US006016991A

United States Patent [19]

Lowe, Jr.

[11] Patent Number: 6,016,991

[45] Date of Patent: Jan. 25, 2000

[54] **EVACUATED ROTATING ENVELOPE AIRCRAFT**

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[21] Appl. No.: **08/788,535**

[22] Filed: **Jan. 24, 1997**

[51] **Int. Cl.**[7] **B64B 1/02**

[52] **U.S. Cl.** .... **244/5**; 244/12.2; 244/23 C; 244/29; 244/97

[58] **Field of Search** .... 244/5, 12.2, 23 C, 244/24, 29, 30, 97, 125, 128

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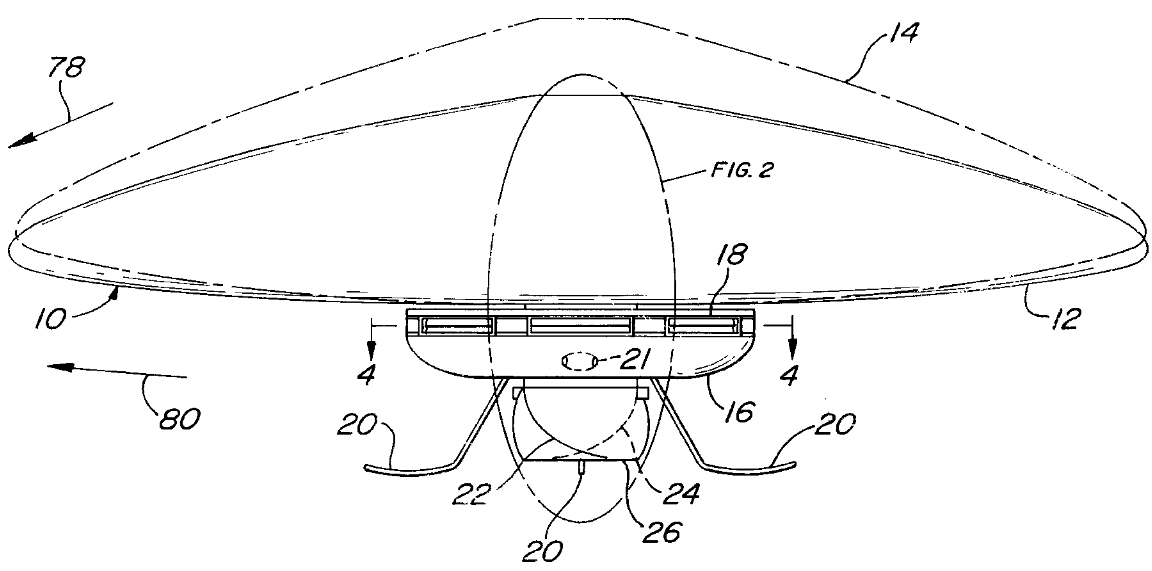
[57] **ABSTRACT**

An aircraft utilizes a buoyant evacuated rotating envelope to provide at least a portion of the lift required. The rotating envelope may be in the form of a disk, cylinder or other suitable shape. In one embodiment, an evacuated rotating envelope in the form of a disk is utilized. The disk is provided with a central core tube with at least one jet engine mounted therein. The deflection of the exhaust causes rotation of the envelope. A non-rotating payload compartment is mounted to the rotating envelope by bearings. Structures are provided for deflecting the exhaust to be utilized for lateral propulsion as well as for stabilizing the payload compartment to prevent rotation. Two other embodiments utilize rotating cylinders which may be rotated either by a jet engine mounted within a core tube or by an off center jet engine which drives the cylinder. In all of the embodiments, the envelope is evacuated by pumps and the centrifugal force of rotation reduces the amount of necessary mechanical structure to maintain the envelope shape. Accordingly, an evacuated envelope may be utilized with a minimum of weight required to maintain its structural rigidity.

