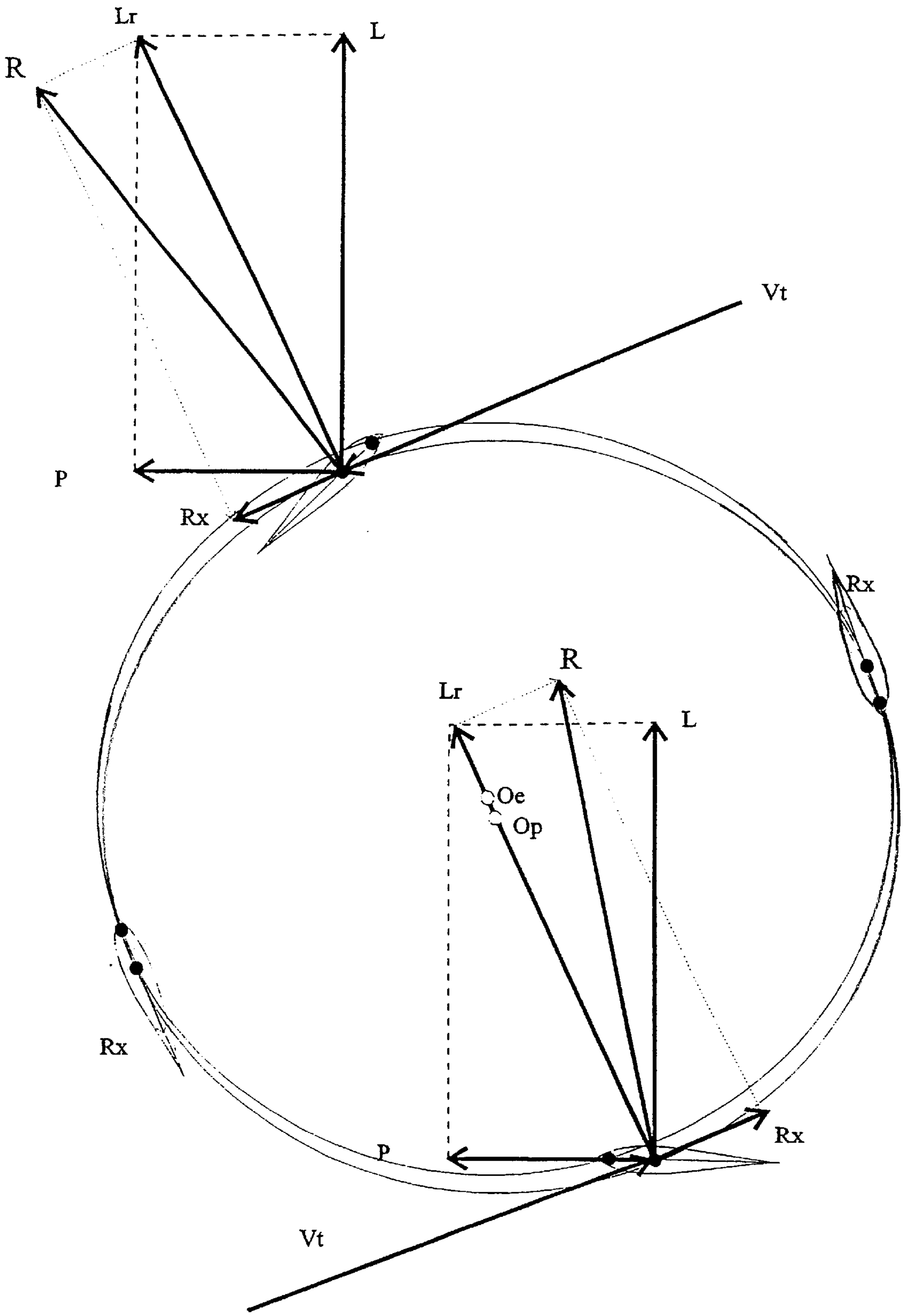

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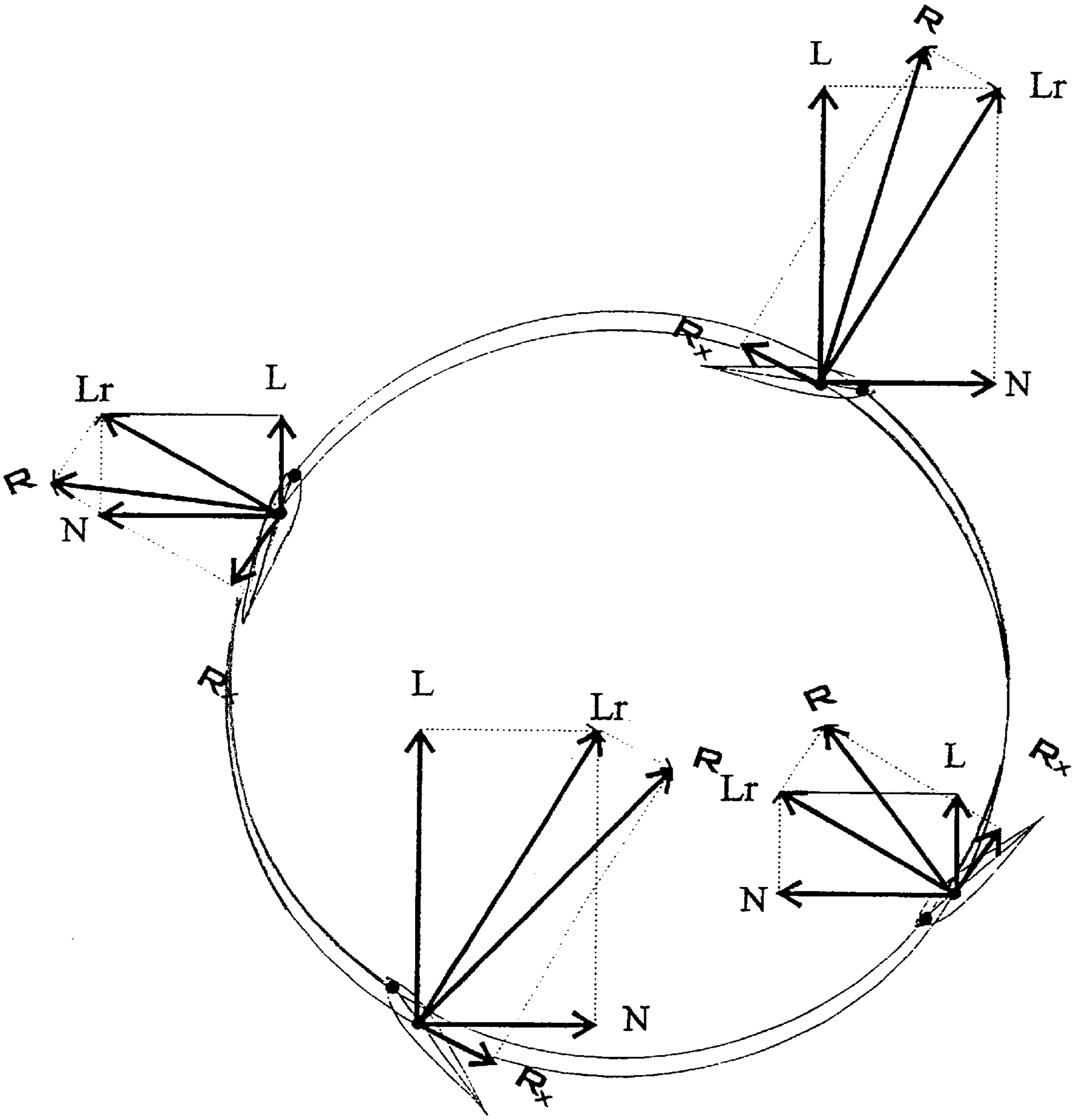

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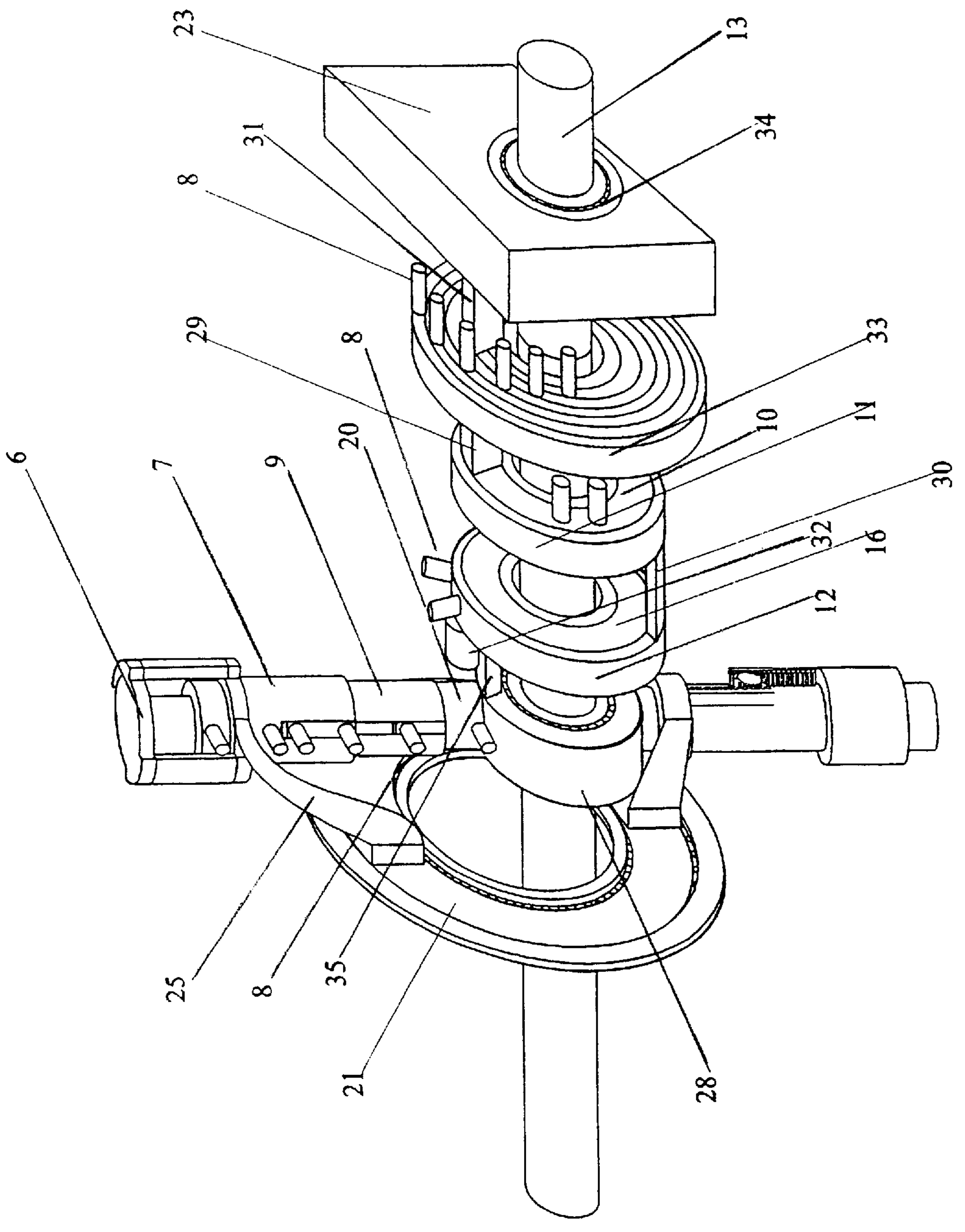

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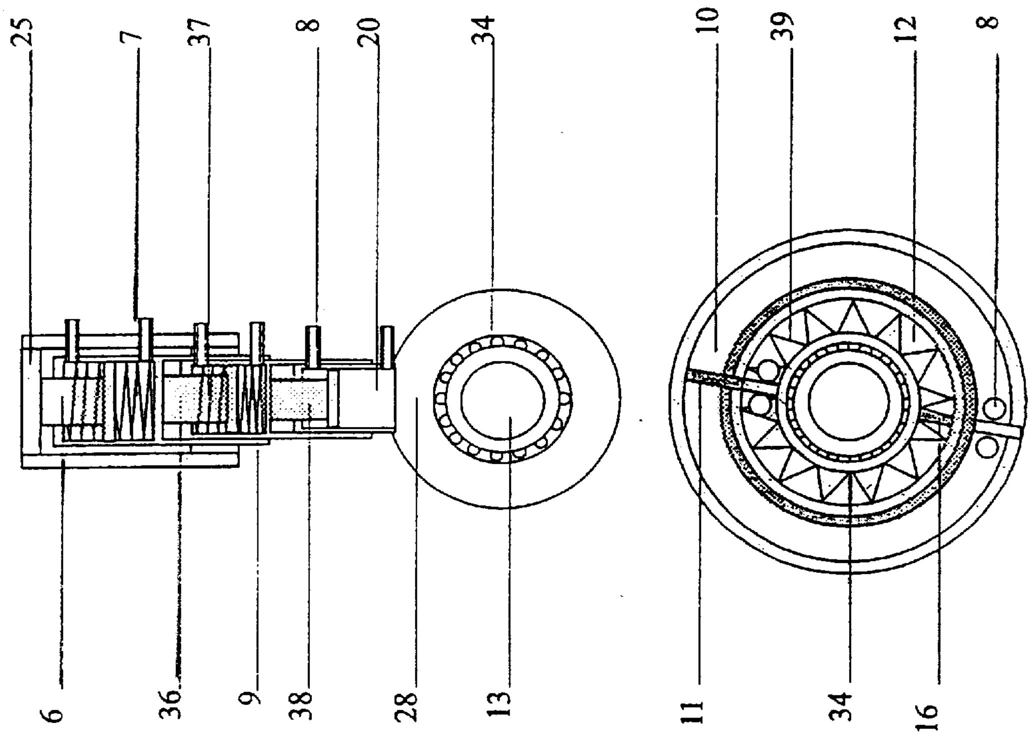

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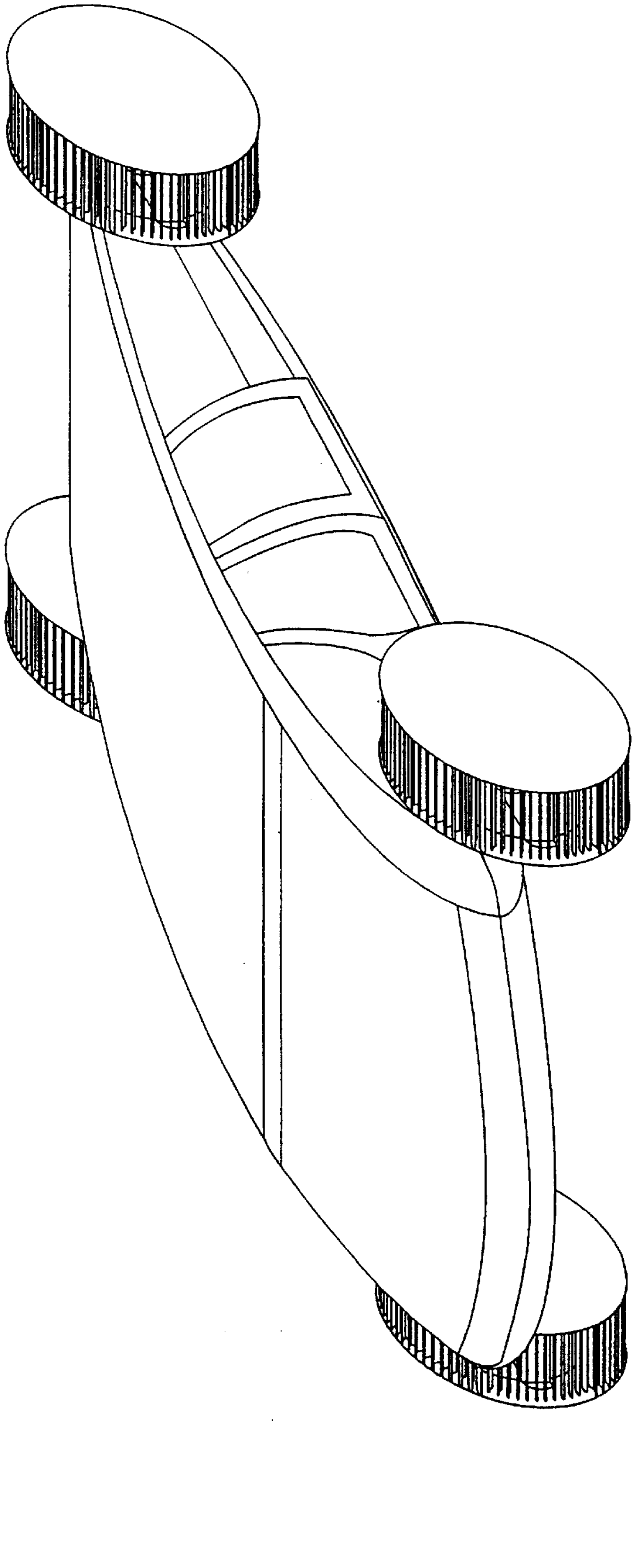

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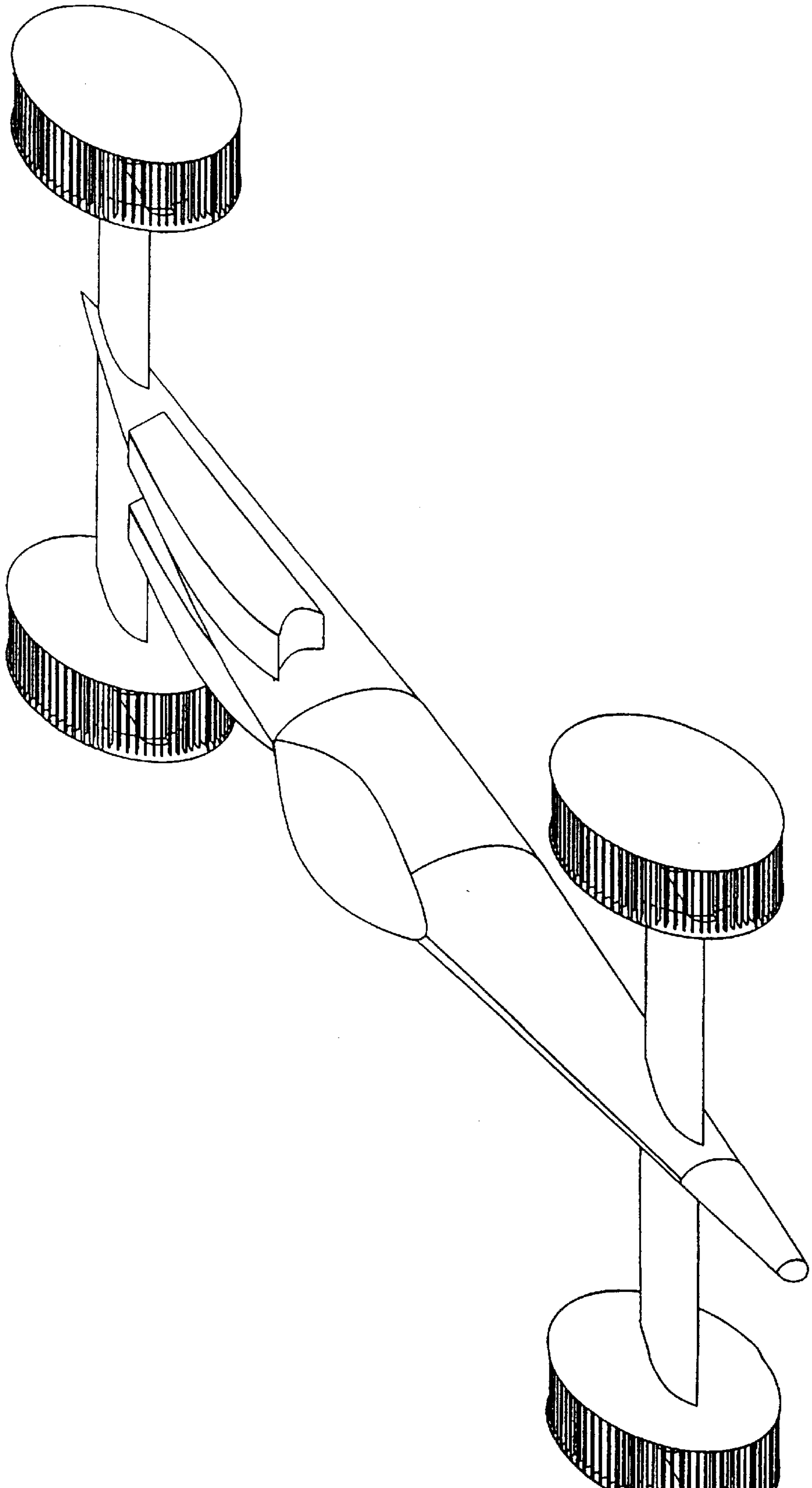