46 Claims, 15 Drawing Sheets



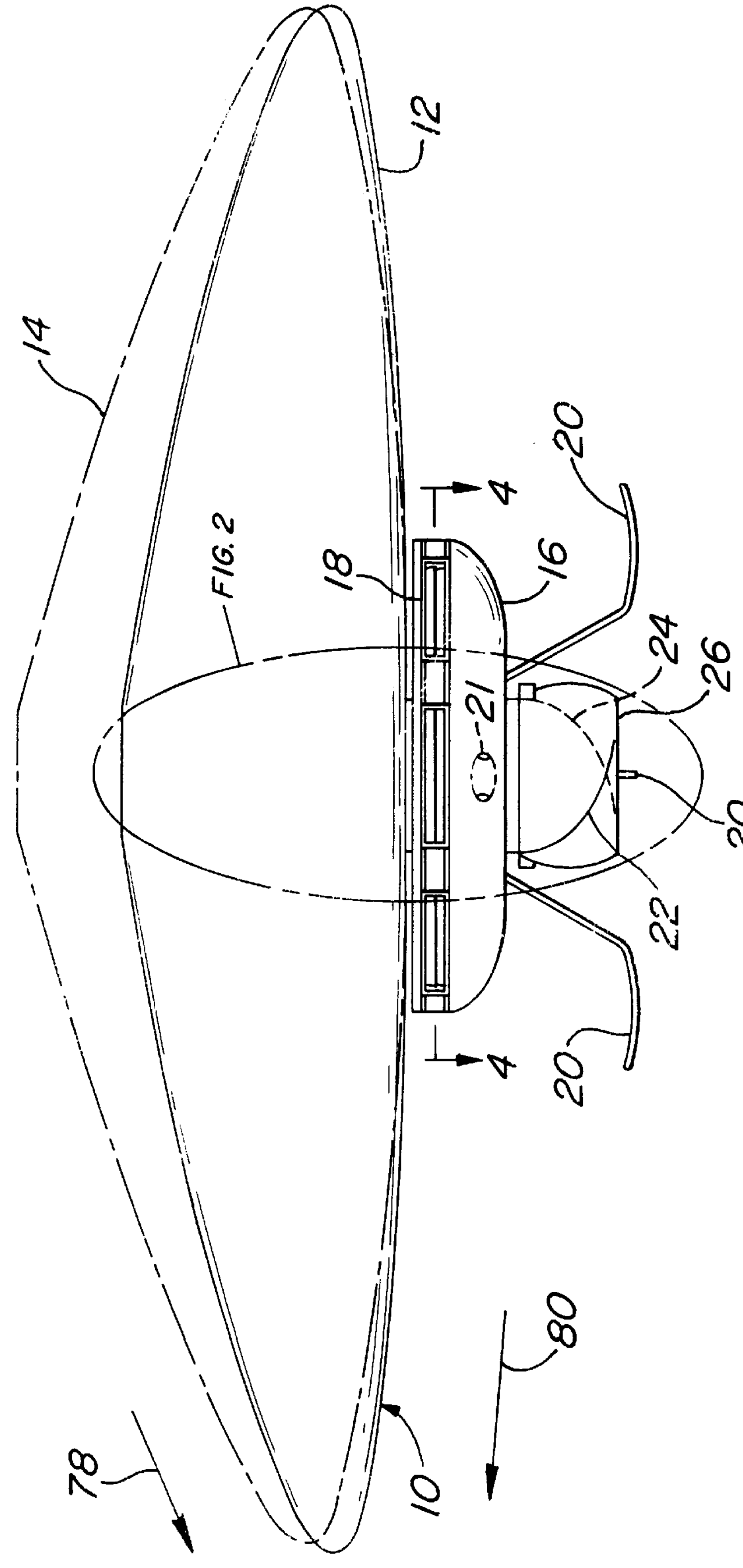
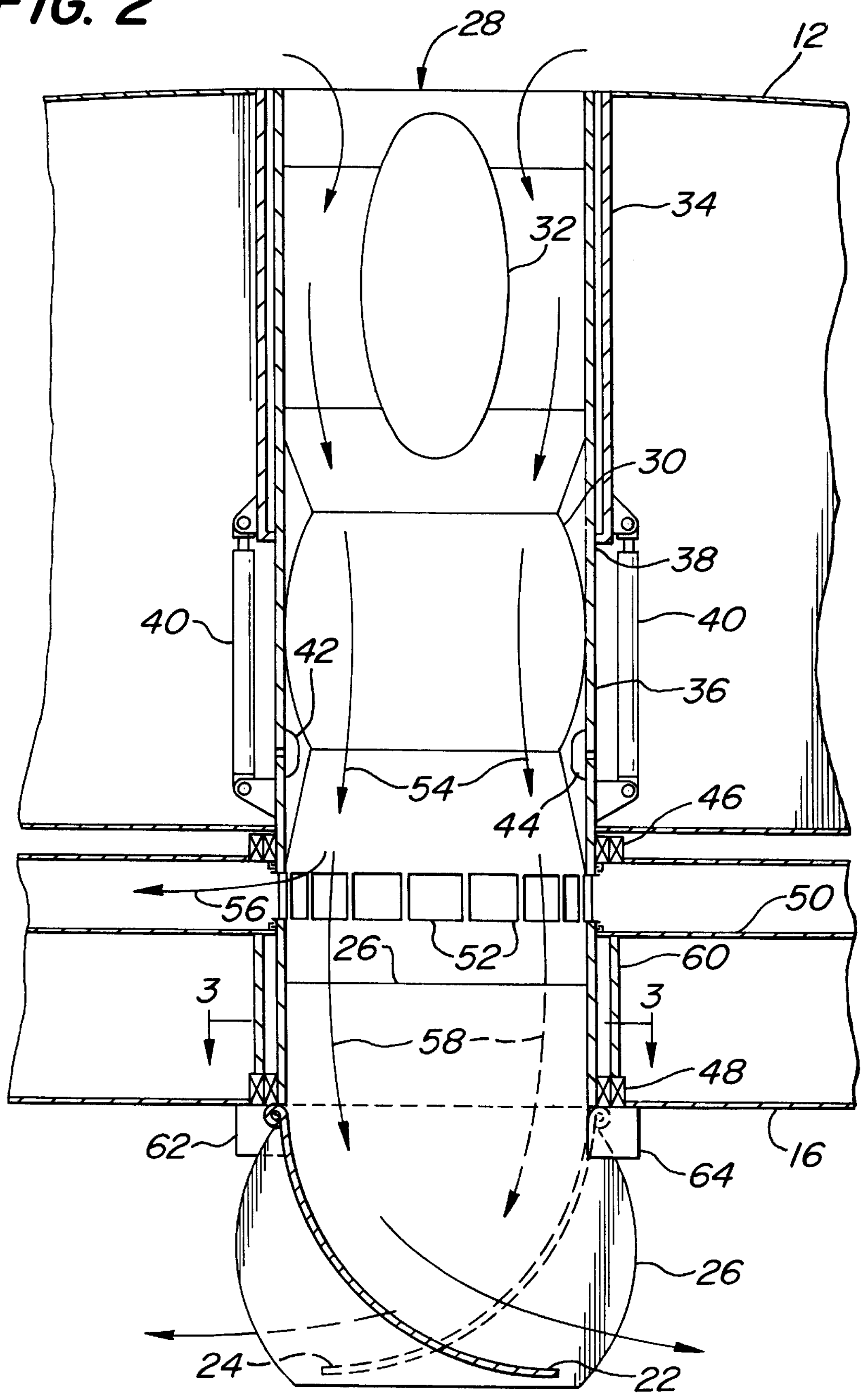


FIG. 1

FIG. 2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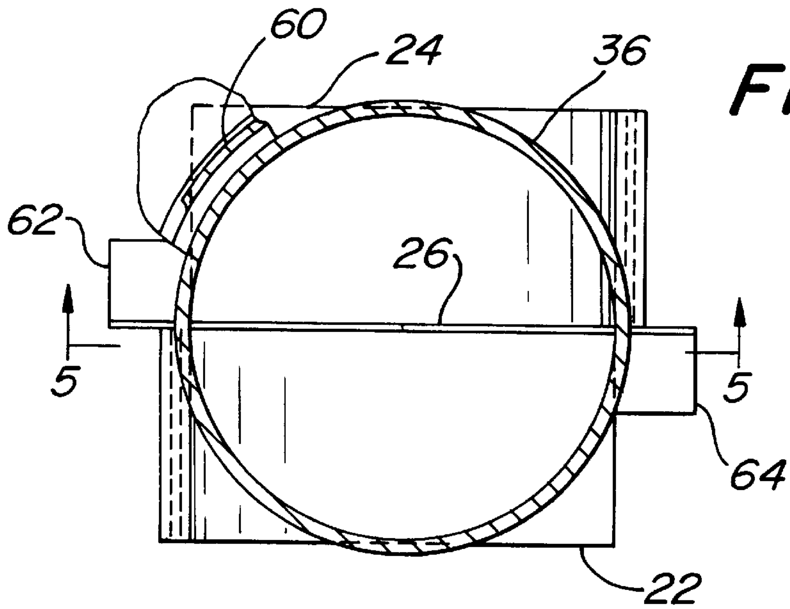