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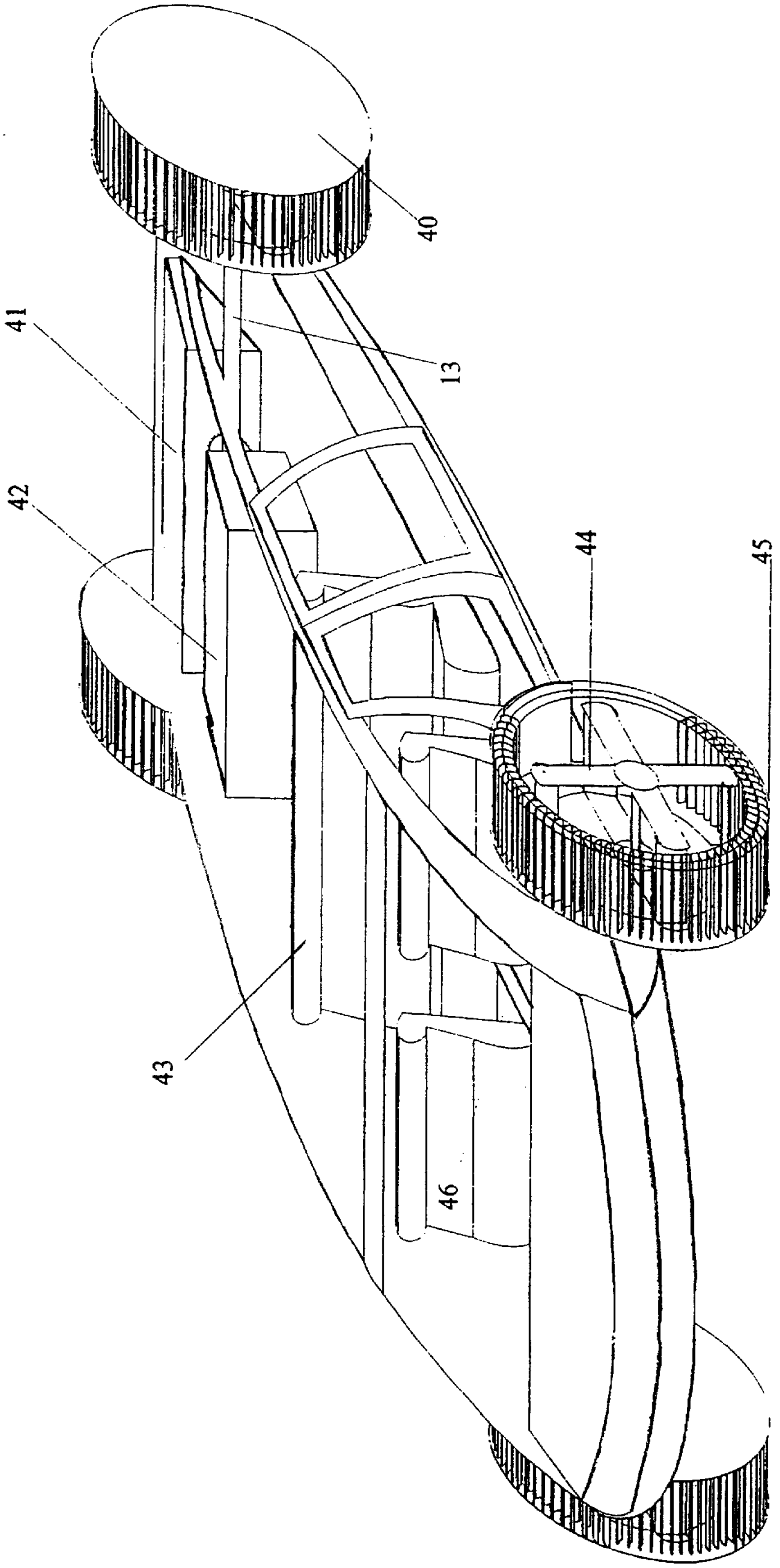

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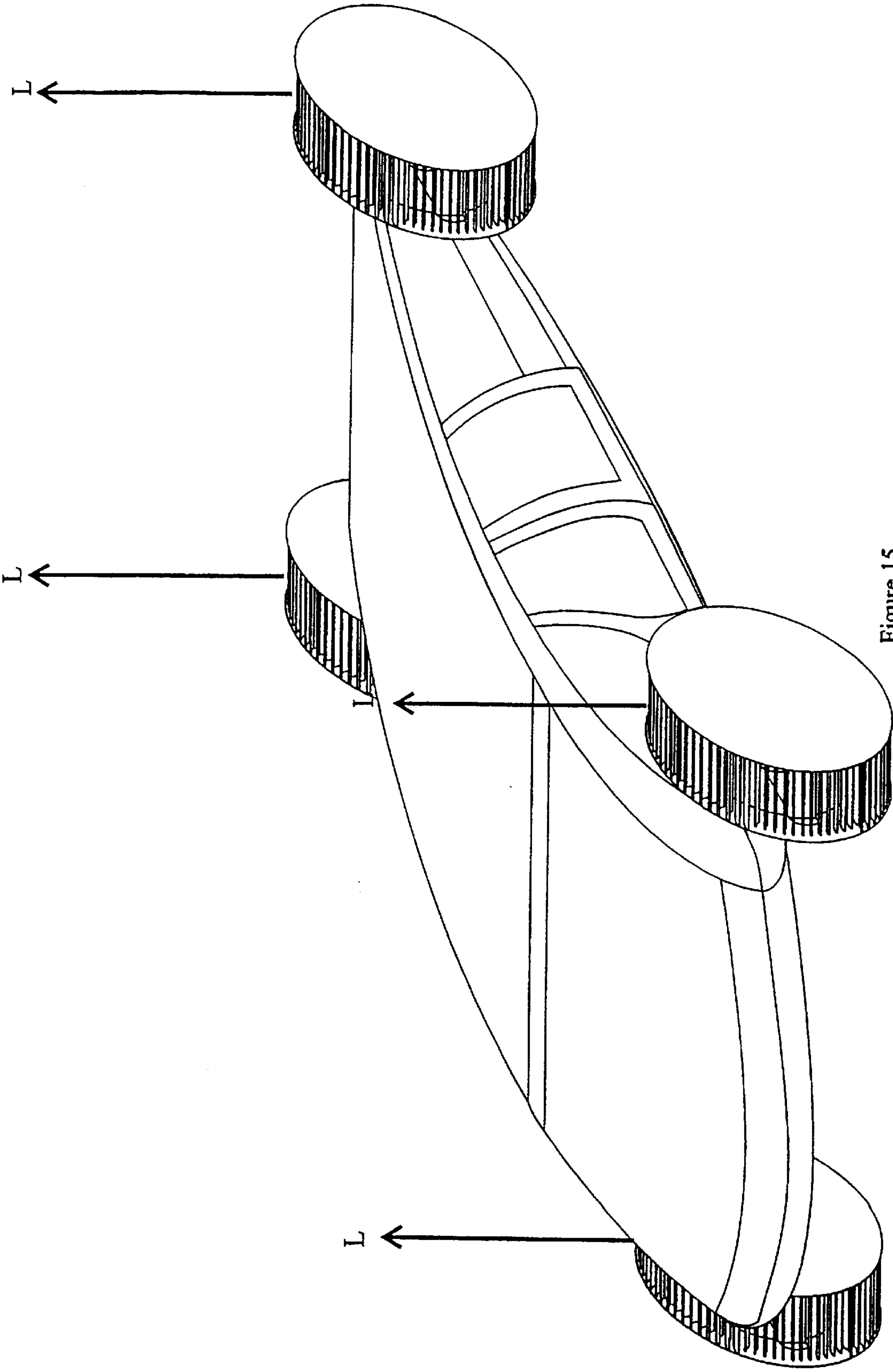

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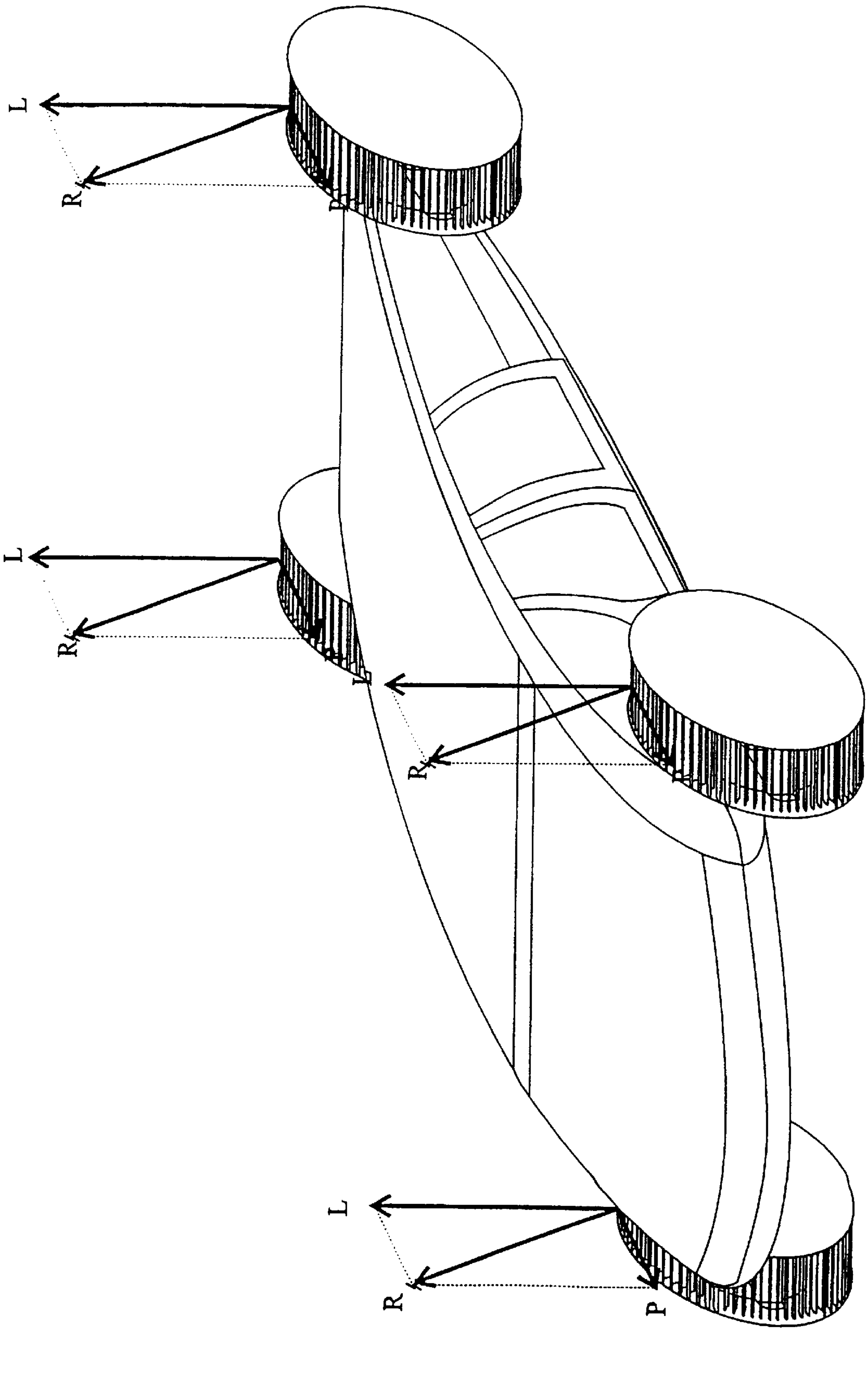

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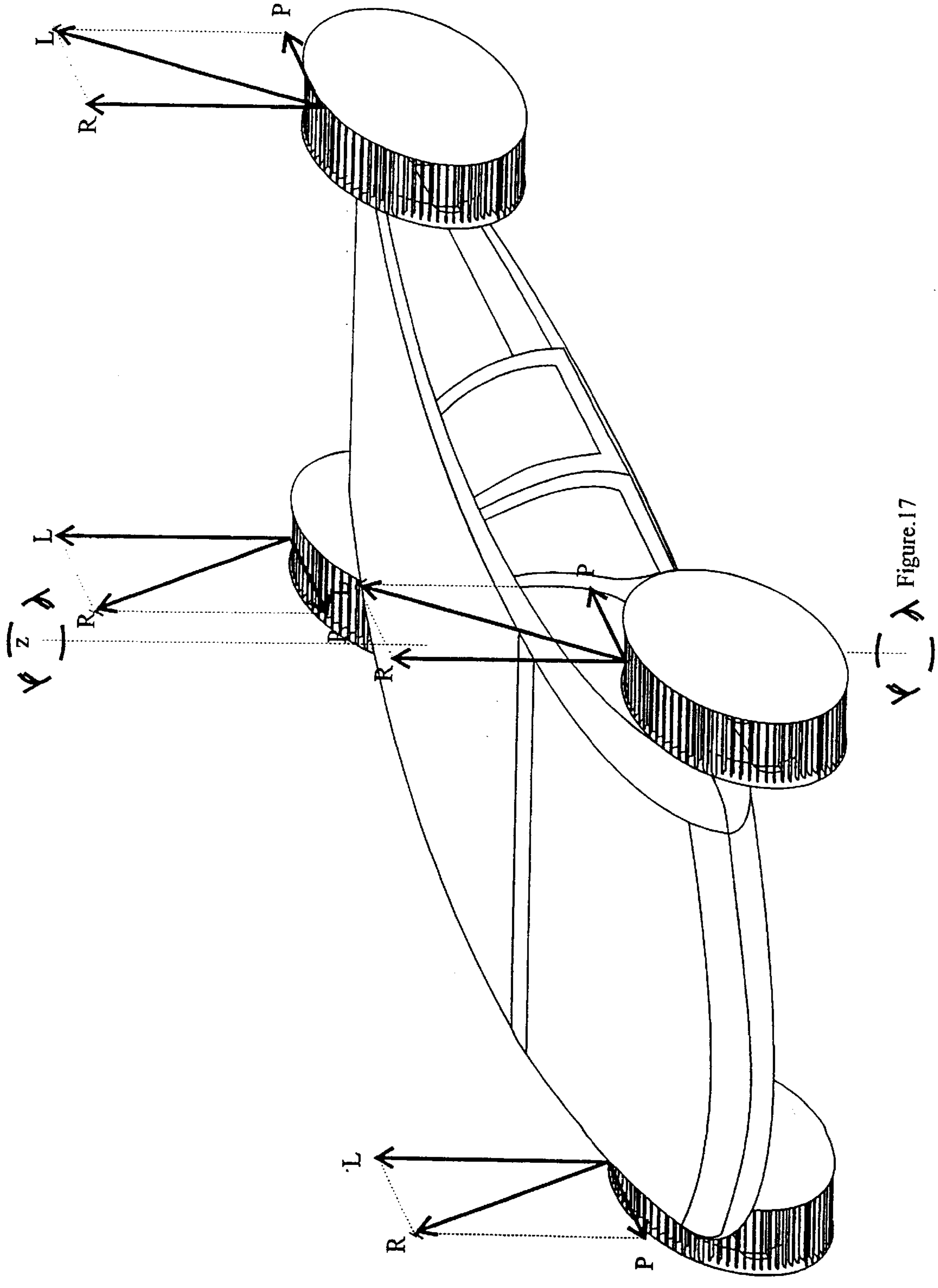

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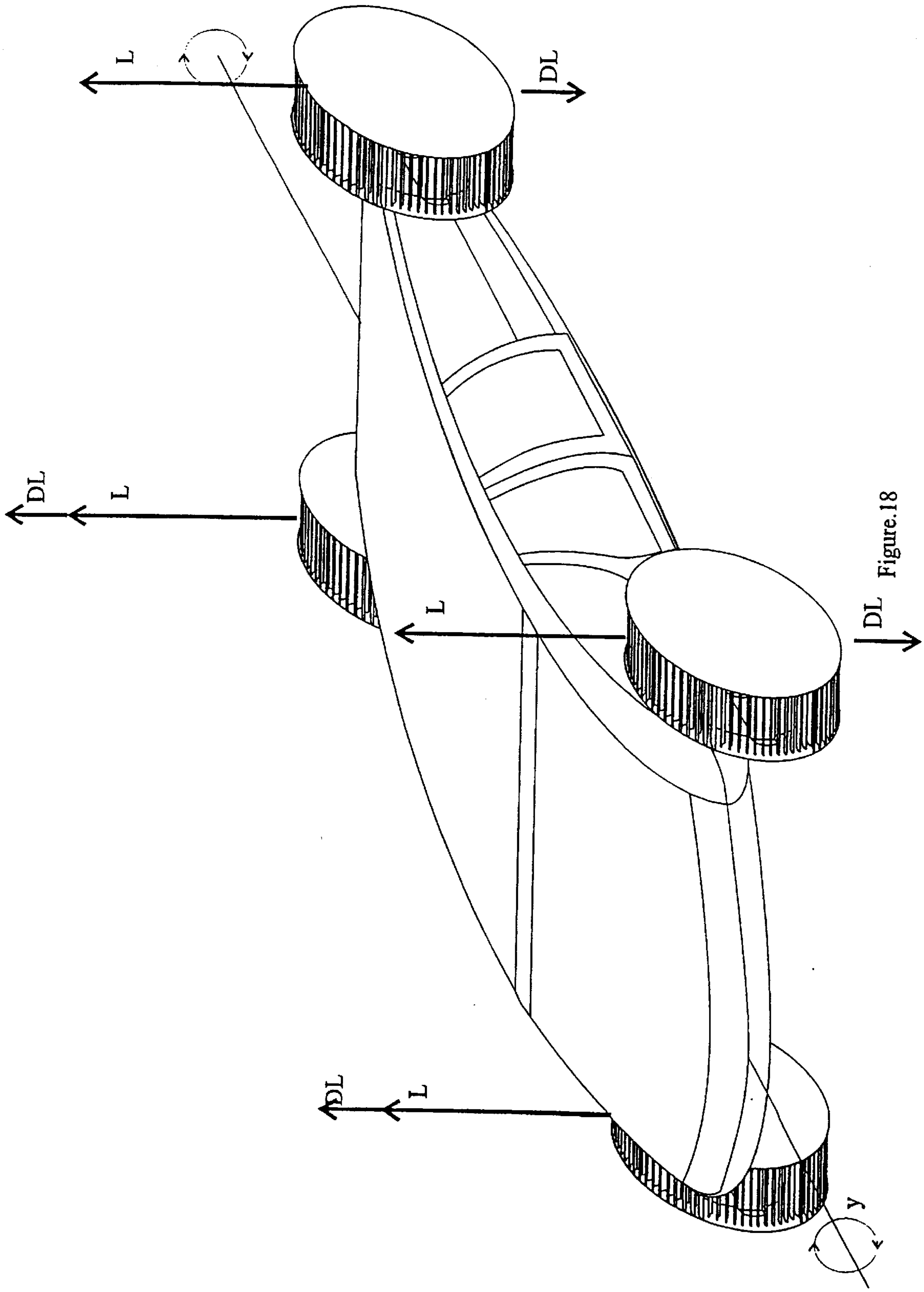

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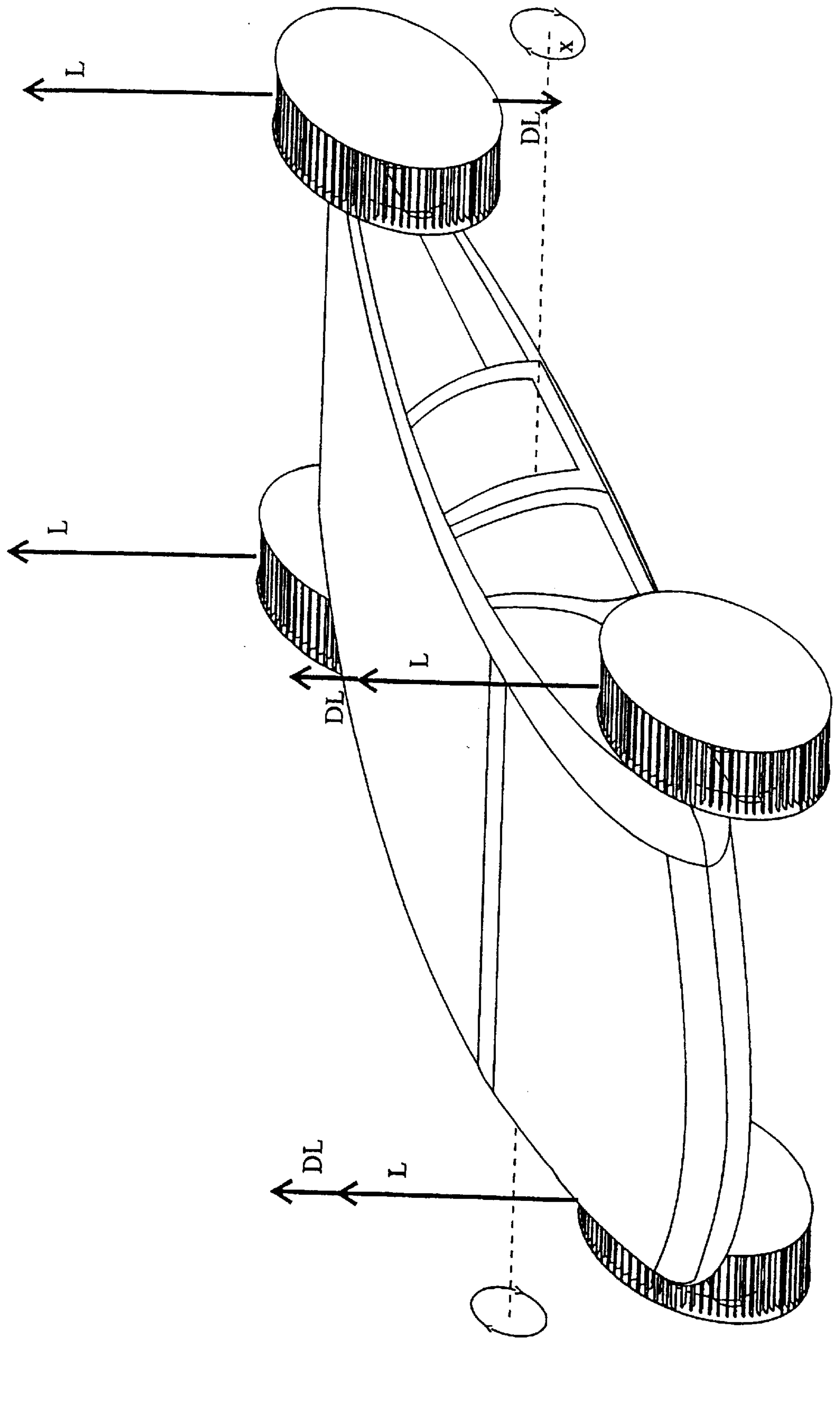