FIG. 3

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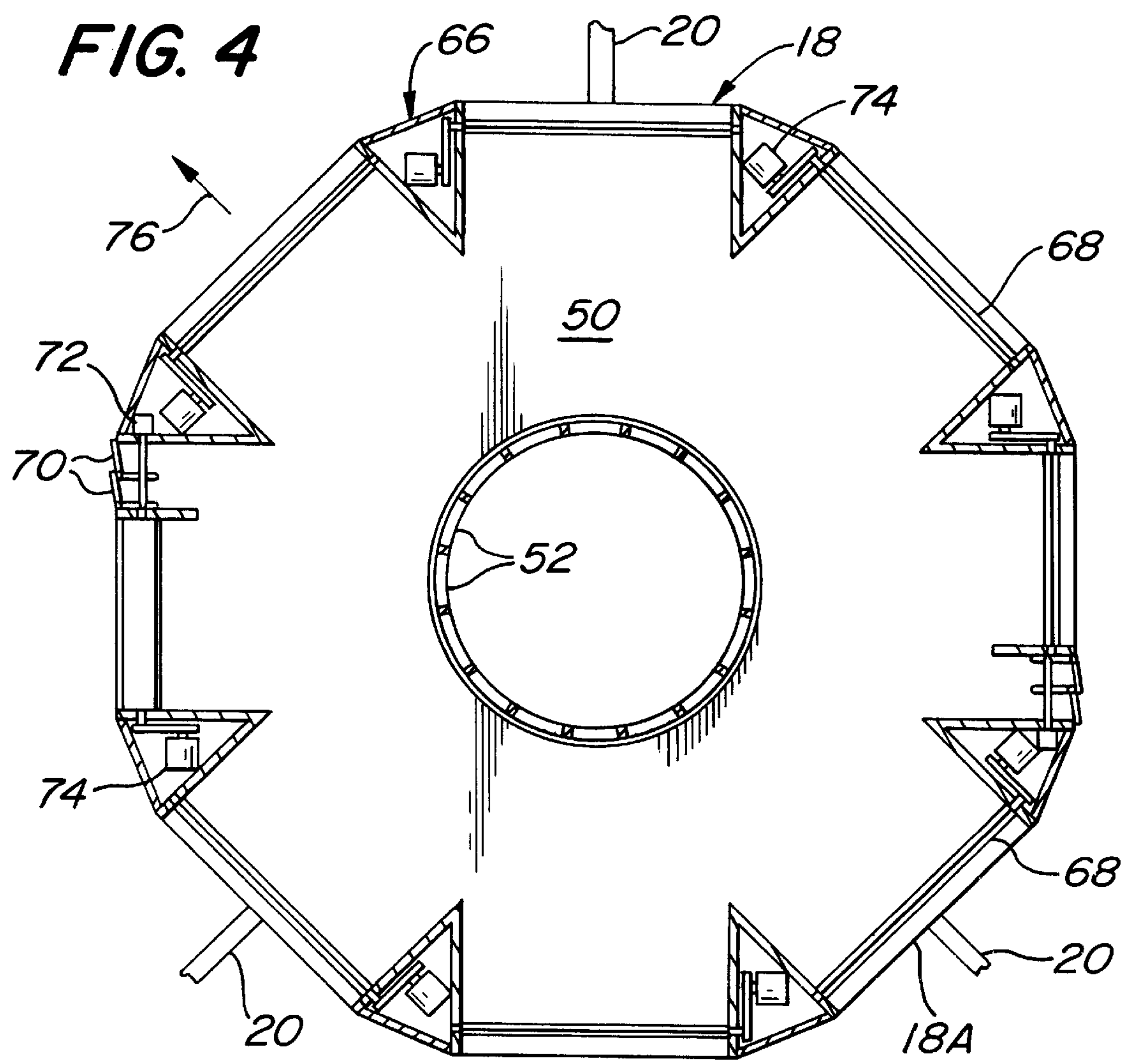

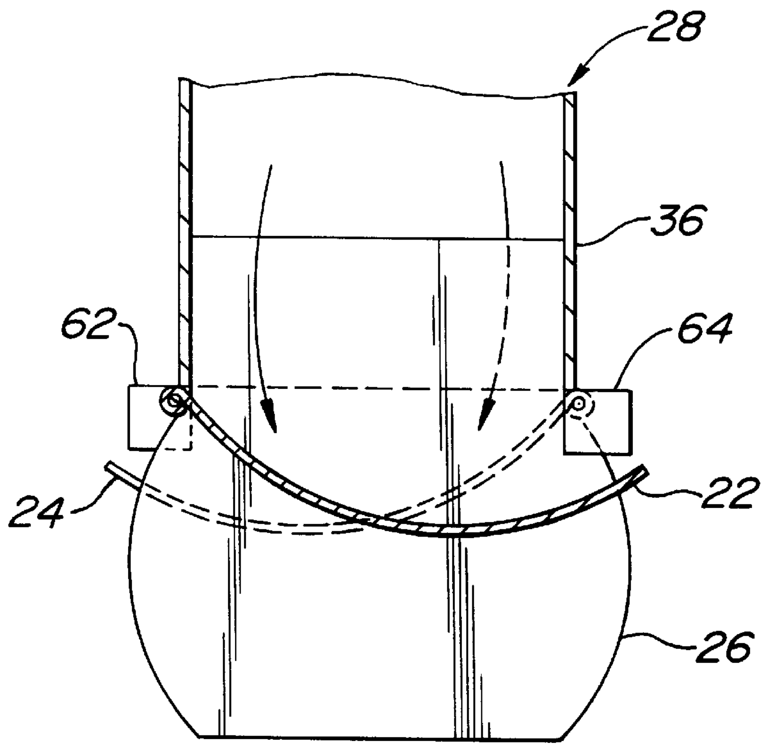

FIG. 5

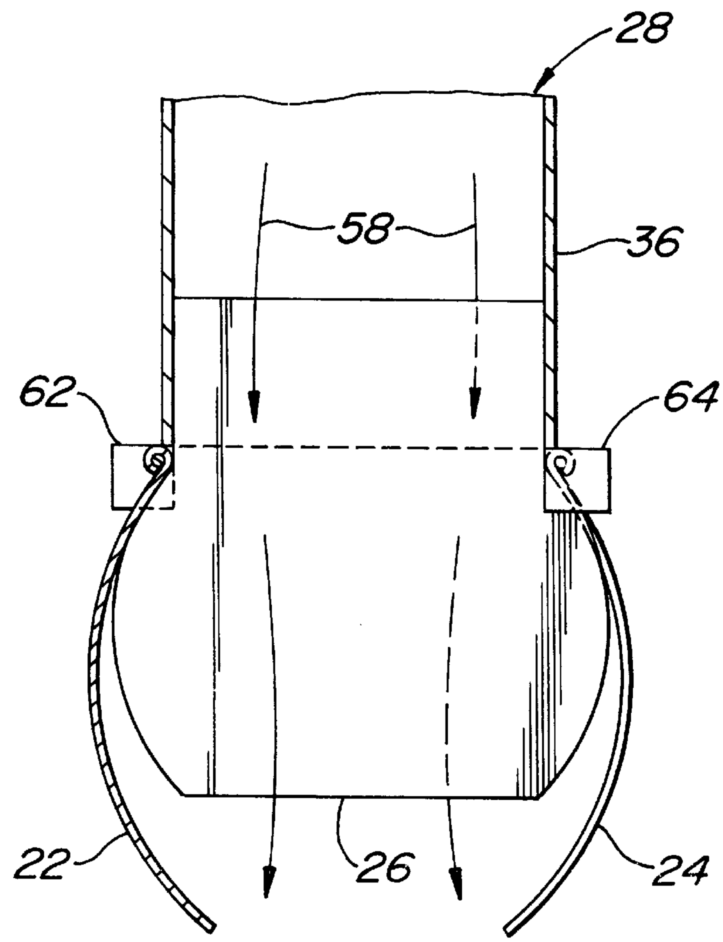

FIG. 6

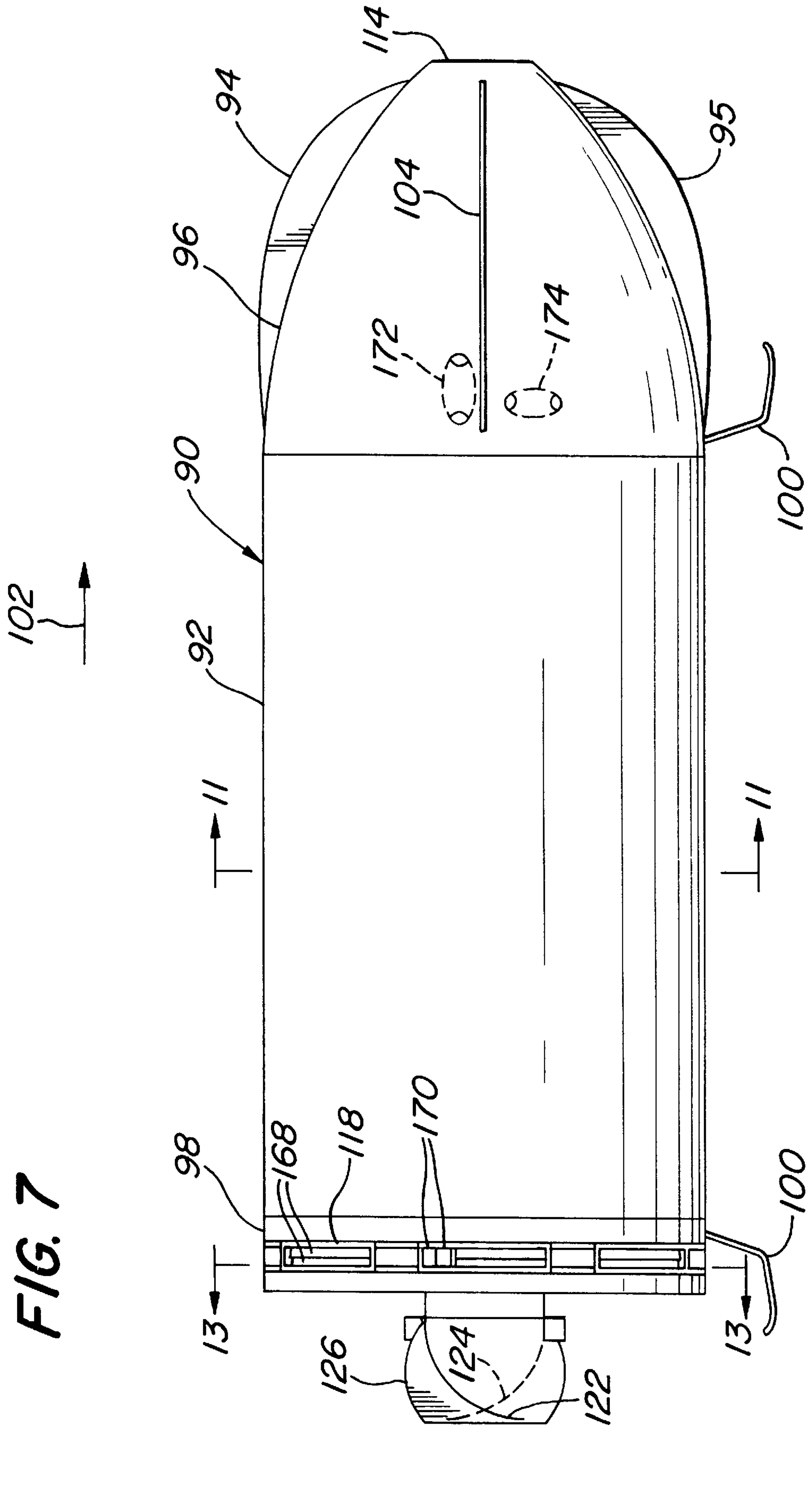
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FIG. 7