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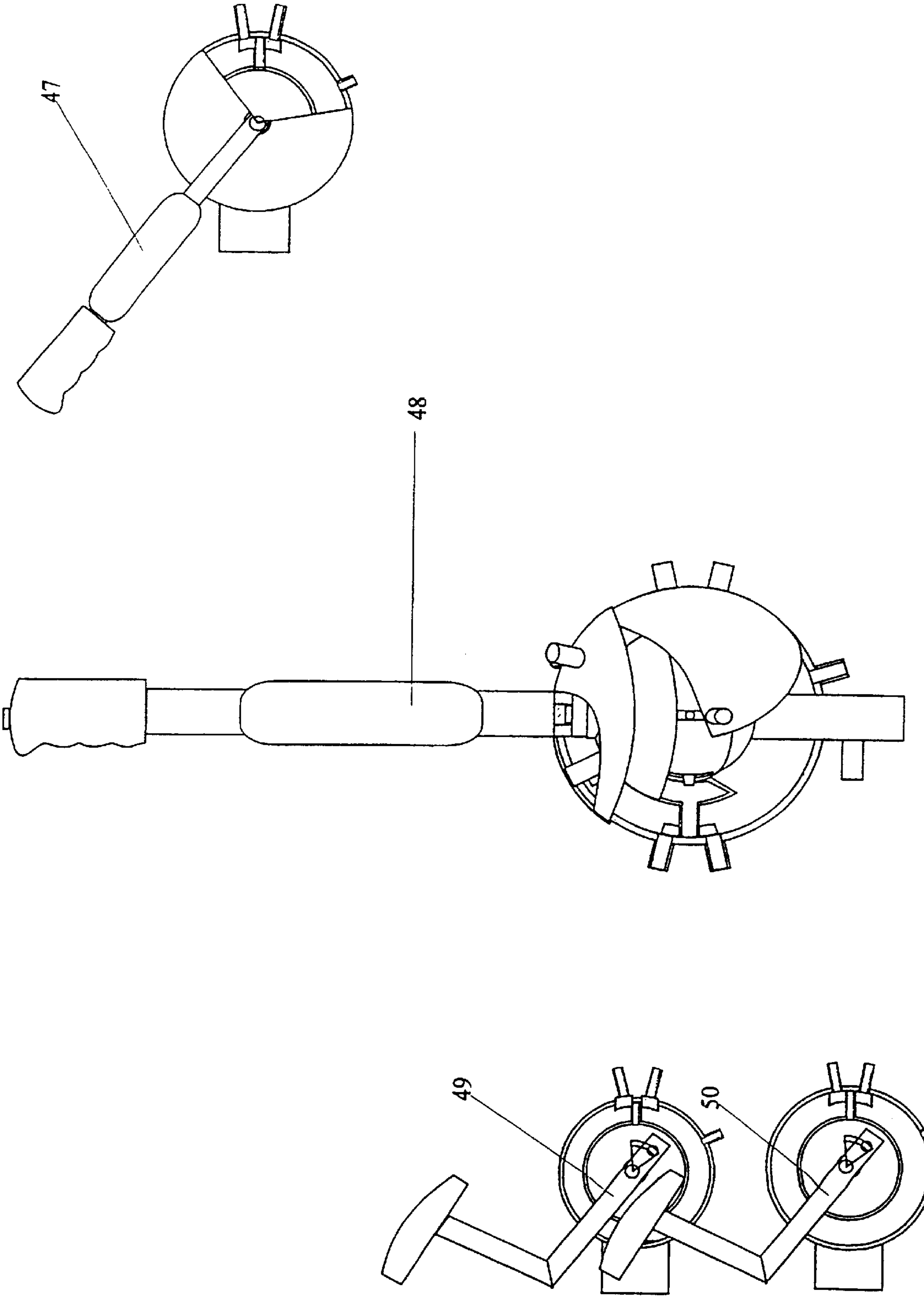

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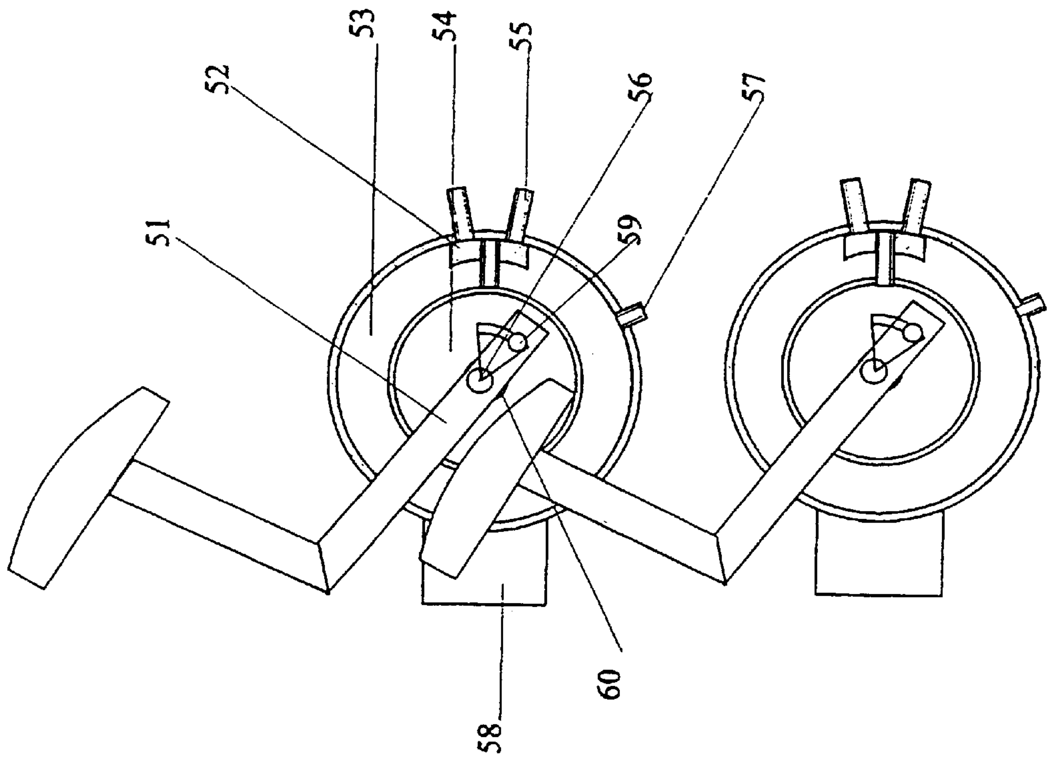

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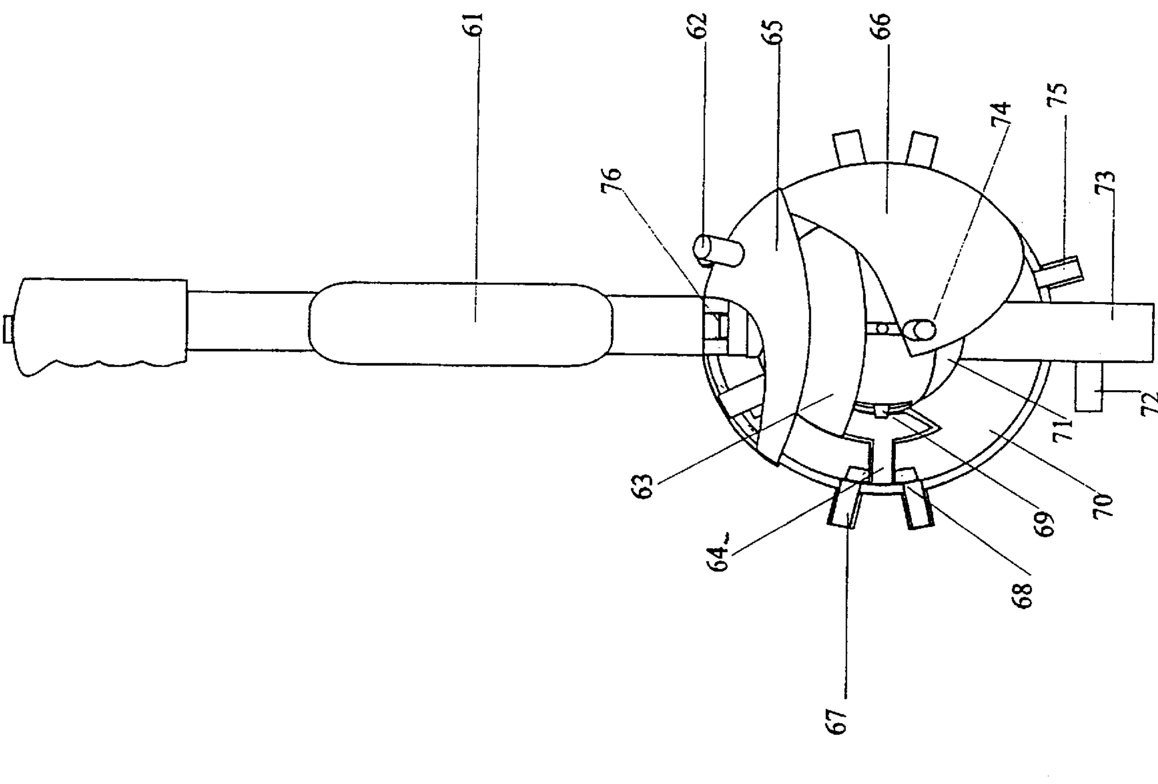

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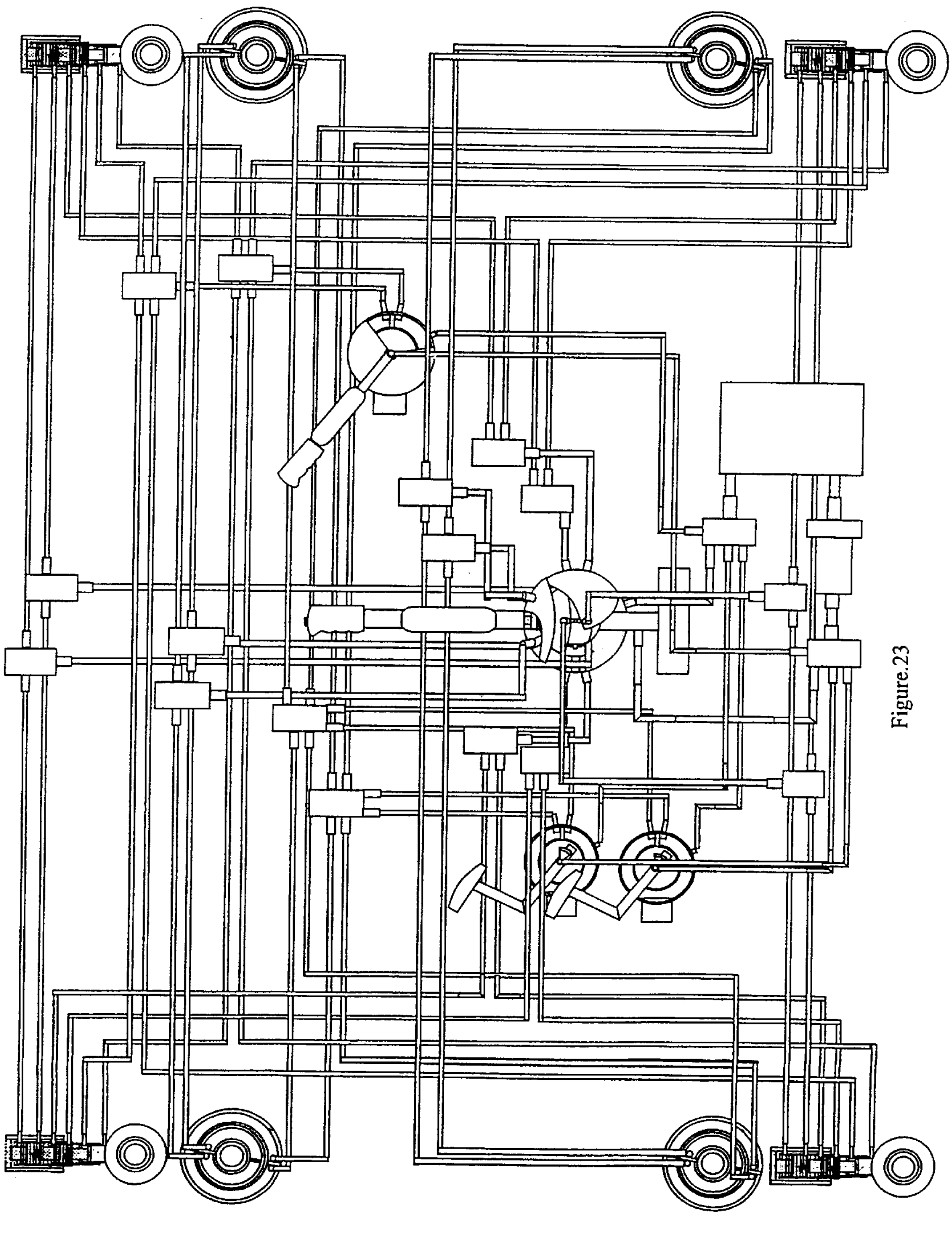

Figure.23

FLYING VEHICLE WITH LIFT GENERATORS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention is related to the field of aerotechnique, aeromechanics and aerodynamics in general.

2. Description of the Related Art

The invention solves the problem of design of dynamic aircraft which should take off and land vertically, have possibility to soar in a big span of altitudes; intensity of aerodynamic force can be changed independently on work of engine; direction of aerodynamic force can be changed and tied to fuselage of the aircraft or set free from fuselage position.

Several kinds of aircraft that are heavier than air have been invented so far, such as: glider, hang glider, gyro din, convertoplan, colopter, airplane, and helicopter. However, among all these flying bodies only airplane and helicopter found use. But even these two aircraft have some major defects which make impossible their mass use as individual, family, private and cargo air means of transportation. Airplane's basic defect is dependence on its takeoff power upon translational speed of its motion. It is impossible for airplane to go upwards and downwards vertically or to soar.

For take off and landing airplane needs special infrastructural installations on land which are very expensive and take large area which can be find only in the outskirts of cities; so individual and family use of this aircraft, as mass means of transportation is out of question.

Great minimum speed of the airplane while flying takes large wings' surface during takeoff and landing; which, during greater speeds, becomes extra gravitational load and extra unnecessary aerodynamic resistance. This large wings' surface requires even extra strong point in fuselage of the plane which becomes more massive and heavier. All that gravitational load and increased streamlined resistance require big thrust; which requires big quantity and consumption of fuel, which causes larger wings' surface and so negative characteristics appear differently. In this case thrust intensity does not depend directly on translational motion of' the aircraft like airplane but the way that helicopter produces aerodynamic force is much more ineffective than the way how wing of the airplane does it. Therefore, surface and angle of attack of a rotor blade of a helicopter must be increased which brings about increasing of aerodynamic resistance which requires increase of-engine power and increase of fuel consumption. This causes increase of gravitational load which can be neutralized only by increasing of rotor blades' surface. However, this increase on one hand is limited by blade mass and it causes strong centrifugal load and bigger aerodynamic resistance; and on the other band, it is limited by peak of rim speed which should not be faster than speed of sound. If thrust coefficient of three blades is also added to this, it comes to peak point of possible blade surface increase on rotor of helicopter and to a total thrust power. This all reflects negatively on possible peak gravitational load and maximum translational speed which is much lesser than translational speed of the airplane.

Design of helicopter is very complex beginning with necessity for powerful engines which are mainly gas turbines which take very complex power transfer and low-range geared system. Very complex head of rotor undergoes great centrifugal, aerodynamic, and inerted loads and blades' production is great challenge in production system.

For all this helicopter is expensive, uneconomical, and complicated aircraft so it could not become mass means of transportation.

BRIEF SUMMARY OF THE INVENTION

Aeromobil unites all positive characteristics of airplane and helicopter along with some genuine characteristics which neither has airplane nor helicopter nor any other known aircraft. Aeromobil generates necessary thrust power independently from its translational speed, so that its blade-surface of rotor is used totally in each phase while flying without any extra unneeded aerodynamic, centrifugal, and gravitational loads. Thrust coefficient of its rotor blades is five times bigger than thrust coefficient of airplane wings, and even many times bigger than the thrust coefficient on rotor blades of a helicopter. This makes possible reduce of blades' surface on Aeromobil's rotor which results also in reducing of a total weight of the aircraft, which also has positive effects on necessary thrust power and fuel consumption.

Rotor blades in aerodynamic generators do not only have big thrust coefficient but also low aerodynamic resistance-coefficient for these blades during work do not produce inductive aerodynamic resistance and practically they always act as a wing of an endless wave that results in very useful consequences: necessary engine power and fuel consumption. Aeromobil can develop translational speeds like a plane and this translational speed does not effect negatively work of its aerodynamic generators; moreover, speed is used as extra airstream in aerodynamic generators for produce of aerodynamic force. Streamlined shape of the fuselage provides produce of lift force by itself during big translational speeds and so all aerodynamic power of generator is directed towards vector of lift force.

The aircraft has got great translational speed; its vertical axis can take up any direction in the space while aircraft soars; from every soaring position it can start translational motion in any direction; translational speed of the aircraft does not influence negatively work of its active aerodynamic surfaces; it has favorable ratio of total weight of the aircraft and useful load which is able to carry; control system that makes possible using of all aerodynamic, maneuvering and flying possibilities of the aircraft; control efficiency that does not depend on translational speed of the aircraft; simple, dependable, compact design of the aircraft; its production takes no complex and costly technologies; it is economical and generating of aerodynamic force demands no big fuel consumption.

All control moments of this aircraft are completely independent of translational speed which makes impossible for aircraft to have equal control efficiency no matter which translational speed or direction is in question.

Aeromobil is simple, dependable, effective and economical aircraft. Its production does not requires any special or expensive technologies.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. 1. Laternal view to section of aerodynamical generator with section of hydraulic cylinders for control of work of generator.

FIG. 2. Aerodynamic generator with Control head and drive shaft.

FIG. 3. Presentation of transformation of translational speed at the entrance of stator into tangential speed at the exit from stator in regard to way of rotor blade.

FIG. **4**. Rotor of aerodynamic generator together with hydraulic Control head and drive shaft.

FIG. **5**. Blade of rotor.

FIG. **6**. Cross-section of rotor blade.

FIG. **7**. Presents periodic change of angle of attack of rotor blades in period of one rotation.

FIG. **8**. Presents periodic change of angle of attack of rotor blades in the state of produce of Lift and Propulsion's vector (P).

FIG. **9**. Presents constant value of horizontal component of Lift Vector.

FIG. **10**. Control head of Lift Vector.

FIG. **11**. Lateral section of hydraulic cylinders on control head of aerodynamical generator.

FIG. **12**. Aeromobil, family version

FIG. **13**. Aeromobil, sports version.

FIG. **14**. Basic parts of Aeromobil.

FIG. **15**. Disposition of Lift vector in order of soaring or vertical translational motion.

FIG. **16**. Disposition of Lift vector and Thrust vector within horizontal translational motion.

FIG. **17**. Disposition of Thrust vector and Lift vector during production of turn around axis z.

FIG. **18**. Disposition of Lift vector during production of turning moment around axis y.

FIG. **19**. Disposition of Lift Vector during production of turning moment around axis x.

FIG. **20**. Steering controls of Aeromobil.

FIG. **21**. Lateral section of Thrust Vector control.

FIGS. **22** and **23**. Section of Distributor and hydraulics of control direction, altitude and bylateral.

DETAILED DESCRIPTION OF THE INVENTION

Aeromobil is dynamic flying machine. It produces necessary force for lift, thrust and control moments, in aerodynamic generators. Aerodynamic generator is compound of two main parts, Aerodynamic Stator and Aerodynamic Rotor.

Stator has function to transform translational air speed (which occurs during translational motion of the aircraft) into secondary rotating air speed, which has same direction as well as primary rotating air speed of rotor. In that way, total rotating air speed in generator during translational motion is increased to value of secondary rotating speed which is proportional to translational motion of the aircraft.

Stator is round aerodynamic grid consisted of aeroprofile put parallelly in regard to drive shaft of rotor (FIG. **2**). Aeroprofiles of stator **(10)** are placed so that translational and parallel air stream (which occurs at entrance in stator's aeroprofiles) is transformed into rotating air stream at the exit of stator's aeroprofiles. Output air speed has direction of tangent line on circle orbit of blades of rotor. Front resistance is lower and total aerodynamic force is positive or zero by putting blades of stator in this way. To achieve this, it is necessary to put two line of stator blades in the position of. stator where lift is negative. It means upper-blades and down-blades of stator are reciprocally opposite. Only the part of stator which produces lift force has a line of blades which are twice bigger proportionally than blades from double line. Besides, it is necessary that rotor rotates in direction of watch hand. Stator is immobile and attached to fuselage of the aircraft.

It is closed from lateral sides so that air can get inside stator only through fissure among stator blades.

Rotor of aerodynamic generator is the most important part of the aeromobil (FIG. **4**). Rotor generates necessary aerodynamic force for lift thrust and control moments. It is consisted of Drive shaft **(13)**, Blades' carriers **4)**, Blades' guide **(5)**, and Control head.

Drive shaft **(13)** is placed horizontally and goes through center of rotor. This shaft has function to move rotor and in the same time accepts all aerodynamic and gravitational force of the aircraft.

Blades' carriers **(4)** have function to hold rotor blades **(19)** and they are firmly attached to Drive shaft and they rotate together with it. Guide **(5)** has function to guide guiding shaft of rotor blades and give them necessary eccentricity. It is not fixed with Drive shaft **(13)**. It is connection between Control head and blades of rotor **(19)**.

Rotor blades (FIGS. **5–6**) are streamlined bodies of symmetrical aeroprofiles with constant vertical section. They have function to generate aerodynamic force necessary for lift, thrust and control.

Two shafts placed parallelly with its front and back edge are situated on them. These are Main shaft **(8)** and Guiding shaft **(2)**. Main shaft **(8)** goes through rotor blade center of gravity and through center of aerodynamic lift which should go along with blade center of gravity **(19)**. This shaft takes on all centrifugal and aerodynamic force from blade and transmits them to carriers of blade **(4)**.

Blades generate aerodynamic force in the way that Main shaft **(18)** of rotor blade **(19)** rotates around Drive shaft and Guided shaft **(2)** of blade **(19)** rotates around shaft of Eccentric bearing **(21)**.

In that way, blades are placed in necessary angle of attack which is the biggest on that part of orbit were eccentricity of Guided shaft **(2)** is the biggest (FIG. **7**). Just on the same place intensity of aerodynamic force is the biggest as well. (This is intensity of its vertical component which presents Lift vector.) Direction of this vector coincides with direction of vector of eccentricity of Eccentric bearing **(21)** with initial point in the center of Drive shaft **(13)**. During turning of this eccentricity or its increase, lift direction and its turning are also increased (FIG. **8**). All horizontal components are cancelled mutually in the way that horizontal component of aerodynamic force of blade (which is located in the first quadrant of circle orbit) is cancelled by horizontal component of neighbouring blade in second quadrant (FIG. **9**). In any point of blade's orbit these components have same intensity and opposite direction. In the same way horizontal component of aerodynamic force (which is located in third and fourth quadrant of circle of orbit of rotor blade) are cancelled.

Every rotor has four blades put symmetrically in regard to Drive shaft **(13)**, so that only one blade of rotor can be found in every quadrant each moment. Forming of angle of attack is done according to sinus law which provides constant value of total sum of Lift vector of all four blades, no mater in which point of circle orbit blades are found. Guided shaft **(2)** has function to put blades in necessary angle of attack. Also, this shaft transmits one lesser part of aerodynamic force to Drive shaft **(13)** across Guide and Eccentric bearing which is necessary for maintaining of lift direction independent from position of the aircraft body which happens in Extreme order of control.

Control head of rotor (FIG. **10**) is consisted of one Eccentric bearing **(21)**, two Carriers of Eccentric bearing **(25)**, three hydraulic Cylinders for change of angle of attack

(CCAA) of rotor blades, two hydraulic Cylinders for change of lift direction (CCLD), Electromagnetic connection (**32**), rotating hydraulic connection (**33**) and rotor carriers (**23**).

Eccentric bearing (**21**) has function to carry guide (**5**) and gives it necessary eccentricity in relation to Drive shaft (**13**) of rotor. It is connected with pistons of hydraulic CCAA which can move up and down if necessary. During this, it increases and reduces eccentricity of Eccentric bearing (**21**), that is, increase and reduce of angle of attack of rotor blades (**19**), which, in the end, causes increasing, reduce of total aerodynamic force. This eccentricity can be as positive as well as negative.

Hydraulic CCAA (FIG. **11**) are: Cylinder of group change of angle of attack (CGCAA) (**20**), Cylinder CMx (**7**) and Cylinder CMy (**9**). Mutual position of these cylinders is conditioned by function they do. Because of this, CGCAA is put as a base for other two cylinders. Piston of this cylinder (**6**) is connected to CMy (**9**) cylinder body. Piston of this cylinder (**36**) is connected with Eccentric bearing (**21**) that is, with Guide (**5**).

During work of piston in CGCAA(**38**), other two cylinders are moved together with its pistons. It is further transmitted to Eccentric bearing (**21**) i.e. to change angel of attack of rotor blades (**19**) during work of piston in cylinder CMx (**7**), translational motion of piston and cylinders CMy (**9**) happens, and all this move Eccentric bearing (**21**) in direction of cylinder's piston CMx's motion. In this case, cylinder as well as piston CGCAA (**20**) are not moving. During activation of cylinder CMy (**9**) only its piston moves tighter with Eccentric bearing. During that time, piston CGCAA and CMx (**97**) are still.

Function of hydraulic CGCAA (**20**) is to bring about equal and simultaneous change of angle of attack of rotor blades (**19**) on all four (or even more) aerodynamic generators (**40**). Cylinder CMx (**7**) has function to produce equal but regarding to direction, opposite change of angle of attack of lateral generators.

Cylinders CMy (**9**) have the same function, only their effect is related to two front and two back generators.

Hydraulic cylinders for change of lift direction (CCLD) are: Cylinder for group change of direction of lift (CGCDL) (**10**) and cylinder CMz (**12**). These cylinders differ from CCAA by the thing that their pistons circle during work i.e. bring about rotation of object for which they are tied. These cylinders are mutually placed in the way that activation of piston in CGCDL brings about moving of cylinder and piston CMz (**12**). During activation of Piston CMz (**16**), motion of CGCDL does not happen because these two are not connected physically. CGCDL (**10**) has function to turn Eccentric bearing (**21**) around Drive shaft (**13**) and in this way change direction of Eccentricity, which means that lift direction has changed for the same angle value. These cylinders move direction of lift simultaneously and in the same direction on all four generators. Cylinders CMz (**12**) do the same only their effect is pointed to lateral generators so that angle of Thrust vector is equal on both sides of the aircraft but has opposite direction.

Electromagnetic connection (**32**) is located between Piston of CMz (**12**) and Carrier of CGCDL. This connection has function to separate these two bodies in order to stop physical contact between Control head of rotor and aircraft fuselage. This is necessary when the aircraft should be in order of work and when lift direction of all generators becomes independent from position of the aircraft.

Rotating hydraulic connection (**33**) is consisted of mobile disk on which are located receptacles for hydraulic cylinders and connection body which is tightly tied to Carrier of generator (**31**) and from which go receptacles to main hydraulic distributors. This connection provides charge to cylinder with oil under pressure in those conditions when aircraft flies and it is necessary that lift direction is independent from position of aircraft.

Carrier of aerodynamic generator (**23**) has function to transmit all gravitational and aerodynamic loads from generator to fuselage of the aircraft. This is Bearing (**13**) through which goes drive shaft (**13**) of rotor on it.

Basic concept of Aeromobil has four aerodynamic generators placed on angles of imagined rectangular base of aircraft (FIG. **12**). Depending on that whether this imagined base goes through gravitational center, above, or below it, the aircraft takes position of indifferent, labile and stable balance, respectively. On FIG. **10**., this base goes through gravitational center and it is in position of indifferent balance.

Aeromobil's fuselage has two basic shapes. One is family or cargo, (FIG. **12**.), and the other is sports version. Both fuselages are designed so that their resistance force is lesser as much as possible. This fuselage should produce aerodynamic lift which provides increase of Thrust vector on aerodynamic generators during certain translational speed.

That phenomenon is particularly expressed in family model of the Aeromobil which is in fact aerodynamic profile similar to wing of airplane. Controls and flying instruments, motor group, fuel tanks and transmission are situated in it. This fuselage (aerodynamic profile) could be. brought under favorable angle of attack during translational speed of the aircraft with the help of activation of hydraulic cylinders CMy (**9**) i.e. bringing about My moment.

Thrust group (**42**) is situated in back part of the fuselage (FIG. **14**) and it is consisted of one or two engines or gas turbines which start Main drive shaft (**46**) which again, by transmission and conical gears, starts all four drive shafts of rotor (**13**). Transmission is classic, it is simple, for -it dermands little ratio of transmission. Pilot and space for passengers are situated in the front part of the aircraft.

Controlling of the Aircraf

All necessary control moments are generated on rotors of Aerodynamic generators of Aeromobil (FIGS. **15–19**). Each Aeromobil has four aerodynamic generators placed on angles of imagined rectangular base of the aircraft. By increasing and reducing of total value of Lift vector on each rotor or changing of its direction and course, it is possible to produce necessary moments around all three space axles initiating with center of gravity of the aircraft. This opposite-proportional change of intensity and direction of Lift vector on front two generators in relation to back two brings about rotation around transverse axle y. This same change of intensity and direction of Lift vector on right two generators in relation to left generators brings about rotating moment round longitudinal axle x of the aircraft.

Opposite proportional change of direction of Lift vector on right in relation to left generators brings about rotating around vertical axle z of the aircraft Change of intensity of Lift vector of each Aerodynamic generator is done by Cylinders of change of angle of attack (CCAA) which increase or reduce eccentricity of Eccentric bearing. Eccentricity is transmitted to Guiding shaft of blades which changes angle of attack of blades that brings about change of Lift vector.

Change of direction of Lift vector is done by Cylinders for change of direction of lift (CCDL) which turns eccentricity of Eccentric bearing in relation to Drive shaft and brings about turning of direction of Lift vector in the same direction. In that way Lift vector gets translational component which is caused on all four generators in the same time and gives thrust force to Aeromobil. This thrust force (Thrust vector) is proportional to angle of turn of Eccentric bearing and intensity of Lift vector. AU these control moments are attained by specific hydraulic system of control.

This hydraulic system is consisted of cylinders which are on each generator in number of five. These are: CGCAA **(20)**, Cylinder CMx **(6)**, Cylinder CMy **(9)**, Cylinder CMz **(12)** and CGCLD **(10)**. These cylinders are connected to special hydraulic distributors by which work of cylinders is controlled.

In this system there are four distributors by which all aerodynamic forces on aeromobil are controlled (FIG. **20**). Those distributors are: Distributor of group change of angle of attack of rotor blades **(47)**, Distributor of thrust vector **(49)**, and Distributor of break vector **(50)**.

Distributor of group change of angle of attack **(47)** has function to activate cylinders CGCAA **(20)** on all four generators simultaneously and equally. In this way, CGCAA causes change of angle of attack of blade **(19)** on all four generators. This brings about equal increase of lift on all four rotors. By this distributor, pilot controls with his right hand, and there is gas handle on its lever, so that work of engine and total value of lift can be controlled simultaneously by the right hand in the same time.

Its design is identical to design of Distributor of thrust vector **(49)**, with the only difference that it is handle, not a foot pedal. Distributor of thrust vector (FIG. **21**) has function to activate cylinders CGCLD **(10)** simultaneously and equally on all four generators and brings about turn of eccentric bearing around thrust shaft which has equal turn of direction of lift on all generators as its consequence. This gives thrust vector to the aircraft, which coincides with its vertical axle and gives to the aircraft horizontal translational speed.

This distributor is consisted of Chamber of high pressure tl **(54)**, Chamber of low pressure tl **(53)**, Conductor of high pressure tl **(77)**, Hydraulic connection for CGCLD **(55)**, Pedal axle **(56)**, Receptacle of low pressure tl **(57)**, Carrier tl **(58)**, Border tl **(59)**, and Spring padel **(60)**. Distributor functions in a way that oil (under pressure) gets into cylindrical Chamber of high pressure tl **(54)** through axle **(56)** which goes through center of that chamber. By pressing on lever **(51)** this chamber (together with Conductor of high pressure tl **(77)** and Breeches tl **(2)**, turns itself around axle **(56)**, opens hydraulic coupling for CGCLD **(55)**. Upper coupling is connected to Conductor of high pressure tl **(77)** through which oil is sent to CGCLD **(10)**. From the other side of piston of that cylinder oil comes back to Chamber of low pressure tl **(53)** and through Connection of low pressure tl **(57)** goes to oil tank. By ceasing of effect of force on pedal under effects of spring, Chamber of high pressure, tl together with Conductor tl **(77)** and Breeches, gets to previous position in which Hydraulic connections for CGCDL **(55)** are closed, which provides the piston to preserve attained position and Lift vector by itself.

Distributor for Brake vector **(50)** has function to annul Thrust vector and gives it opposite direction which it has in progressive translational motion ahead. Result of that is occurrence of negative thrust which put aircraft in soaring position, and according to wish, the aircraft can get into progressive motion backwards.

Distributor for control of direction, altitude and laterally (FIG. **22**) has function to provide to the pilot setting of the aircraft in any position in space whether it is in order of soaring or translational motion in any direction. Distributor is consisted of: Chamber of high pressure **(63)**, Chamber of Low pressure **(70)**, Joint ball **(71)**, Conductor of high pressure **(64)**, Distributor cap for Cylinders CMz **(65)**, Breech **(68)**, Hydraulic connection for CMx **(74)**, CMy **(671**, CMz **(62)**, and Control lever **(61)**. During effect on Control lever **(61)**, which has two handles (for left and right hand), starts rotating of Chamber of high pressure **(63)** around Joint ball **(71)**. During that conductor of high pressure **(64)** is connected to Hydraulic connection, which conditions pass of oil under pressure to hydraulic cylinder on Control head of Aerodynamic generator with simultaneous coming out of oil, on the other side of cylinder's piston into Chamber of Low pressure **(70)** and from this over to Connection of low pressure **(75)** and into oil tank. Oil comes from oil tank into Chamber of high pressure **(63)**, over oil pump, Connection of High pressure **(72)**, Carrier **(73)**, Joint ball **(71)**, respectively, and through Stopper **(69)** gets into Chamber of low pressure **(63)**. In this place wall of Chamber of low pressure **(70)** keeps it, until lever of control and connection of conductor of High pressure **(64)** affects hydraulic connections.

During effect on lever of control **(61)** forward there is rotating of Chamber of high pressure **(63)** around lateral Stopper **(69)** and connecting of Conductor of high pressure **(64)** with Hydraulic connections CMy **(67)** which are situated on the outside of the wall of Chamber of law pressure **(70)**. In that moment there is connecting of conductor **(64)** on the lower Hydraulic connections CMy **(67)**, and from back outside of this distributor there is connection with upper Connection CMy. This brings about moving of the piston in Cylinders CMy **(9)** so that pistons in front two generators go down and reduce angle of attack of blades i.e. lift until pistons in two back Generators go up and increase angle of attack of rotor blades i.e. lift. This control brings about occurrence which results in turning of the aircraft around transverse axle. Bringing of lever **(61)** into initial position there are turning off and ceasing of turning of the aircraft around this axle for immediate putting in the same level of the pressure on the both side of Piston of CMy. This makes possible for springs, which are situated in cylinders, to get piston back to the initial position which leads to putting on the same level of lift on all four aerodynamic generators.

During effect on lever **(61)** in opposite direction, there is occurrence of the same but in opposite direction. This turns itself off by bringing Lever **(61)** into neutral position. If Lever for control **(61)** moves itself right, there is connecting of lateral Conductors of high pressure on lower Hydraulic connections CMx **(74)**, which is situated on the. right side of the wall of Chamber of low pressure **(70)** and there is connection of upper coupling on the left side, too. By this, oil gets into CMx **(7)** on Control head of generators in the way that pistons in CMx **(7)**, on the left side, go up and increase angle of attack of blades i.e. Lift vector on the left side of the aircraft but Lift vector is reduced for the same value on generators on the right side of the aircraft. This brings about occurrence of lateral moment which turns the aircraft around longitudinal axle of the aircraft. Bringing the lever back into neutral position this turns itself off.

During bringing of lever into opposite side, there is turn of the aircraft into opposite direction. If Lever of control **(61)** turns itself around vertical axle which goes through poles of Chamber of high pressure **(63)**, there is connecting of Hydraulic Coupling CMz **(62)**; which is situated on Distributor cap **(65)**; with Conductor of high pressure. This provides pass of oil from Chamber of high pressure **(63)** into

Cylinders CMz (**12**) on Control head of rotor. That causes turning of pistons of Cylinder CMz (**12**) around Drive shaft (**13**) of rotor which brings about turn of Lift vector. This also brings about occurrence of Lift vector which is according to intensity equal on right as well as on left generators, but their direction is opposite. This process turns the aircraft around vertical axle z. Direction of turn of the aircraft is equal to direction of turn of Lever of control. By bringing of this lever into neutral position there is putting of pressure on both sides of piston of cylinders CMZ (**12**) on the initial level. Under effect of springs (**39**) which are on both sides of pistons within these cylinders there is bringing of lift of direction to initial position. By this, provoked coupling is off and turning of the aircraft around vertical axle is ceased.

Total scheme of hydraulic control system of aeromobil is presented on (FIG. **23**). All controls of aeromobil are independent from each other so they can be switched on individually or all in the same time but their effect will be totally preserved and independent. It means that Aeromobil can turn simultaneously around all three space axles and it can go up and move translationally in any direction.

Aeromobil has two orders of control: Optimal order of control and Extreme order of control.

Optimal order of control is condition of control when direction of force of lift of aerodynamic generators is tied to position of the aircraft in space (it means that if the aircraft turns itself into any direction i.e. around any of its space axles), for the same angle and into same direction is direction of lift force turned. However, in order of extreme control direction of lift force is not tied to position of the aircraft in space; therefore, in this condition, control of the aircraft can be turned and even rotated around its transverse axle y. And during this, lift direction of the aircraft will stay the same as in the moment when the aircraft gets into this order of control. It means that the aircraft (if it was in the, soaring position on constant height) in the moment before getting into Extreme order, preserves that soaring state (condition) and the height, and if it turns itself for 180 degrees, it is turned itself totally upside down. This order makes possible for the aircraft that its vertical axle x can take any direction in space, and in the same time, the aircraft soars and changes height. Aeromobil can also have translational speed in direction of its cross (transversal) axle y. During this motion it can turn itself or even rotate for full circle around its cross axle X; and during motion of the aircraft neither height nor direction is changed.

Extreme order of control is activated by pressing electric switch (**78**) which is located in the top of lever of Distributor of control to direction, height and laterally (**48**).

By pressing this button electromagnetic coupling is activated (**32**) which **20** separates hydraulic cylinders CGCAA (**20**) from hydraulic cylinders CGCLD (**10**). That separates physically cylinders of angle of attack, together with Eccentric bearing (**21**), and Guide (**5**), Eccentric bearing (**21**), Hydraulic cylinders COCLD (**20**), and in this way transmits grip of this vector to center of Drive shaft (**13**) which direction is identical with direction of lift vector. In this way, lesser part of aerodynamic force is transmitted to Drive shaft (**13**) not only over Main axle of blade (**18**) and carrier of blades (**4**) but over Guide axle of blade (**2**), Guide (**5**) and Hydraulic cylinders CGCAA (**20**). So aerodynamic force of rotor blades (**19**) maintains direction of aerodynamic force. As fuselage of the aircraft is separated from cylinders CGCAA (**20**), Eccentric bearing (**21**), and Guide (**5**); it provides to Eccentric bearing (**21**) to maintain direction of its eccentricity regarding Drive shaft (**13**) although fuselage itself turns around that axle.

In Extreme order of control of aeromobil, only cylinders of change of angle of attack (Cylinder CGCAA (**20**), Cylinder CMx (**7**), and Cylinder CMy (**9**)) are active, until cylinders of change of direction of lift (Cylinder CMz (**12**), and Cylinder (**10**)) are excluded (switched off), for their work in that order have no sense. By repeated press on switch (**78**) of Extreme order, effect of electromagnet on electromagnetic coupling (**32**) stoops, and under influence of springs there is connecting of Cylinders of change of angle of attack with cylinders of lift-direction-change so that aircraft gets into optimal order of control.

In FIG. **1** is shown a Lateral view to section of aerodynamical generator with section of hydraulic cylinders for control of work of generator **5** including a (1. Stator blades, 2. Guiding shaft, 3. Crevice for guiding , 4. Girder of blades, 5. Guide, 6. Piston of cylinder CMx, 7. Cylinder Cmx, 8. Hydraulic links, 9. Cylinder Cmy, 10. Cylinder CGCLD, 11. Cylinder piston CGCLD, 12. Cylinder CMz, 13. Drive shaft, 14. Counterweight, 15. Ball bearing, 16. Piston of cylinder CMz, 18. Main shaft, 19. Rotor blade, 20. Cylinder CGCAA, 21. Eccentric bearing)

In FIG. **3** is shown a Presentation of transformation of translational speed at the entrance of stator into tangential speed at the exit from stator in regard to way of rotor blade. (Translational speed of aircraft).

In FIG. **4** is shown a Rotor of aerodynamic generator together with hydraulic Control head and drive shaft.

In FIG. **5** is shown a Blade of rotor including a (26. Guiding shaft bearer, 27. Blade body).

In FIG. **6** is shown a Cross-section of rotor blade.

In FIG. **7** is shown a periodic change of angle of attack of rotor blades in period of one rotation including a (Lift vector (L), Aerodynamical resistance force (Rx), Drive shaft center (**0**p), Center of Eccentric bearer (**0**e), Main shaft center (Og, Guiding shaft center (Ov).

In FIG. **8** is shown a periodic change of angel of attack of rotor blades in the state of produce of Lift and Propulsion's vector (P).

In FIG. **9** is shown a constant value of horizontal component of Lift Vector. (N) Horizontal component of Lift Vector. (Lr) Radial component of Lift Vector.

In FIG. **10** is shown a Control head of Lift Vector including a (28. Cylinders' carrier, 29. Cylinder carrier CGCLD, 30. Cylinder's carrier Cmz, 31. Carrier of rotating hydraulic link, 32. Electromagnetic link, 33. Rotating hydraulic link, 34. Drive shaft bearing, 35. Cylinder piston CMz)

In FIG. **11** is shown a Lateral section of hydraulic cylinders on control head of aerodynamical generator including a (36). Piston of cylinder CMy, 37. Spring, 38. Piston of cylinder PNU, 39. Spring for piston CMz)

In FIG. **12** is shown a Aeromobil, family version

In FIG. **13** is shown a Aeromobil, sports version.

In FIG. **14** are shown the Basic parts of Aeromobil including (Aerodynamic generator, 41. Fuel tank, 42. Engine group, 43. Seats, 44. Rotor of aerodynamical generator, 45. Stator of aerodynamical generator, 46. Main drive shaft)

In FIG. **15** is shown a Disposition of Lift vector in order of soaring or vertical translational motion.

In FIG. **16** is shown a Disposition of Lift vector and Thrust vector within horizontal translational motion.

In FIG. **17** is shown a Disposition of Thrust vector and Lift vector during production of turn around axis z.

In FIG. **18** is shown a Disposition of Lift vector during production of turning moment around axis y.