FIG. 8

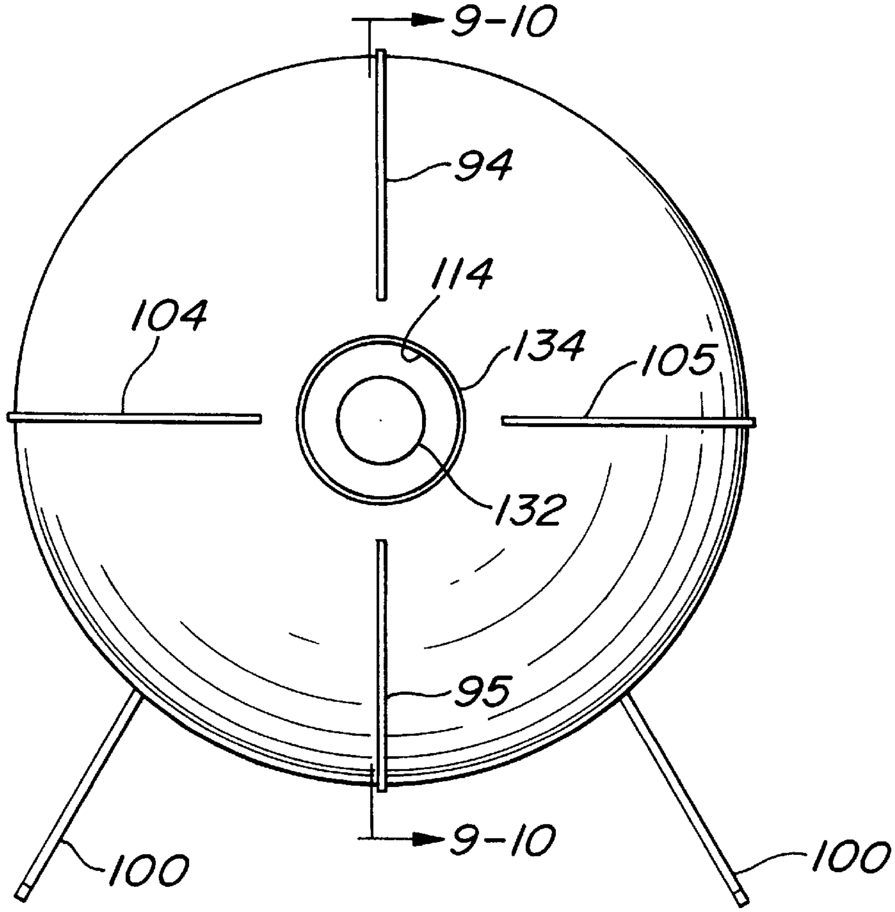
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FIG. 11

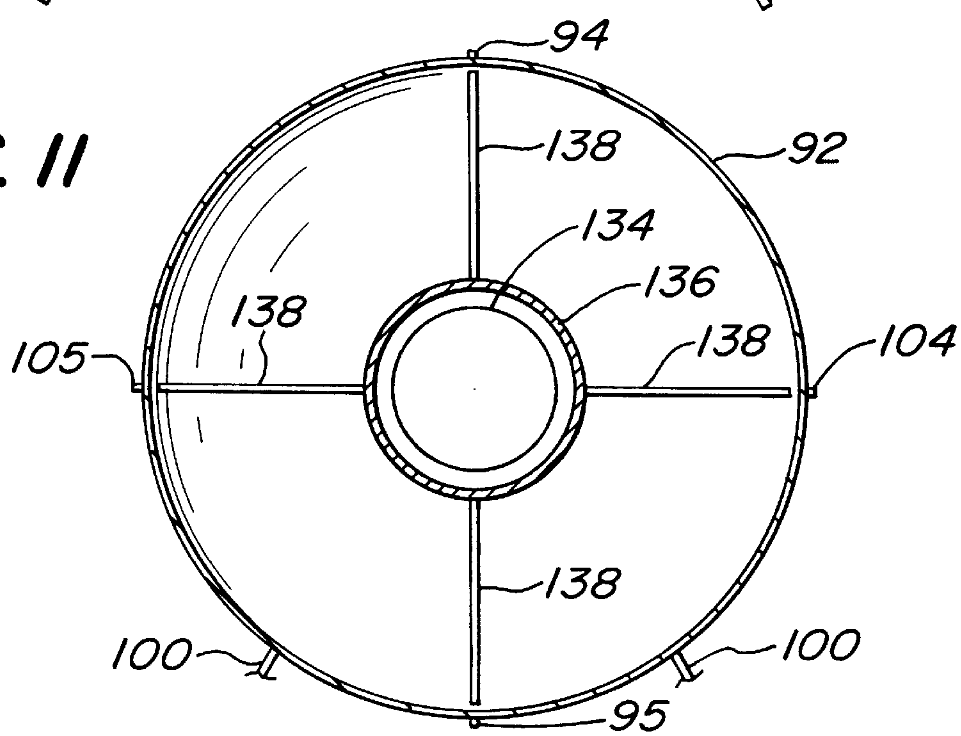
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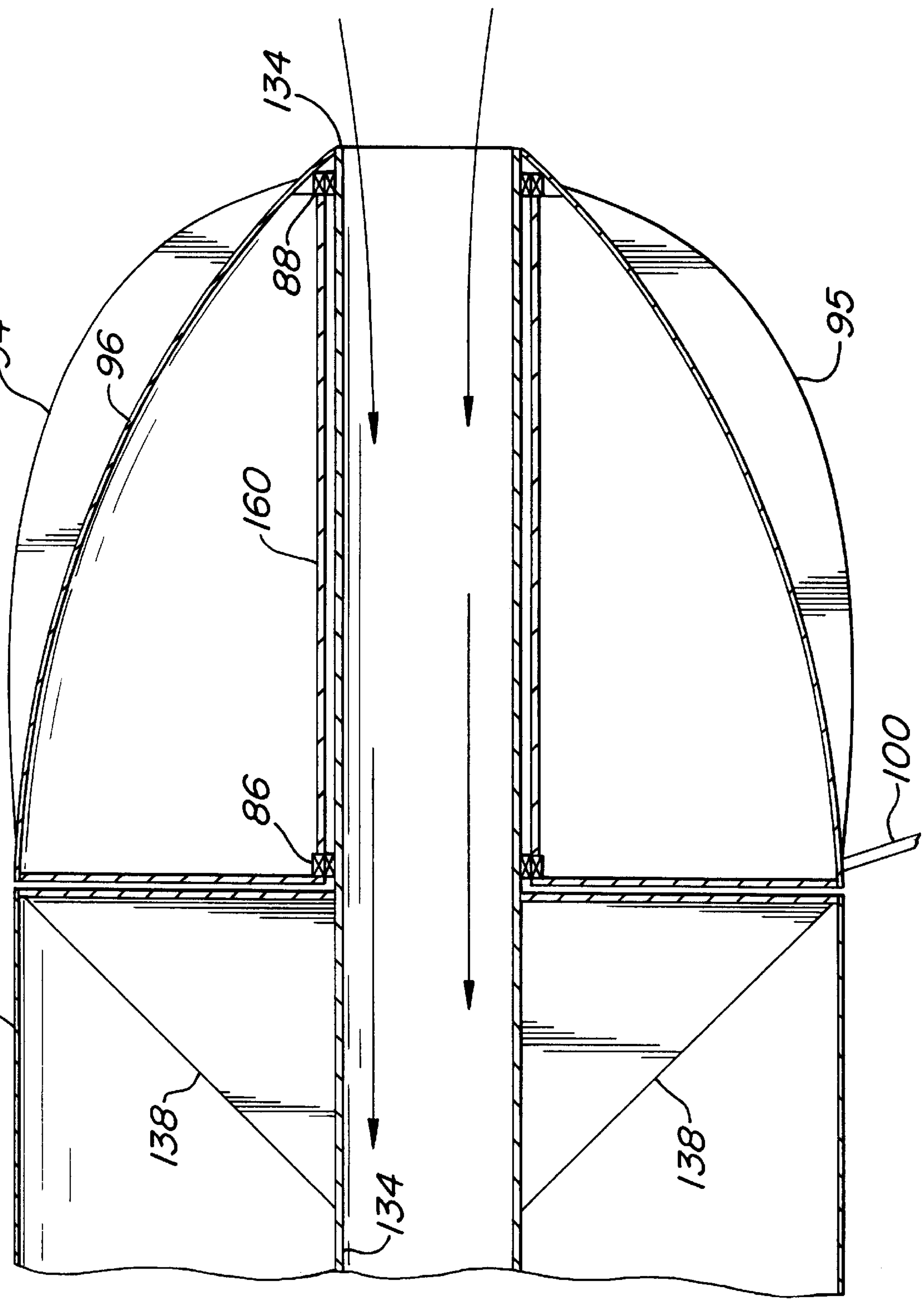
FIG. 9