In FIG. **19** is shown a Disposition of Lift Vector during production of turning moment around axis x.

In FIG. **20** is shown the Steering controls of Aeromobil including (47. Distributor for group change of angle of attack, 48. Distributor for control of direction, altitude and laterally, 49. Thrust Vector pedal, 50. Brake Vector pedal.

In FIG. **21** is shown the Lateral section of Thrust Vector control including (51. Pedal, 53. Low pressure chamber tl. 54. High pressure chamber tl., 55. Hydraulic connection for CGCLD, 56. Pedal axle, 57. Low pressure connection tl., 58. Carrier tl. 59. Stopper tl, 60. High pressure chamber body).

In FIGS. **22** and **23** is shown the Section of Distributor of control direction, altitude and by lateral including (61. Lever, 62. Hydraulic connection for CMz, 63. High pressure chamber, 64. High pressure conductor, 65. Distributor cap for cylinders CMz, 66. Low pressure chamber body dl, 67. Hydraulic connection for CMy, 68. Breech, 69. Stopper, 70. Low pressure chamber, 71. Joint bowl, 72. High pressure connection, 73. Carrier, 74. Hydraulic connection for CMz 75. Low pressure connection, 76. Shaft of distributor cap CMz).

What is claimed is:

1. An aircraft comprised of:

a fuselage;

a drive shaft rotatably disposed in said fuselage, said drive shaft having an end;

an aerodynamic generator disposed around said end of said shaft consisting of an aerodynamic rotor attached to said end of said shaft; and

an aerodynamic stator fixed to said fuselage over said rotor;

a control device fixedly attached to said fuselage;

said control device having an actuator;

said control device controlling said aerodynamic generator with said actuator;

said control device being responsive to a plurality of commands;

wherein said aerodynamic generator produces an aerodynamic force in response to one of said commands whose intensity, direction and sense of direction can be controlled through said control device;

wherein vertical lifting and landing are achieved by orienting the direction and sense of direction of the aerodynamic force vertically in respect to the horizon plane;

wherein said aerodynamic rotor further comprises a blade carrier fixedly attached to said shaft end;

four aeroprofiles disposed symmetrically about said shaft on said blade carrier, said aeroprofiles having a Main Axis and a Guided Axis;

said control device including an eccentric bearing having an eccentric axis;

a guide linkably connecting said eccentric bearing and said guided axis of said aeroprofile;

wherein the aeroprofiles are rotatably connected to said blade carrier about the Main Axis of the aeroprofile;

said aeroprofiles rotating around the Drive Shaft and oscillating in circles around the main axis of the aeroprofile wherein the Eccentric Bearing can be translated with respect to the Drive Shaft and can rotate around a center of Drive Shaft from 0 to 360°;

wherein translating the center of the Eccentric Bearing with respect to the Drive Shaft provokes an eccentricity of the Eccentric Bearing which is then transmitted by the Guide-bar to the Guided Axis on the rotor aeroprofiles, causing rotation of the aeroprofile around the Main Axis for the angle of attack proportional to the eccentricity of the Guide-bar and which in one full revolution changes as function of a sinus of an angle of the aeroprofile with respect to a center of Drive Shaft.

2. An aircraft comprising:

a fuselage;

a drive shaft rotatably disposed in said fuselage, said drive shaft having an end;

an aerodynamic rotor attached to said end of said shaft;

wherein said aerodynamic rotor comprises a blade carrier fixedly attached to said shaft end and four aeroprofiles disposed symmetrically about said drive shaft on said blade carrier, said aeroprofiles having a main axle and guided axle and being connected to said blade carrier for rotation around the main axle;

a control device being responsive to a plurality of commands, said control device being fixedly attached to said fuselage and including an eccentric bearing and said guided axle of said aeroprofile;

wherein said aeroprofiles rotate around said drive shaft and oscillate in circles around said main axle of the aeroprofile, and said eccentric bearing can be translated with respect to said drive shaft and can rotate around a center of said drive shaft from 0 to 360 degrees;

wherein translating the center of the eccentric bearing with respect to the drive shaft involves an eccentricity of said eccentric bearing which is then transmitted by a guide-bar to said guided axle of said aeroprofiles, thereby causing rotation of said aeroprofile around said main axle for changing an angle of attack proportional to said eccentricity, said angle of attack changing during one full revolution as a function of a sinus of an angle of said aeroprofile with respect to a center of said drive shaft, whereby said aerodynamic rotor produces an aerodynamic force in response to one of said commands whose intensity, direction and sense of direction can be controlled through said control device;

wherein vertical lifting and landing of said aircraft are achieved by manipulating the translation of the center of the eccentric bearing with respect to said drive shaft and orienting the eccentricity of the eccentric bearing, on all four rotors, vertically in respect to the horizontal plane;

wherein horizontal flight of said aircraft is achieved by orienting the eccentricity of said eccentric bearing, on all four rotors, under certain angle in respect to the horizon, and depending on whether the angle of rotation is in respect to the front or back part of the aircraft horizontal flight forward or backward, respectively, is obtained;

wherein rotation of said aircraft around pitch axis is obtained by opposite changing the eccentricity of said eccentric bearing on two front-side rotors with respect to two back-side rotors in a way that if the eccentricity on front-side rotors is increased, the eccentricity on back-side rotors is decreased for the same value;

wherein rotation of said aircraft around roll axis is obtained by opposite changing the eccentricity of the eccentric bearing on two left-side rotors in respect to two right-side rotors in a way that if the eccentricity of the eccentric bearing on left-side rotors is increased, the eccentricity of the eccentric bearing on right-side rotors is decreased for the same value;

wherein rotation of said aircraft around vertical axis is obtained by opposite rotating the eccentricity of the eccentric bearing on two left-side rotors in respect to two right-side rotors in a way that if the rotation of the eccentricity of the eccentric bearing on left-side rotors changes for a certain angle towards front part of the aircraft and on the left-side rotors towards back part of the aircraft or the opposite, the rotation leftward or rightward, respectively, will be obtained;

wherein all commands of the said aircraft are independent one from another and can be applied one by one individually or all of them simultaneously, without changing the sense of any of them; no matter in which position and speed the aircraft is.

* * * * *

PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvement relating to Aircraft

We, NIKOLAUS LAING, of Albrecht-Dürer-Weg 14, Stuttgart-N., Germany, and BRUNO ECK, of Geissbergstrasse 24, Köln-Plettenberg, Germany, both of German nationality, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to aircraft.

Aircraft have hitherto normally been powered by motor-driven axial flow fans, whether unducted or ducted.

The present invention provides an aircraft where at least a part of the vertical and/or horizontal thrust required in flight is provided by air ejected by one or more motor driven blowers each comprising a bladed cylindrical rotor and means to guide air twice through the blades of the rotor in a direction always transverse to the rotor axis, said rotor and guide means being such as to stabilize in operation a cylindrical vortex eccentric to the rotor axis whereby to guide air through the rotor in a curved path, the flow tubes with the highest velocity traversing the blades where they have a velocity component opposite to the main direction of flow through the rotor.

In the following, preferred forms of blower will first be described: after this various drive means will be discussed and thereafter various aircraft will be mentioned incorporating the preferred blowers and drive means.

The invention will now be described with reference to the accompanying diagrammatic drawings, in which:—

Figure 1 shows the flow of air through a blower which can be used with aircraft according to the invention;

Figure 2 shows an ideal relation of vortex to rotor in a blower according to the invention;

Figure 3 is a vector diagram showing air velocity at the inner and outer edges of a blade of the rotor;

Figure 4 shows in cross-section a rotor blade construction for increasing turbulence;

Figure 5 shows a combination of rotor and guide means in which the guide means are contained within the rotor;

Figure 6 is a diagram showing the shaft power and the efficiency of the blower plotted against the flow coefficient;

Figure 7 is a front view of a rotor showing means for supporting the blades;

Figure 8 shows two rotors coupled to one drive means;

Figures 9 and 10 show in front and end elevation respectively, a rotor arranged to be driven by a gas stream from, for example, the exhaust of a gas turbine;

Figures 11 and 12 show another arrangement for driving a rotor, in which the rotor carries axial-flow turbine blades;

Figures 13 and 14 show still another arrangement for driving the rotor by turbine blades associated therewith;

Figure 15 shows in section a double rotor blower according to the invention;

Figure 16 shows in section another double rotor blower;

Figures 17 and 18 show respectively a front view and a part end view in section of a thrust unit suitable for use in an aeroplane or a helicopter;

Figure 19 is a top plan view of a high-speed aircraft according to the invention, showing the arrangement of blowers to provide thrust, a central part of the figure being a vertical transverse section;

Figures 20, 21 and 22 are respectively a plan, an end elevation, and a side elevation of a vertical lift aircraft, and show the arrangement of blower therein, Figures 20 and 21 showing some parts cut away;

Figures 23, 24 and 25 are three views similar to Figures 20 to 22 of another vertical lift vehicle aircraft in operative conditions;

Figures 26, 27 and 28 show the aircraft of Figures 23 to 25 with blowers folded to unoperative condition for use of the aircraft as a road vehicle;

Figure 29 is a diagram showing how folding takes place in the aircraft of Figures 23 to 28;

Figures 30 and 31 show a modification of the vertical lift vehicles shown in Figures 23 to 29, Figure 30 being a front view section and Figure 31 a partial transverse section;

Figures 32 and 33 show an arrangement for long range aircraft or rocket, Figure 32 being a partial longitudinal vertical section and Figure 33 a partial transverse section;

Figures 34 and 35 are respectively a side elevation and a partial plan of a blower arrangement for a piston-engined light aeroplane, parts of both figures being shown cut away;

Figures 36, 37 and 38 are respectively partial side, plan, and end views of a glider with auxiliary power, and

Figures 39 and 40 show respectively a partial plan and side view of an aeroplane according to the invention with built-in rotors.

Referring to Figure 1, the blower there diagrammatically shown comprises a drum-shaped rotor designated generally 1 having its interior entirely clear of obstruction, which rotor is mounted, by means not shown, for rotation about the axis of the drum and driven at a predetermined speed in the direction of the arrow 2, also by means not shown. The rotor 1 is provided with blades 3 extending longitudinally and having inner and outer edges 4, 5 lying on inner and outer cylindrical envelopes indicated at 6, 7. The blades are concave facing in the direction of rotation, and have their outer edges leading their inner edges.

Guide means are provided adjacent the rotor 1. This guide means comprises a guide body 9 extending the length of the rotor. The guide body 9 divides the suction region S from the pressure region P; that part of the body 9 which is chiefly effective to influence flow through the rotor 1, being the wall portion 9*a*, lies spaced from the rotor by more than one third of the rotor blade depth, is gently curved and convex to the rotor, and extends over only a very small arc thereof; (in fact it subtends at the axis of the rotor an arc of less than 20°).

The ends of the blower are closed off by walls, not shown.

In operation of the Figure 1 blower a Rankine vortex is set up, the core of which is eccentric to the rotor axis, and indicated by the flow lines shown chain dotted at V; the whole throughput flow twice through the rotor blades 3 in a direction always perpendicular to the rotor axis as indicated in general direction only by the chain dotted flow lines F. Figure 2 shows the distribution of velocity in the vortex. The chain dotted line 21 represents a radius of the rotor taken through the axis 22 of the vortex core V. Velocity of fluid at points on the line 21 by reason of the vortex is indicated by the horizontal lines 23*a*, 23*b* etc., the length of each line 23*a*, 23*b* etc. being a measure of the velocity at the point $23a^1$, $23b^1$ etc. respectively. The envelope of these lines is shown by the curve 24, which has two portions, one 24*a* approximately a rectangular hyperbola and the other, 24*b*, a straight line. The curve 24*a* relates to the field region of the vortex and the curve 24*b* to the core: it will be understood that the curves are those of an ideal or "mathematical" Rankine vortex and actual flow conditions will only approximate to these curves.

The core of the vortex is a whirling mass of air with no translational movement as a whole, and velocity diminishes going from the periphery of the core to its axis 22. The core V intersects the inner blade envelope. The vortex core V is a region of low pressure, and the location of the core can be discovered by investigation of pressure distribution within the rotor. Although for convenience the vortex core V have been shown circular and has been regarded as possessing an axis, the core will usually not be truly circular.

The velocity profile of the fluid at the second entrance thereof to the rotor blades will be that of the vortex. In the ideal case of Figure 2 this profile will be that of the Rankine vortex there shown by curves 24*a*, 24*b*: in an actual case the profile will still have the general character of a Rankine vortex. Thus there will be in the region of the periphery of the core V a flow tube of high velocity indicated at MF in Figure 1 by the heavier chain dots while the flow tubes remote from the periphery of the core will have a very much smaller velocity.

It will be appreciated that much the greater amount of air flows in the flow tubes in the region of maximum velocity. With a given construction the physical location of the flow tube MF is fairly closely defined. Therefore in the restricted zone of the rotor blades 3 through which this flow tube MF passes, the relative velocity between blades and fluid is much higher than it would be in a flow machine which, following the principles adhered to hitherto in the art, was designed for a rectangular velocity profile and uniform loading of the blades in the zones thereof where fluid passes.

In the restricted blade zones through which the flow tube MF passes there will be much less separation and energy loss than if that tube flowed at the average velocity of throughput taken over the whole area of the zone of the blades through which fluid can pass, that is, transfer of momentum to the fluid occurs under excellent conditions. The transfer of momentum in the flow tubes travelling below the average velocity will be poorer, but on balance there is a substantial gain. It will be seen that ideally the maximum velocity flow tube MF undergoes a change of direction of about 180° in passing through the interior of the rotor. Including the traversals of the blades the change of direction will then exceed 180°. It is particularly to be noted that the major part of the throughput (represented by the flow tube MF) passes through the rotor blades where they have a component of velocity in a direction opposite to the main direction of flow within the rotor.

A vector diagram is shown in Figure 3 for the velocities at the points 34 and 35 where the maximum velocity flow tube MF intersects inner and outer envelopes 6, 7 of the blades 3. In the diagram V_{P1} is the peripheral velocity of the inner edge of the blade 3 at the point 34, V_{A1} at the absolute velocity of the air in the flow tube MF at the point 34, and V_{R1} the velocity of that air relative to the blade as found by completing the triangle. The direction of the vector V_{R1} coincides with that of the blade at its inner edge and fluid enters the blade without shock. Similarly, V_{P2}, V_{A2} and V_{R2} respectively represent the peripheral velocity, the absolute velocity of the air, and the velocity of the air relative to the blade, at the point 35 on the outer edge of blade 3. It is considered that the blade angles and blade curvature determine the character of the vortex while the position of the vortex core is determined by means of the guide body (the body being in the example of Figure 1 designated 9, and that part of it chiefly of influence on the vortex being shown at 9*a*). It is considered that in a given case the particular blade angles and blade curvature, depend on the following parameters among others: the diameter of the blades, the depth of a blade in radial direction, the density and viscosity of the fluid, the disposition of the external guide body and the rotational speed of the rotor, as well as on the ratio between overall pressure and back pressure. These parameters must be adapted to correspond to the operating conditions ruling in a given case. In order to put the invention into practice in a given case quite definite blade angle and shape have to be adopted: this means not only the curvature of a blade of uniform thickness, but also the curvature of the contours of profiled blades. Whether or not the angle and shape of the blades have been fixed at optimum values is to be judged by the criterion that the flow tubes close to the vortex core should be deflected by approximately 180°.

Figure 4 shows a rotor blade construction that can be used in a flow machine according to the invention where it is desired to increase the turbulence of the boundary layer flowing over the blades. The blades 40 illustrated in Figure 4 have thickened inner edges 41 which, besides increasing turbulence, reduce the shock at entry to the blades of the lower-velocity flow tubes. Further increase of turbulence can be obtained by flutings 42 as shown at the inner edge of one of the blades 40.

Figure 5 shows another combination of rotor and guide means: the rotor 1 is similar to that of Figure 1 and will not need further description. The reference numerals used in connection with the rotor have the same significance as in Figure 1. Unlike the rotor and guide body combination of Figure 1 where the rotor has its interior completely unobstructed and the guide means are outside it, in this instance the guide means are entirely contained within the rotor. These guide means comprise four spaced aerofoil guide bodies 50, 51, 52 and 53 located stationary within the rotor 1 and extending with constant cross-section over its whole length: of these guide bodies 50—53, the first three designated 50, 51 and 52, have the median lines 50¹, 51¹ and 52¹ of their cross-section forming smooth curves which are without point of inflection. Supplementary guide bodies 54, 55 and 56 of thin sheet material, also extending the length of the rotor and forming in section smooth uninflected curves, are mounted at the downstream side of the flow channels between the guide bodies 50—53, one supplementary guide body in each channel. Control flaps are mounted within the rotor 1 with their axes lying in a common plane and intersecting the rotor axis. In the section illustrated three flaps are shown at 57*a*, 57*b* and 57*c*, one for each of the three channels defined between the guide bodies 50—53, which are rotatable in the manner of butterfly valves about a common axis 58 The flaps can be set to produce negiligible obstruction to through-flow, or to prevent flow altogether, or to intermediate positions.

It will be appreciated that the vortex core V formed about the guide body 53 of Figure 5 has the same sort of flow-guiding-effect as the vortex core V of Figure 1, in that fluid circulates around this body through the rotor blades, a vortex forms, and a velocity profile having the character of that of a Rankine vortex is imposed on the fluid at its second entrance to the rotor blades.

In Figure 6 η and N_w are represented as ordinates and ϕ as abscissae. These symbols are defined as follows:—

$$\eta = \frac{\text{energy added to the throughput}}{\text{shaft power taken by blower}}$$

N_w = shaft power taken by blower

$$\phi = \frac{\text{throughput per unit time}}{\text{effective surface of rotor} \times \text{peripheral speed of rotor}}$$

(As will be understood, η is efficiency and ϕ is a dimensionless number representative of the throughput per unit time).

The η/ϕ and N_w/ϕ curves shown in Figure 6 relate to a blower as described with reference to Figures 1 to 4.

The first main point of interest is that as throughput is throttled to zero, so the power taken diminishes to nearly zero: this contrasts with axial flow blowers where throttling does not substantially reduce, and may even increase, the power taken.

The second main point of interest is the flat top of the η/ϕ curve showing a wide working range between the points A, B.

The degree of throttling in a blower as shown in Figures 1 to 4 can readily be varied by modification of the vortex. For this purpose the core region V can be displaced: alternatively, or in addition, it can be expanded. Where a guide wall is placed opposite the guide body 9, as in numerous embodiments later described, throttling can be modified by moving this wall towards or away from the guide body. Various ways of modifying the vortex are described in the specification of the copending Application No. 20871/57 (Serial No. 876,611) which should be referred to.

By varying the throttling the blower can be adapted to the variation of the coefficient η which diminishes with increasing altitude, without any change in the speed of the blower.

The efficiency of the above described blower is lower than that of large airscrews, and is approximately equal to that of small airscrews. The reason for this is that the correlation of the vectors described by reference to Figure 3 with the flow lines of the vortex field can be an optimum only within a narrow entry and exit region and although this accounts for the major part of the flow it does not account for all of it.

Figure 7 illustrates one method of securing and stiffening the blades 3 of a cross-flow blower e.g. that of Figure 1. Discs or rings 70 are spaced axially along the rotor and the blades 3 are secured to the discs or rings. When desirable, discs and rings may be used alternately.

The Figure 8 arrangement comprises a pair of rotors 81, 82 each similar in construction to the rotor shown in Figure 7. Drive means for the rotors 81, 82 is shown at 83 and may be of any convenient kind: this drive means drives a shaft 84 one end of which is rigid with one end of the rotor 81. The other end of the rotor 81 carries a stub-shaft 85 supported by a self-aligning bearing of which only the inner or rotatable part is shown at 86. The other end of the shaft 84 is connected by means of a universal coupling 87 to a stub-shaft 88 rigid with the adjacent end of the rotor 82.

The rotor 82 can take up an angle to the axis of the shaft 81—(one extreme position is shown chain dotted at 82[1])—without this interfering with either the supporting or the driving of the rotor. Thus the mounting arrangement of the rotor 82 can be used where the supporting structure is not absolutely rigid or where absolute alignment of shaft and bearings is either not practicable or for some reason it is not desired to go to the trouble of such alignment.

Figures 9 and 10 show a method of driving by means of gas stream a rotor similar in principle to the rotor above described. The rotor, designated generally 90, comprises a number of sections 91 each consisting of fan blades 3 supported between discs 92. Each disc 92 carries beyond the envelope of the fan blades 3 a narrow ring of axial flow turbine blades 93 mounted between inner and outer cylindrical shrouds (the outer one *93a* only being shown). The gas stream is led to the blades 93 by a narrow duct 94 having its end portion 95 embracing the turbine blades 93 over some 90° of the periphery of the rotor. The duct portion 95 carries a series of fixed blades 96 which guide the gas stream generally axially into the turbine blades 93. Gas leaving the blades 93 enters a section 97 of the duct portion 95 which guides it into the fan blades 3 adjacent the corresponding disc 92. The turbine blades are curved not only in the sense usual in axial flow turbine blades, but also so as to give the gas in the duct section 97 a radially inward component so that they add energy to the fan blades on passing therethrough.. Gas entering the fan blades 3 mixes with the air which flows therethrough in the manner previously described.

It will be understood that in operation the fan blades 3 of the rotor 90 will be associated with a guide body as previously described.

Figures 11 and 12 show another method of driving a rotor by means of a gas stream. The rotor generally designated 110 is divided into a number of sections 111 each comprising fan blades 3. Each section 111 has a narrow ring of axial flow turbine blades 112 at one end thereof, the turbine blades 112 being in the same peripheral zone of the sections 111 as the fan blades 3. Annular ducts 113 for the gas stream are disposed adjacent each ring of turbine blades 112. A ring of stator blades 114 is provided in each duct

113, so that the gas stream is directed by each ring of stator blades 114 onto the turbine blades 112 with a major velocity component in the axial direction. Gas leaving the blades 112 on each section 111 is directed between the blades 3 where it mixes with the air stream passing therethrough. Unlike the method illustrated in Figures 9 and 10 the gas does not add energy to the fan blades 3. The gas may be supplied to the ducts 113 from the exhaust of a gas turbine indicated only schematically by the chain-dotted lines 120.

Figures 13 and 14 show a still further method of driving a blower rotor here designated 130 by means of a gas stream. The rotor 130 comprises sections 131 having blades 3 and operating as described with reference to Figures 1 to 4: adjacent sections 131 are separated by a narrow ring of impulse turbine blades 132 mounted between rings 133 which also support the blades 3. Each ring of impulse blade 132 is embraced by a narrow volute 135 supplied with gas under pressure. Nozzles 134 on the inside of the volute 135 are directed generally tangentially to the rotor 130 so that gas issuing from the nozzles 134 impinges upon the blades 132 so as to rotate the rotor. The gas travels to the inside of the rotor 130 and mixes with the airstream which is caused to traverse the blades 3.

It will be under stood that the rotors of Figures 7 to 14 are intended to co-operate with a guide body as explained with reference to Figure 1.

The Figure 15 flow machine includes two similar contra-rotating bladed rotors 150, 151 mounted adjacent one another on parallel axis, the direction of rotation being indicated by the arrows 152 but the driving means not being shown. Guide members 153, 154 for the rotor 150 and 155, 156 for the rotor 151 extend the length of the rotors with constant cross-section and define entry arcs 150*a* and 151*a* for the rotors and a common exit duct 157. Guide members 153, 155 provide walls 153*a* and 155*a* on the exit side of rotors 150 and 151 the radius whereof from the rotor axis increases steadily in the direction of rotation from the point of nearest approach. At their lines of nearest approach to the rotor these walls 153*a* and 155*a* are spaced substantially more than a working clearance from the blades. Guide members 154, 156 provide on the exit side of rotors 150, 151 walls 154*a* and 156*a* convering with the rotor in the respective direction of rotation, auxiliary bodies 154*b* and 156*b* being located in the wedge-shaped recess thus formed. In operation a Rankine vortex forms in each rotor 150, 151 having a core shown at V, and flow is induced as indicated by the lines F. The foregoing description of flow conditions in the fan unit of Figure 1 is referred to to complete the description of what is shown in Figure 15.

The guide members 153, 155 define between them a gap 158 and an additional fluid flow in induced through this gap.

It will be seen that the rotor, guide members and guide walls thereof, and vortices and flow lines form a mirror image of one another about a plane indicated at 159. This gives the advantage that the flow from one rotor acts as a guide wall for the flow from the other thus avoiding the need for the physical presence of separate guide walls one for each flow: the arrangement also avoids the skin friction which such actual guide walls would cause. Now this friction, if it were acting, would affect the slowest stream tubes most, thus accentuating the peaky nature of the velocity profile which is produced at the outlet from the rotor on following the teaching of our aforesaid specification. Thus the Figure 15 construction minimizes this peaky profile and enables the profile at the outlet from the machine to approximate to rectangular without excessive mixing losses. An approximate velocity profile for the exit 157 is shown in dash-dotted lines at 157*a*.

Figure 16 shows a blower similar to that of Figure 15 except that there is no gap through which fluid is introduced in addition to that flowing through the rotors. The same numerals are used as in Figure 15, the guide members 153', 155' being distinguished by a prime because of the absence of a gap between them.

Figures 17 and 18 show an arrangement of two rotors 170, 171, coupled to two turturbines 172 and 173. Each rotor has four sections 172' and 173' respectively, provided with fan blades 3 and is supported on bearings 174 to 177. The rotors 170, 171 are arranged to operate as a double rotor in the manner described with reference to Figure 16 above, guide bodies 178, 179 and 180 being provided along the length of the rotors to guide the air flow and to create the vortices. The turbines 172 and 173 are disposed coaxially with the rotors 170, 171 respectively: clutches can be provided to disconnect the rotors from the turbines. Means may be provided (not shown) at the bearings 174 to 177 to hold these bearings rigidly when starting up and to release the bearings successively when the critical speed of revolution is reached so that the rotors 170, 171 may act as flexible shafts.

It is contemplated that the double-rotor arrangement of Figure 17 can be used—possibly in multiple units—to provide lift in a high speed V.T.O.L. aircraft wherein forward thrust is provided by one or more jet propulsion units:—

Such air aircraft would maintain a horizontal position not only in normal flight but also in take-off and landing. The power consumption of such an arrangement would exceed that of a comparable helicopter but would be less than that developed by the jet propulsion unit or units, so that for take-off and landing the turbines 172, 173 could be driven by the exhaust from the jet propulsion unit or units, using jet deflecting means. Thus the net extra weight due to the Figure 17 lift arrangement would be small. This proposal is considered especially applicable to supersonic aircraft.

The Figure 17 arrangement, or analogous arrangements, could be used also in wingless aircraft or in craft resembling motor vehicles, or, for example, inflatable boats for air-sea rescue operations, or rocket launchers. Certain examples of such utilization of the Figure 17 arrangement or modifications thereof are described with reference to the following figures. In all cases the relatively large cross-section of the jet (i.e. that of the passage between the guide bodies 178, 180) and the approximately rectangular velocity profile across this cross-section (see Figure 15) promote economy in power consumption.

As regards the possible modifications just referred to, several rows of rotors can be arranged side by side, as later illustrated. Moreover, multi-stage blowers can be used, comprising serially connected stages each constructed on the principles enunciated with reference to Figures 1 to 3, a diffuser being interposed between successive stages. Multi-stage blowers are recommended where space is limited.

Figure 19 illustrates a high-speed (e.g. supersonic) delta-wing aircraft wherein the lift for vertical flight is generated by four rotors 190 driven by three interconnected turbines 190*a*. Air enters from the top through openings 91 flush with the upper wing surface and issues out of the rotors in the direction 192. Stabilisation of the aircraft in vertical flight can be effected by jets at 193 and 194. In high speed flight, when the delta-wing provides the required lift, the openings 191 can be closed by covers 196. The part of Figure 19 showing the rotors 190 in section which part is bounded by the wavy line 199 is a projected view at right angles to the rest of the figure.

It will be appreciated that the Figure 19 rotor arrangement is broadly similar to a pair of Figure 17 arrangements side by side.

The Figure 19 aircraft can be modified for use in the subsonic speed range.

Figures 20, 21 and 22 shows a vertical lift aircraft which can also be used as a road vehicle. Four rotors 200, each in four sections are shown, these rotors being driven by a centrally located twin power unit 200*a*. Air enters from the top at 201 and 202 on either side of the fuselage 205 and issues out of the openings 203 and 204. A cowling 206 prevents the air from escaping laterally during the take-off of the aircraft, thus helping the lift and reducing the amount of dust that may be sucked into the intake. The rotors are equipped with control means (not shown) such as previously referred to; adjustment of these control means enable manoeuvre of the aircraft as desired. For use as a road vehicle the wheels 207 are swung from retracted to operative position. The power unit can be jettisoned in emergency. Because of its central position this will not affect the equilibrium of the aircraft.

Figures 23 to 28 show another vertical-lift vehicle also suitable for road use. On either side of a fuselage 230 there is mounted in a frame 231 fixed thereto a pair of rotors 232 arranged side by side longitudinally of the vehicle and associated with guide means (e.g. as shown in Figures 1 to 3) rigid with the frame. A further pair of rotors 233 similar to the first pair is mounted on either side of the fuselage 230 is a sub-frame 234 pivoted to the frame 231 at 235. The sub-frames 234 can be pivoted between an extended or operative position shown in Figures 23 to 25 and a retracted or non-operative position shown in Figures 26 to 28. In the first position the axes of the rotors 232, 233 lie more or less in a horizontal plane, while in the second position the sub-frames 234 overlie the frames 231; in this latter position of the sub-frames 234 the vehicle can be used as a road vehicle, for which purpose wheels 236 are provided. Each rotor 232, 233 is driven (through reduction gearing if required) by a turbine 237 connected by a conduit 238 to a single central gas-generator 239. The conduits to the rotors 233 are such as to permit the required pivoting. Alternatively a piston engine could drive the rotors through gear trains.

In modifications of the embodiment of Figures 23 to 28 the sub-frames 234 can be made to stack on the frames 231 instead of to fold thereover.

Figure 29 is an enlarged view showing the folding of the sub-frames 234 upon the frames 231.

In jet lift machines the following relation applies:—

$$n \approx 1/\sqrt{F}$$

where n is the power taken and F the cross-sectional area of the jet outlet. The embodiment of Figures 23 to 28 enables a comparatively large value of F to be obtained with a compact mechanical arrangement: the arrangement is in fact fore compact for a given shaft power and weight than the equivalent conventional helicopter.

The aircraft of Figures 30 and 31 is a modification of that of Figures 23 to 29: like the aircraft of those figures it comprises four rotors 300 arranged close together on each side of a central fuselage 301, the outer two rotors on each side being foldable to a retracted position indicated in dots 302 from the extended or operative condition shown in full lines. The rotors 300 when in extended condition lie—as seen in transverse section—on an arc 300*a* symmetrical with the fuselage 301 and concave towards the ground. Each rotor 300 is associated with a guide body 303 which performs the same general function as the guide body 9 of Figure 1: the guide bodies 303 divide the rotors 300 one from the next and define an entry area for each rotor indicated approximately at 304, and also an exit area indicated at 305. By reasons of the shape of the guide bodies and more especially the dispositions of the axes of the rotors 300 on an arc the entry areas are much greater than the exit areas, as is appropriate to the much greater velocity of air across the exit areas. In the arrangement shown the jets of air from the rotors 300 on each side coalesce to form a single homogeneous jet of large area.

Instead of disposing the rotor axes on an arc as seen in transverse section the axes could be arranged on the equal sides of an isosceles triangle symmetrical with the fuselage. The arc shown approximates to such a triangle; in fact Figure 31 shows a variation in the shape of guide bodies 303 as compared with Figure 30.

Figures 32 and 33 show a vertical-lift launcher for a rocket 320; alternatively the launcher could be modified to serve for a long-range aircraft. Three arms 321 radiate symmetrically and horizontally from a central annular supporting platform 322 providing a guideway 322*a* for the rocket and each arm mounts four rotors 323 running parallel to each other and longitudinally of the arm. A depending housing 324 is carried at the end of each arm 321 within which are located two vertically arranged gas turbine propulsion units 325 which drive the rotors 323 of that arm: downwardly and outwardly directed exhaust cowlings 326 for the power units 325 permit exhaust therefrom to add to the lift produced on rotation of the rotors 323. Wheels 327 project downwardly from the housings 324 to provide support for the apparatus when on the ground.

On account of the symmetrical arrangement of the launcher the rocket 320 leaves it without causing any shift in the centre of gravity: slits 328 are provided in the central platform 322 to allow the tail fins 329 of the rocket to pass through it on launching.

Figures 34 and 35 show a light aeroplane with a propulsion unit 340 generally similar to that of Figure 15 arranged on an inclined axis behind the pilot's cabin 341. The cabin 341 is suspended from wings 342 of conventional construction and a tail 343 is carried rearwardly on a boom 344.

The rotors of the propulsion unit 340 are shown at 345 and are driven by small high speed piston engines 346 without reduction gearing. The power unit 340 can be throttled, either by movement of the guide body (not shown) stabilizing the vortex of each rotor 345 or by movement of deflecting members (also not shown), when the aircraft is near the ground and opened up when the aircraft has gained height.

This aircraft has various advantages: thus airscrew drag when gliding is eliminated, as also the danger of accidents arising from a revolving airscrew; in addition an engine 346 can be jettisoned in emergency.

Figures 36, 37 and 38 show a glider with auxiliary power. The glider comprises a normal wing and fuselage arrangement (these elements being designated 360, 361 respectively) and in addtion a propulsion unit designated generally 362 pivotally mounted in the fuselage behind the cabin 363 for angular movement about a transverse axis 362*a*. The propulsion unit 362 includes a high speed internal combustion engine 364 of the opposed-piston type and a blower 365 comprising a rotor 366 driven directly by the engine and guide means designated generally 367 co-operating with the rotor: the blower is constructed as previously described with reference to Figures 1 to 3. The pivotal mounting of the propulsion unit 362 enables it to adopt either the operative position shown in the figures where the blower 365 projects vertically above the fuselage, or a retracted position wherein the blower is accommodated in a longitudinal slot 368 in the fuselage 361. The propulsion unit 362 can be adjusted to intermediate positions; for gliding the unit 362 is moved to its retracted position wherein it produces no drag.

In an alternative arrangement the rotor can be arranged transversely in the fuselage.

Figures 39 and 40 show an aeroplane with wings 390, fuselage 391 and tail plane 392. The wings 390 have jet flaps adapted to produce forward thrust, having longitudinally arranged blowers comprising rotors 393 mounted within the wing section as seen in Figure 40. The blowers are constructed as previously described with reference to Figures 1 to 3 and the rotors of both wings are driven by a single engine 394 disposed centrally in the fuselage. The engine 394 may as shown be of the high speed radial type and may have a cooling air duct in the form of a volute discharging rearwardly at 395 to supplement the forward thrust. Although in the aeroplane of Figure 39 and 40 the whole of the forward thrust is developed by the jet flaps, this aeroplane could be modified to have additional, or alternative, means for producing thrust in normal flight (e.g. turbo-jet or ram jet power units) the jet flaps being used only to generate lift during take-off and landing.

Attention is drawn to the claims of the following specifications, which may cover some of the embodiments herein described:—

20871/57(Serial No. 876,611), 44292/60 (Serial No. 876,612), 44293/60 (876,613).

Attention is drawn to copending Applications 29473/61 (Serial No. 885,665) and 29475/61 (Serial No. 885,666).

WHAT WE CLAIM IS:—

1. An aircraft wherein at least a part of the vertical and/or horizontal thrust required in flight is provided by air ejected by one or more motor-driven blowers each comprising a bladed cylindrical rotor and means to guide air twice through the blades of the rotor in a direction always transverse to the rotor axis, the rotor and guide means being such as to stabilize in operation a cylindrical vortex eccentric to the rotor axis whereby to guide air through the rotor on a curved path, the flow tubes within the highest velocity passing through the rotor blades where the blades have a velocity component opposite to the main direction of flow through the rotor.

2. An aircraft as claimed in Claim 1, wherein one guide means includes a guide body outside the rotor and extending the length thereof with constant section, the interior of the rotor being clear of stationary guides.

3. An aircraft as claimed in Claim 1, wherein said guide means includes at least one body which is prevented from rotating with the rotor, which extends within the rotor along the length thereof, which divides the fluid flow within the rotor so that a substantial part of the flow takes place on each side of the body, which has a cross-section the median line of which is a generally smooth curve which is without inflection, and which guides the fluid flowing over each side of the body so as to flow in a path curved in the same sense as the median line.

4. An aircraft as claimed in Claim 3, wherein a plurality of guide bodies are located within the rotor and said bodies comprise a plurality of aerofoils of constant cross-section along the length of the rotor.

5. An aircraft wherein at least a part of the vertical and/or horizontal thrust required in flight is provided by air ejected by one or more motor-driven blowers each comprising a bladed cylindrical rotor and means to guide air twice through the blades of the rotor in a direction always transverse to the rotor axis, said guide means including a guide body which extends the length of the blades and outside it, the angles and curvature of the blades being chosen so that in operation the rotor blades and the body form and stabilize an approximately cylindricals vortex including a field region with a velocity profile approximately that of a Rankine vortex and a core region eccentric to the rotor axis and induce the flow tubes with the highest velocity to pass through the blades where they have a component of velocity in a direction opposite to the main direction of the flow within the rotor, the guide body dividing the suction region from the pressure region, the guide body (or at least that part of it which chiefly affects flow through the rotor) extending over only a small arc of the outer blade envelope so that the stream of tubes of the throughput nearest the vortex core leave the blades on their second traversal with a velocity component in the opposite direction to the velocity with which those stream tubes enter the blades at their first traversal and the velocity profile at the second entrance to the rotor blades having the general character of the velocity profile, of said Rankine vortex, the interior of the rotor being clear of stationary guides at least over a substantial part of its cross-section adjacent the guide body.

6. An aircraft as claimed in either of Claims 2 or 5, including a guide wall extending the length of the blades and defining with the guide body an exit arc from the rotor.

7. An aircraft as claimed in any of the preceding claims including means to vary the throughput of air through the blades for a given angular velocity of the rotatable member.

8. An aircraft as claimed in Claim 7, as dependent on Claim 3 or on Claim 4, wherein said throughput-varying means comprises flaps pivotally mounted within the blades about axes perpendicular to the rotor axis so as to be movable between a position in whiach they substantially close off the interior of the blades and a position in which they present negligable resistance to the flow therethrough.

9. An aircraft as claimed in Claim 6, wherein the guide wall approaches nearest the blades at a line which is spaced substantially more than a working clearance from the blades.

10. An aircraft as claimed in any of the preceding claims, wherein the rotor is reinforced by a plurality of discs or rings secured to the blades at intervals along the length of the rotor and extending in planes perpendicular to the rotor axis.

An aircraft as claimed in any of the preceding claims, wherein the motor driving the rotor comprises one or more turbine blade rings forming a unitary structure with the rotor and disposed coaxially therewith.

12. An aircraft as claimed in Claim 11, wherein the rotor is divided along its length into a series of sections and one turbine blade ring is associated with each rotor section.

13. An aircraft as claimed in Claim 11 or Claim 12, wherein each blade ring is an axial-flow ring discharging gas into the rotor blades.

14. An aircraft as claimed in any of Claims 11 to 13, wherein each blade ring lies beyond the outer cylindrical envelope of the rotor and is associated with a duct for a gas stream which is adapted to lead the gas through the ring from one side to the other and then to direct it inwardly so that it traverses the rotor blades adjacent said ring.

15. An aircraft as claimed in Claim 14, wherein said duct terminates in an arcuate por-

tion which embraces the blade ring thereof and carries fixed blades which impose upon the stream in said arcuate duct portion a velocity component along the rotor axis.

16. An aircraft as claimed in Claim 13, wherein each blade ring lies substantially within the outer cylindrical envelope of the rotor and is adapted for dischange of gas directly into the rotor blades adjacent said ring.

17. An aircraft as claimed in Claim 11 or in Claim 12, wherein each blade ring is an impulse blade ring adapted for gas flow with an inward radial component, said ring being associated with a duct for a gas stream which duct carries nozzles to direct gas from the duct generally tangentially on to the blade ring.

18. An aircraft as claimed in Claim 17, wherein the duct has the form of a volute with a nozzle ring extending in arc on the inside of the volute.

19. An aircraft as claimed in any of the preceding claims wherein the or each blower includes a pair of contra-rotating similar rotors and guide means to co-operate with both rotors as aforesaid and to direct the outflow from each rotor into the same general direction along or parallel to the plane of symmetry.

20. An aircraft as claimed in Claim 19, wherein said guide means provides an inlet symmetrically located between the rotors for air to be drawn into the blower without passing through the rotors and to mix with the outflow therefrom.

21. An aircraft as claimed in either of Claims 19 and 20, wherein each said pair of rotors is driven by a pair of coupled turbines.

22. An aircraft as claimed in Claim 21, wherein bearings are provided for the rotors intermediately in their length which can be clamped on starting up and released for operation of the blower at speed the rotor being such as then to act as flexible shafts.

23. A V.T.O.L. aircraft as claimed in either of Claims 21 and 22, comprising one or more jet propulsion units to produce thrust for forward flight, said blower or blowers being arranged to produce lift and the propulsion unit or units being provided with means to deflect the jet to drive the blower turbines.

24. A V.T.O.L. aircraft as claimed in Claim 23, including a wing operative to produce lift in forward flight and also including means to enclose the blower or blowers when out of use.

25. A V.T.O.L. aircraft as claimed in Claim 24, including a wing to produce in forward flight, the blower or blowers being mounted in said wing in associated with entry and exit openings for air in the surfaces of the wing, and means being provided to close at least one set of such openings in forward flight to preserve the continuity of the corresponding surface.

26. An aircraft as claimed in any of the preceding claims, said aircraft having a body mounting at least a pair of rotors longitudinally thereof at either side.

27. An aircraft as claimed in Claim 26, said rotors being all driven from a central power unit.

28. An aircraft as claimed in Claim 26 and 27, having wheels and being adapted for use as a road vehicle.

29. An aircraft as claimed in Claim 28, wherein an equal number of rotors on either side of the body are mounted in sub-frames and adapted to be swung towards the body when inoperative to reduce the overall width of the aircraft.

30. An aircraft as claimed in Claim 29, having said sub-frame pivotally mounted.

31. An aircraft as claimed in any of the preceding claims including a plurality of rotors mounted longitudinally of the aircraft, the axes of the rotors as seen in a section taken transversely of the aircraft lying on the equal sides of an isosceles triangle whose base is horizontal or on an arc or arcs conforming approximately to the equal sides of a triangle.

32. An aircraft as claimed in Claim 31, wherein said rotors on each side are close together and separated by guide bodies providing one outlet wall for one rotor and an opposite wall for the next.

33. A V.T.O.L. aircraft as claimed in any of Claims 1 to 22, comprising a central launching platform and a series of generally horizontal arms extending outwardly therefrom, each arm mounting at least one blower with its rotor running longitudinally of the arm, the arrangement being such that the launch of a rocket or other craft launched from the platform does not change the position of the centre of gravity.

34. A V.T.O.L. aircraft as claimed in Claim 33 including a gas turbine motor mounted at the each of each arm and driving the rotors thereof, the exhaust of the motors being arranged to contribute to the left.

35. An aircraft as claimed in any of Claims 1 to 22 including wings, said blower being arranged with the rotor axis vertical or inclined slightly to the vertical.

36. An aircraft as claimed in Claim 35, as dependent on any of the Claims 19 to 22, the blower being mounted symmetrically to the rear of a cabin.

37. An aircraft as claimed in Claim 35, wherein the blower and motor form a propulsion unit moveable as a whole between an operative position and an inoperative position wherein said unit is substantially wholly concealed so as to cause no drag.

38. An aircraft as claimed in Claim 1, the

blower having the characteristics explained with reference to Figures 1 to 3.

39. An aircraft as claimed in Claim 1, the rotor being combined with the motor as hereinbefore described with reference to Figures 9, 10 or 11, 12, or 13,14 of the accompanying drawings.

40. An aircraft as claimed in Claim 1, the blower being as herein described with reference to Figure 15, or to Figure 16 or to Figures 17 and 18.

41. An aircraft as herein described with reference to Figures 20 to 22 or Figures 23 to 29 or Figures 30 and 31 or Figures 32 and 33 or Figures 34 and 35 or Figures 36 to 38 or Figures 39 and 40.

ALLAM & TREGEAR,
Chartered Patent Agents,
2 & 3, Norfolk Street, Strand,
London, W.C.2.

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FIG.1.

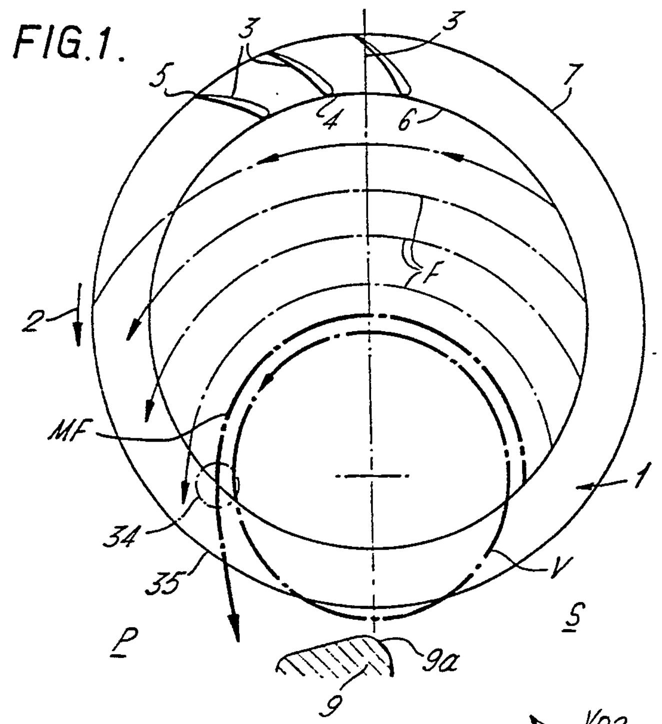


FIG.2.

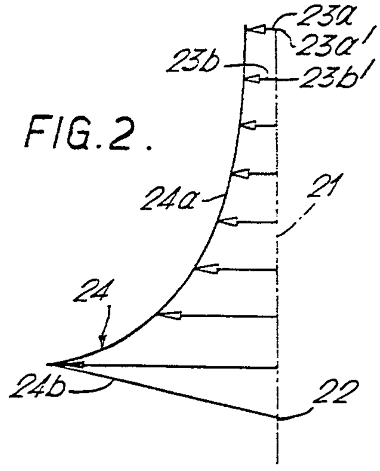
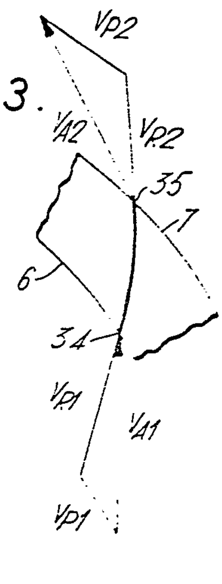


FIG.3.



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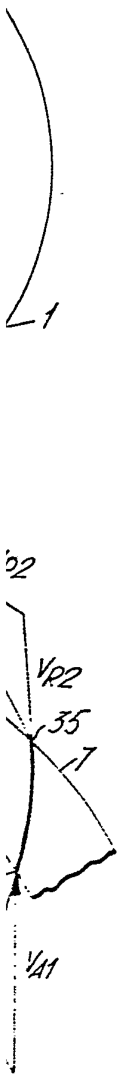


FIG.4.

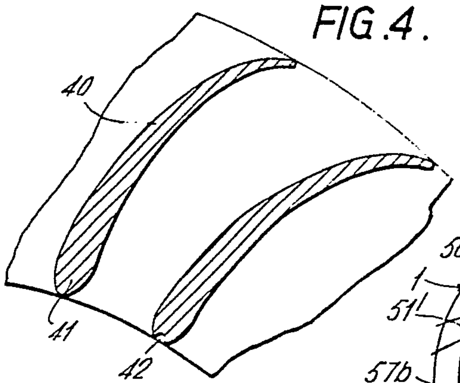
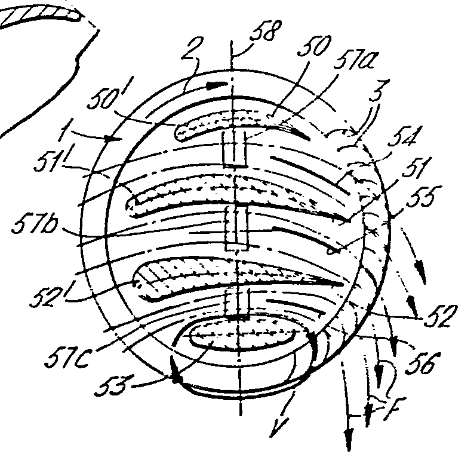


FIG.5.



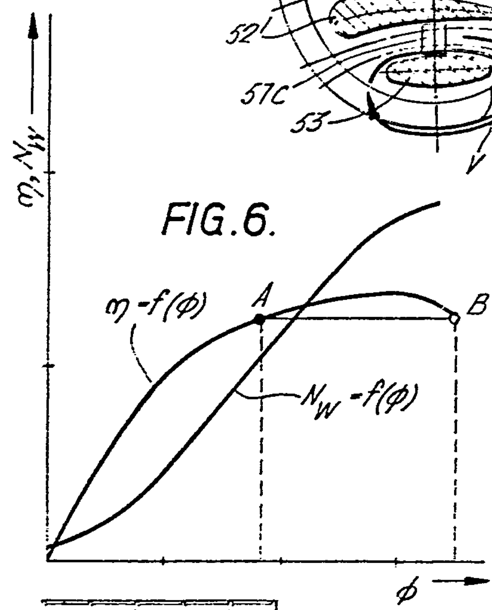


FIG.6.

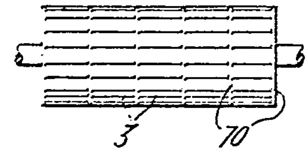


FIG.7.

FIG.8.

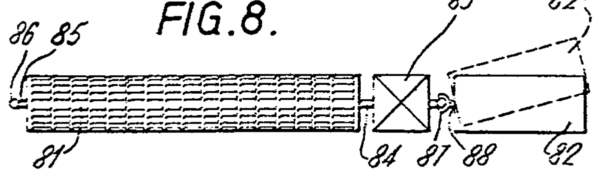


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FIG.1.

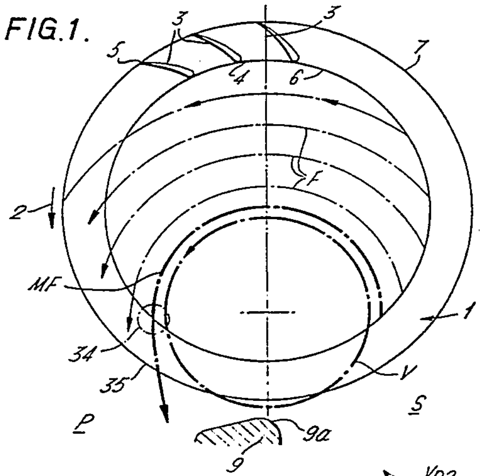
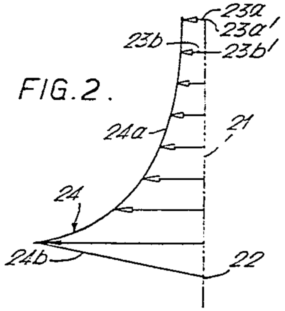


FIG.2.



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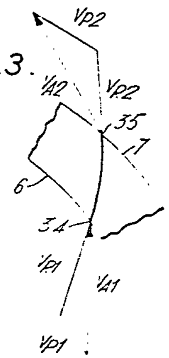

FIG.4.

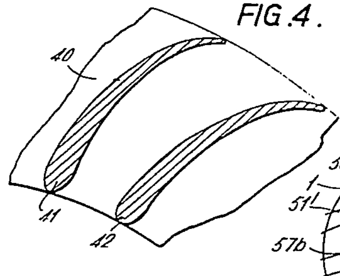

FIG.5.

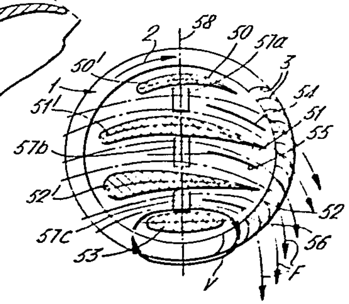

FIG.6.

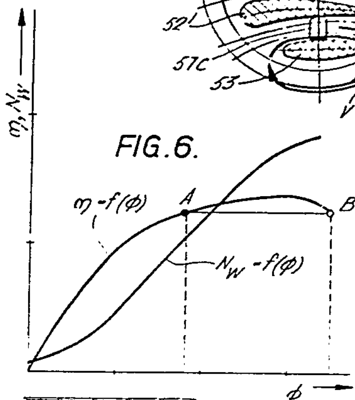

FIG.7.

FIG.8.

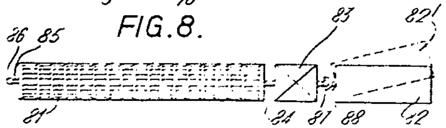

FIG. 9.

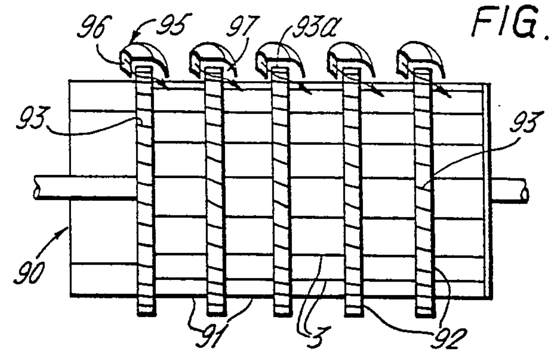

FIG. 10.

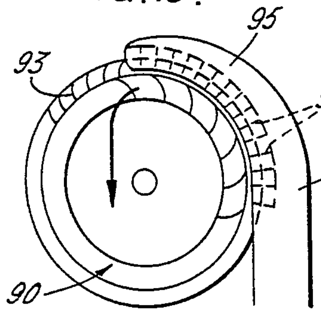

FIG. 11.

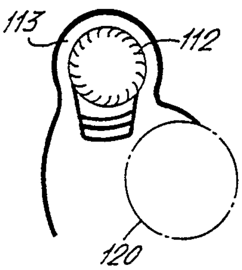

FIG. 12.

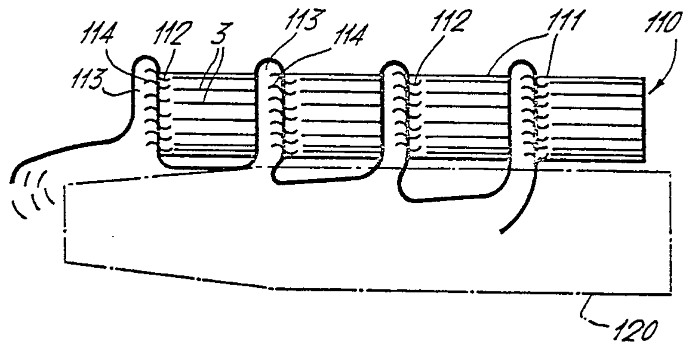

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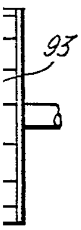
FIG. 9.



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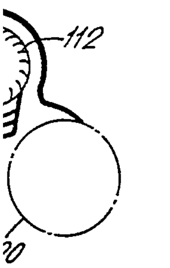


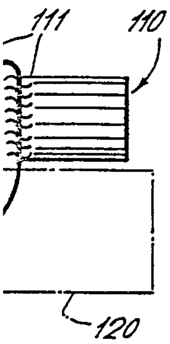


FIG. 13.

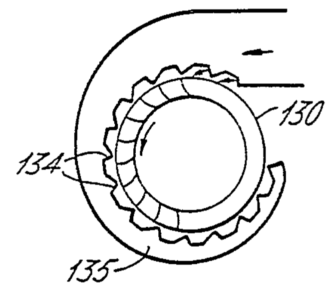
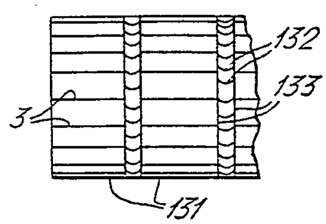


FIG. 14.



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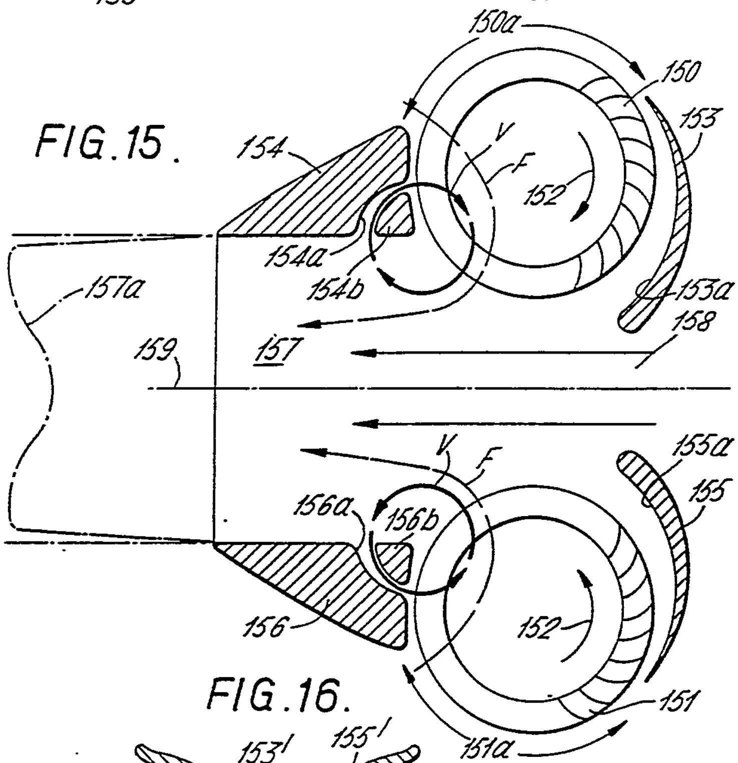

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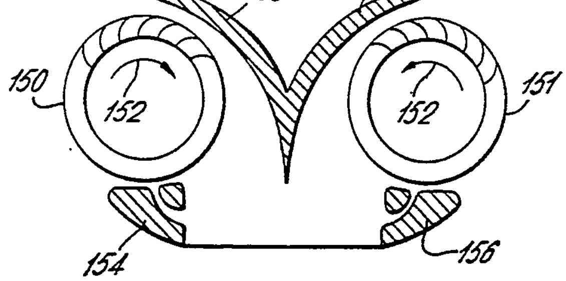

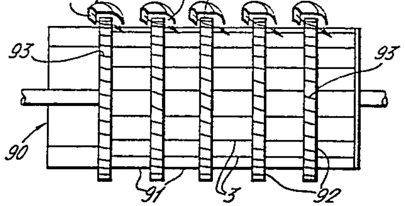

FIG. 9.

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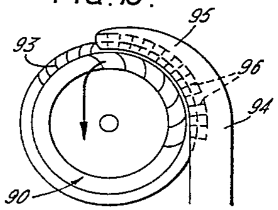

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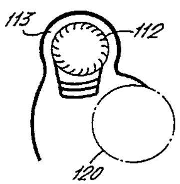

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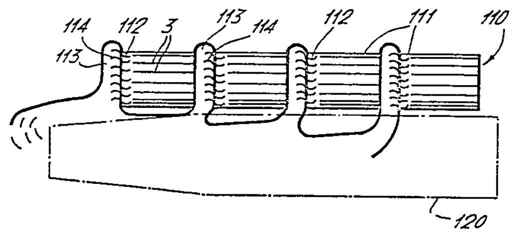

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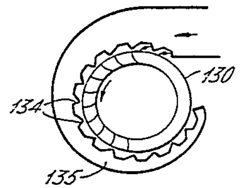

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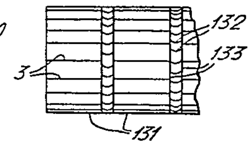

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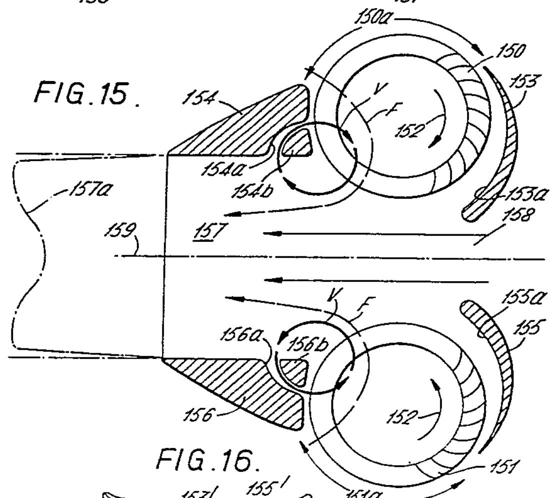

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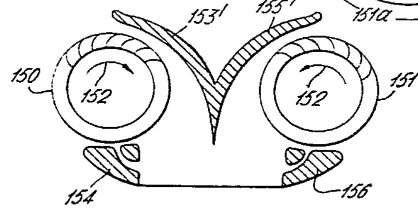

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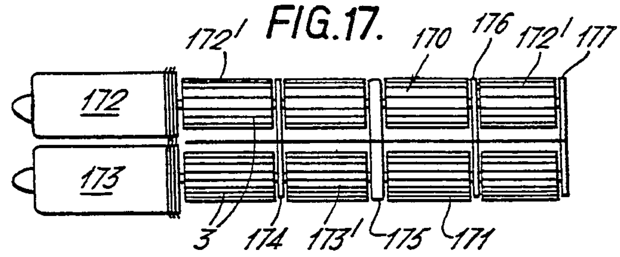

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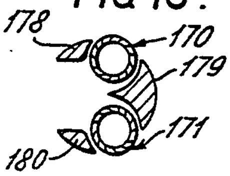

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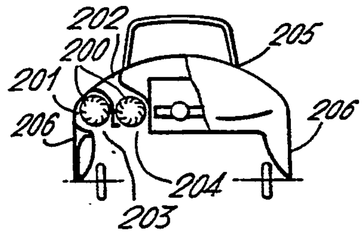
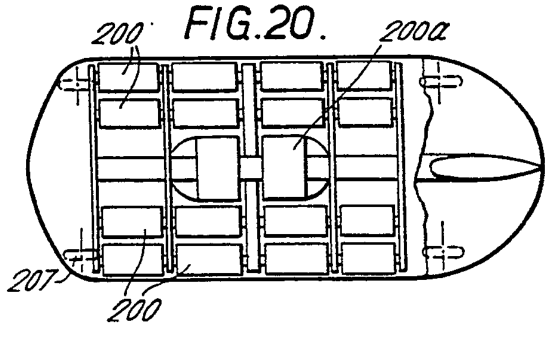


FIG.20.



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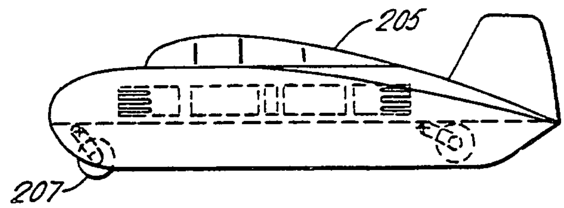

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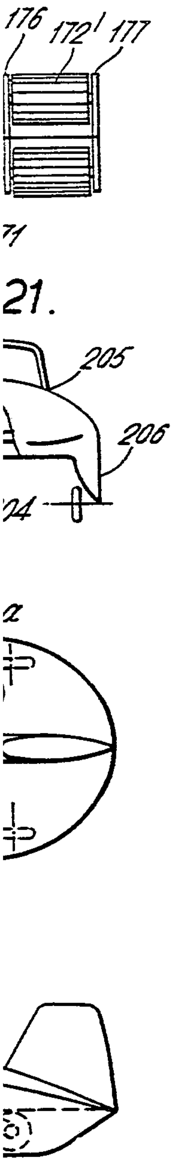

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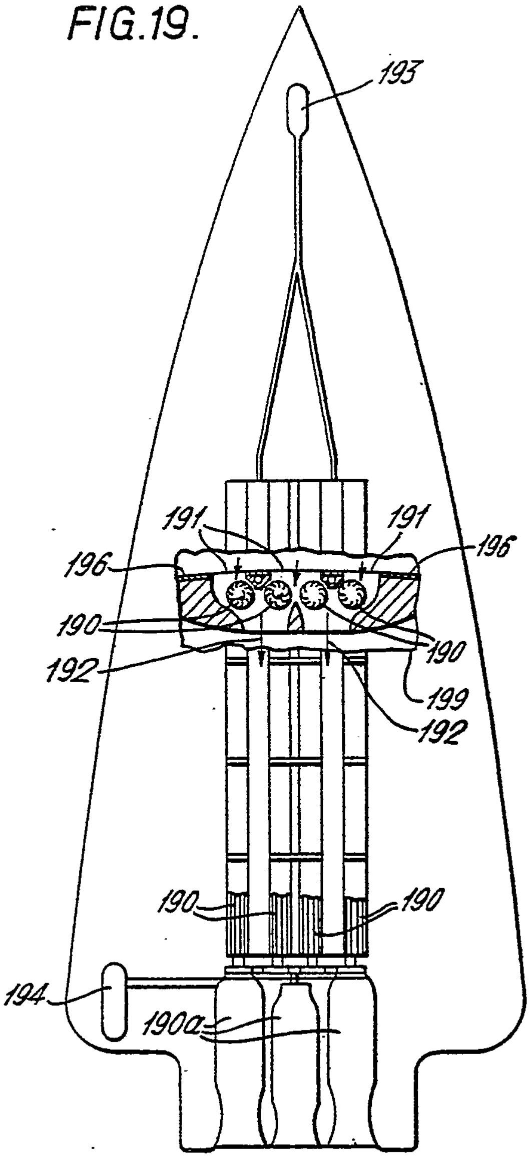

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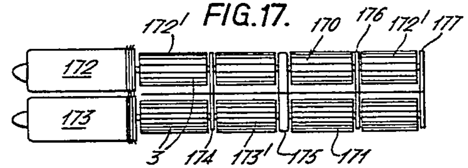


FIG 18.

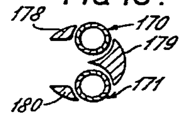


FIG.21.

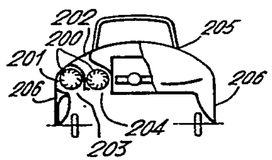


FIG.20.

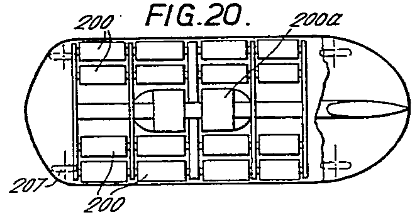


FIG.22.

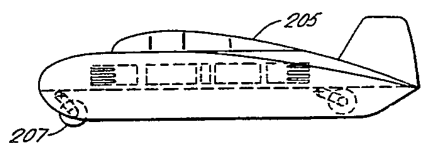


FIG.19.

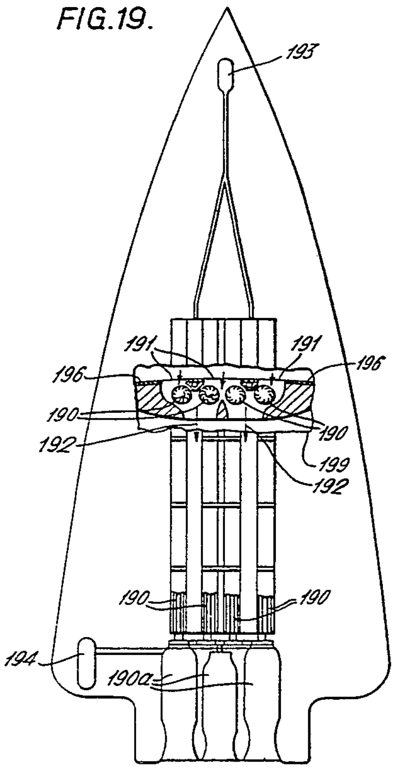


FIG. 23.

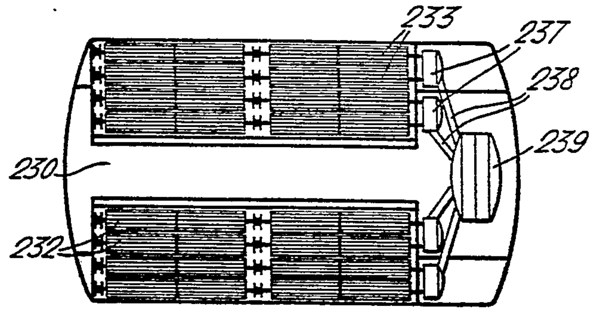


FIG. 24.

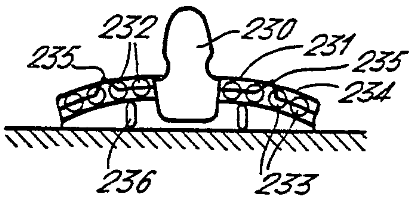
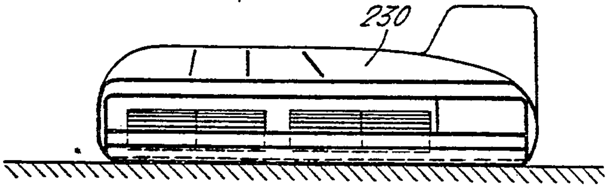
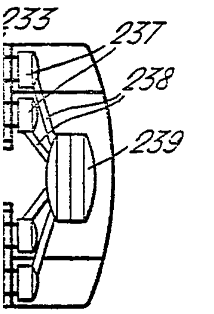
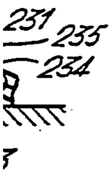


FIG. 25.



885663 COMPLETE SPECIFICATION
12 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 7 & 8





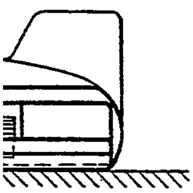


FIG.26.

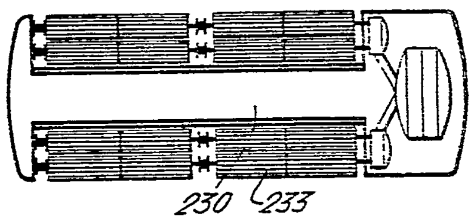


FIG.27.

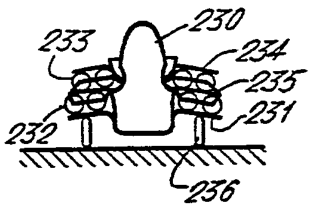


FIG.29.

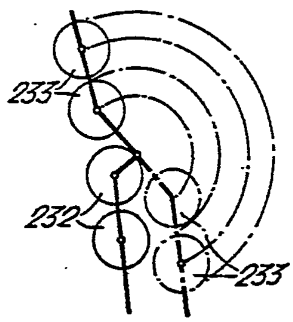


FIG.28.

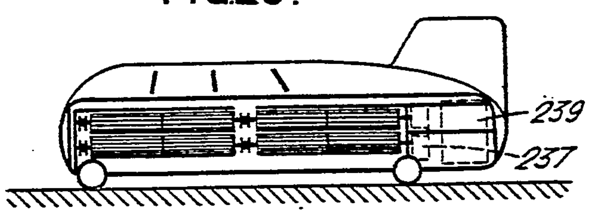


FIG.23.

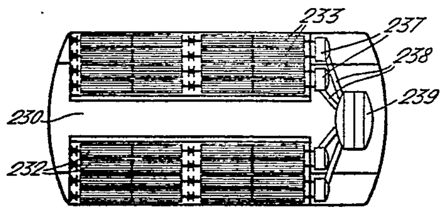


FIG.24.

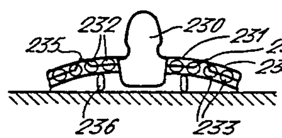


FIG.25.

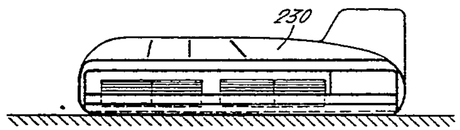


FIG.26.

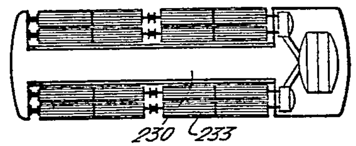


FIG.27.

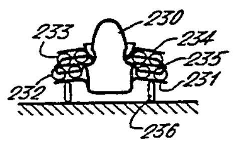


FIG.29.

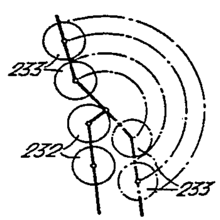


FIG.28.

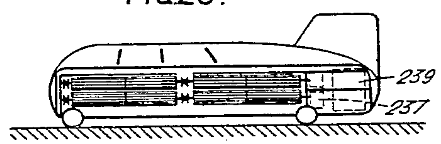


FIG.30.

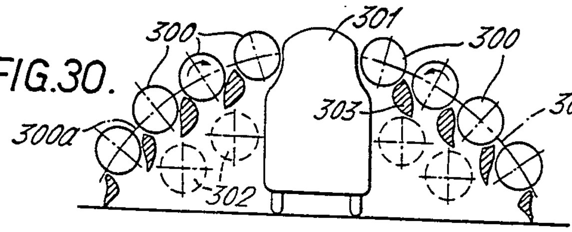


FIG.31.

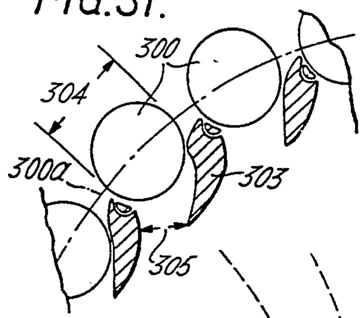
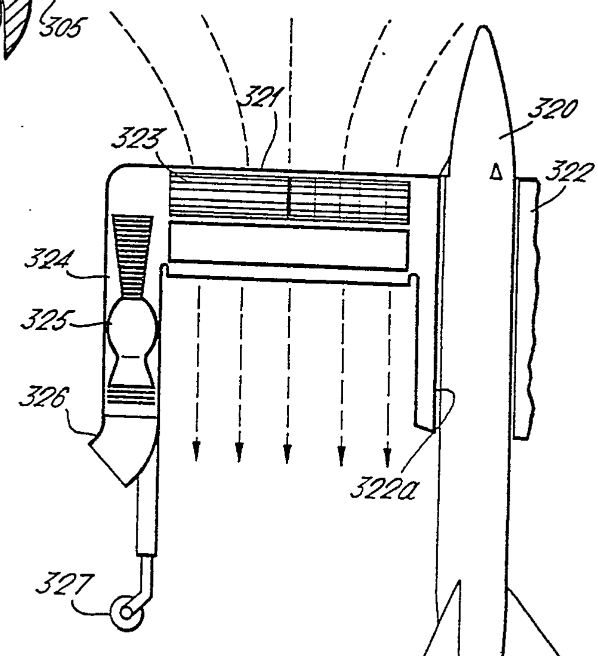


FIG.32.



885663 COMPLETE SPECIFICATION
12 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 9 & 10

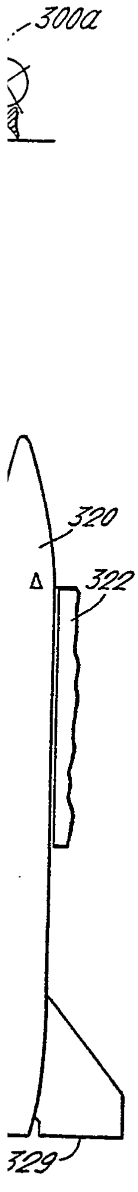


FIG.33.

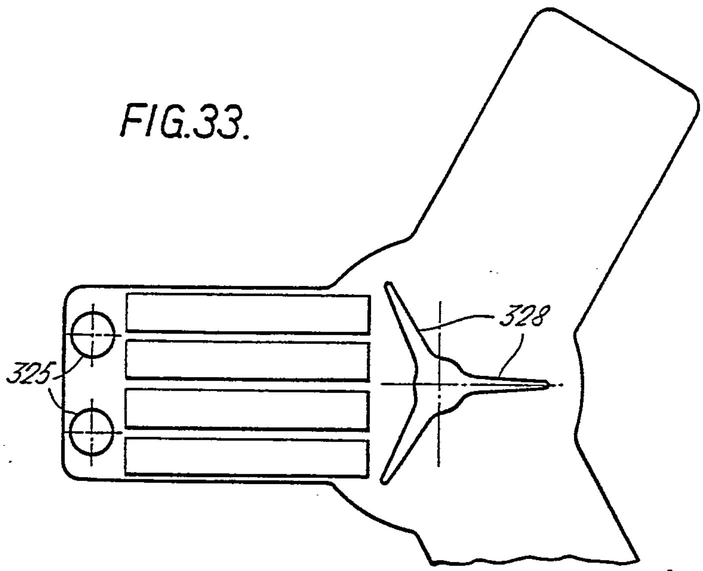


FIG.34.

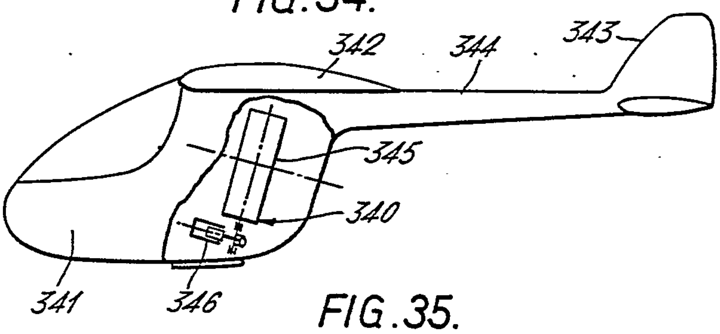
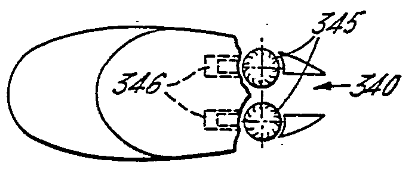


FIG.35.



885663 COMPLETE SPECIFICATION
12 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 9 & 10

FIG.30.

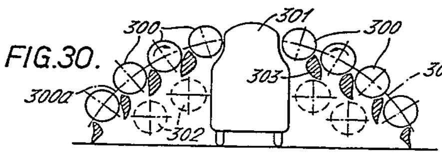


FIG.31.

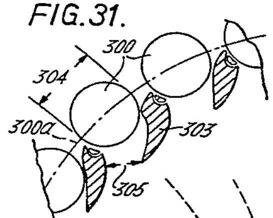


FIG.32.

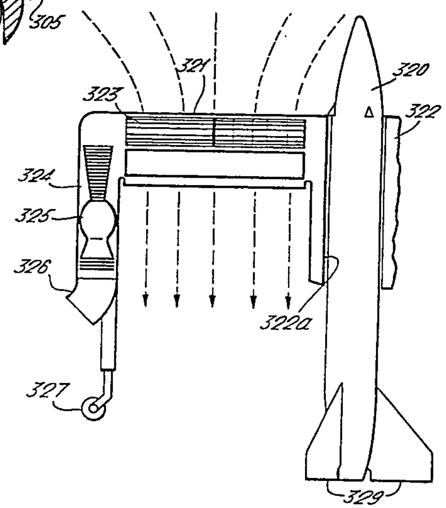


FIG.33.

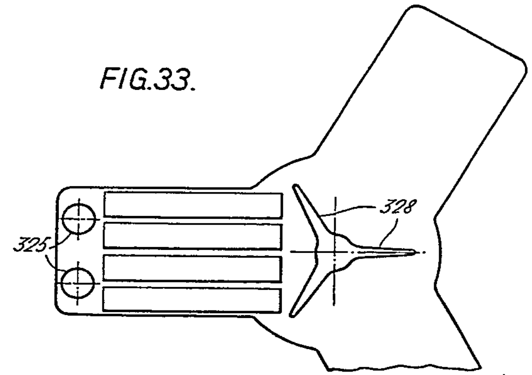


FIG.34.

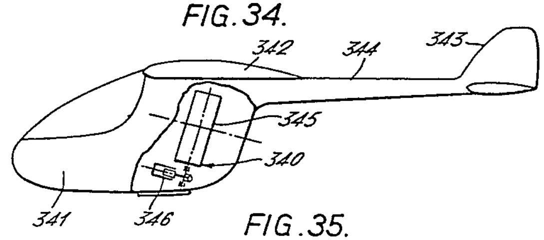


FIG.35.

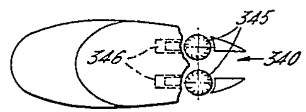


FIG .36.

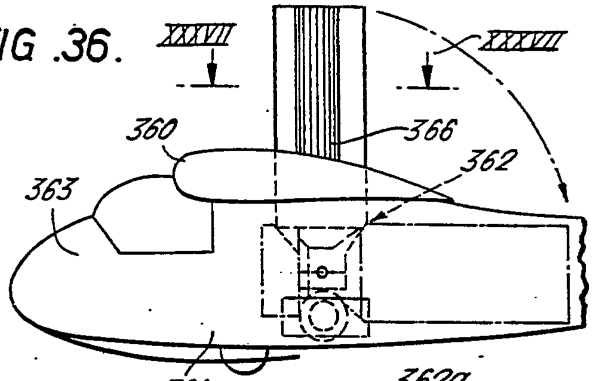


FIG.37.

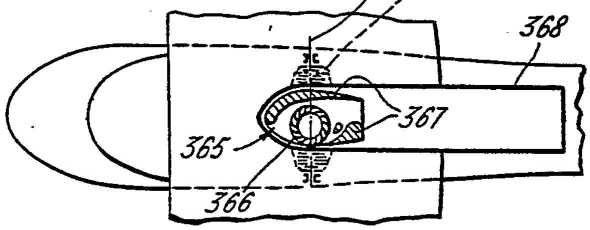
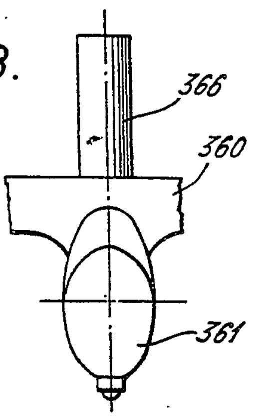


FIG.38.



885663 COMPLETE SPECIFICATION

12 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 11 & 12

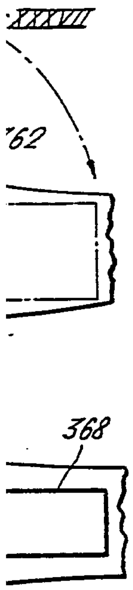


FIG. 39.

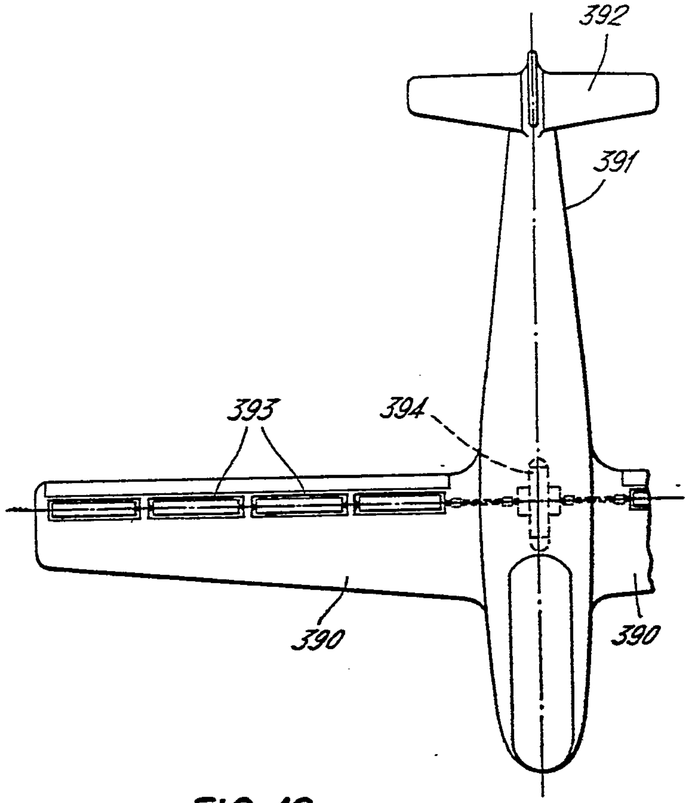
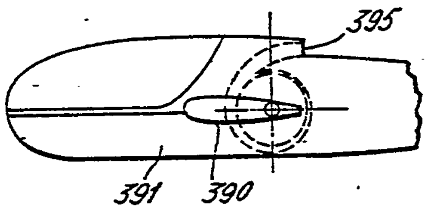


FIG. 40.



885663 COMPLETE SPECIFICATION

12 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 11 & 12

FIG. 36.

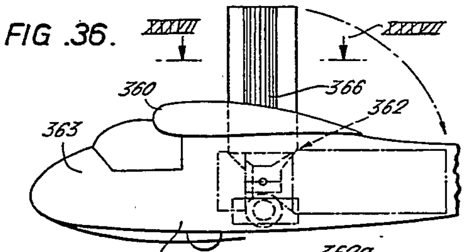


FIG. 37.

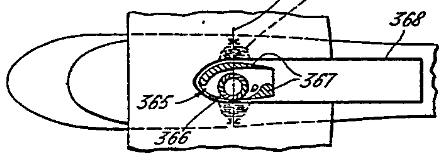


FIG. 38.

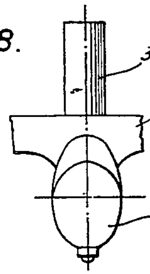


FIG. 39.

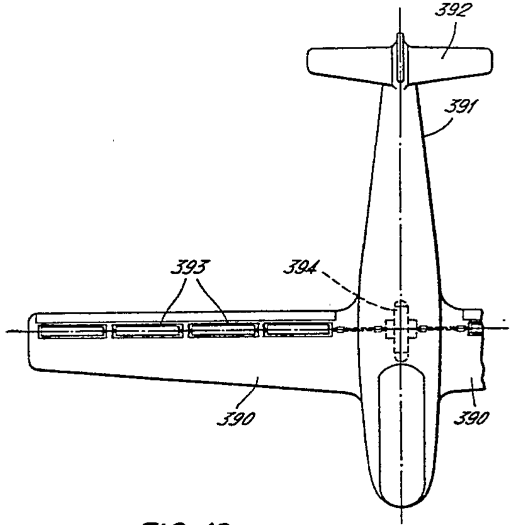


FIG. 40.