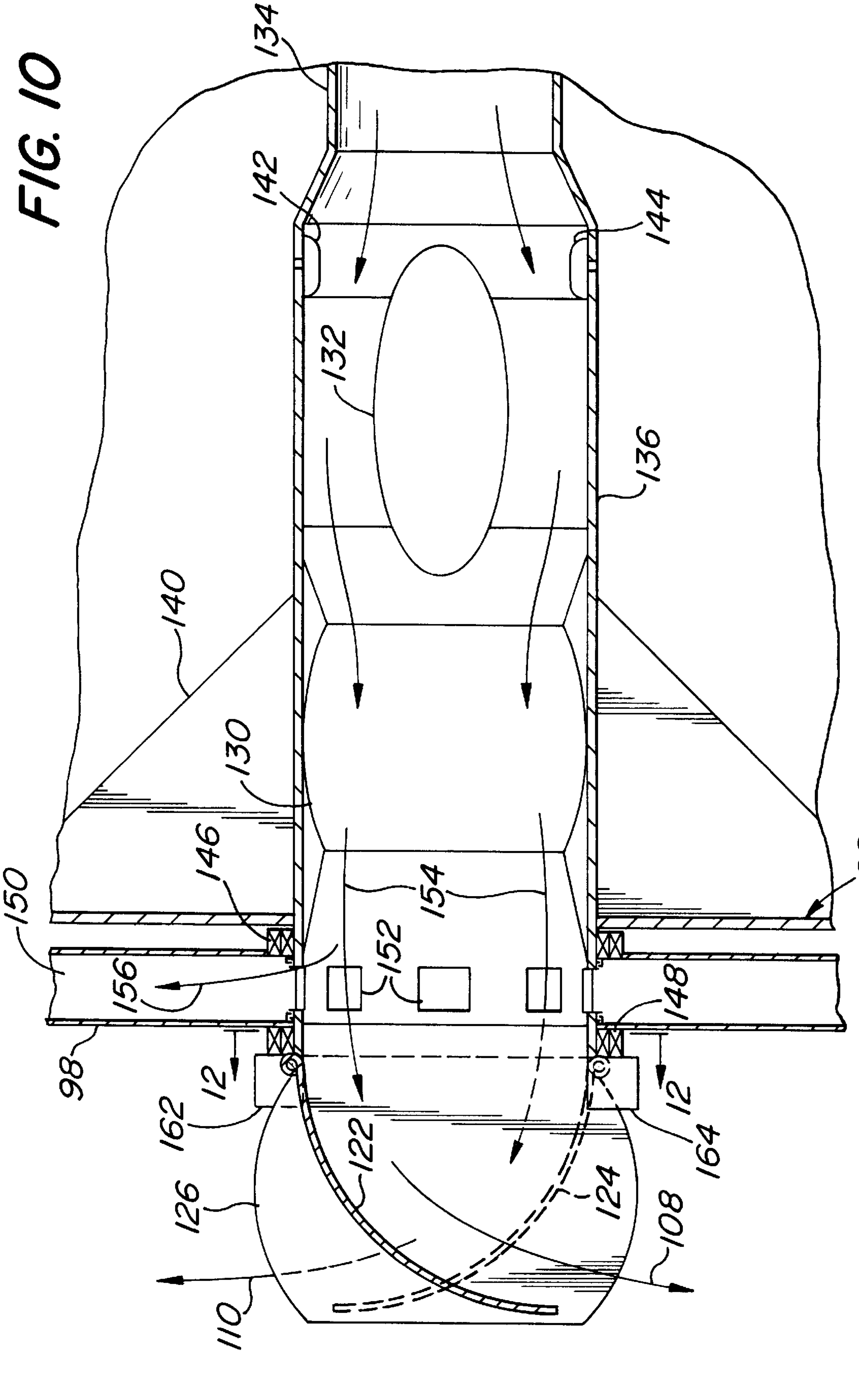

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FIG. 10

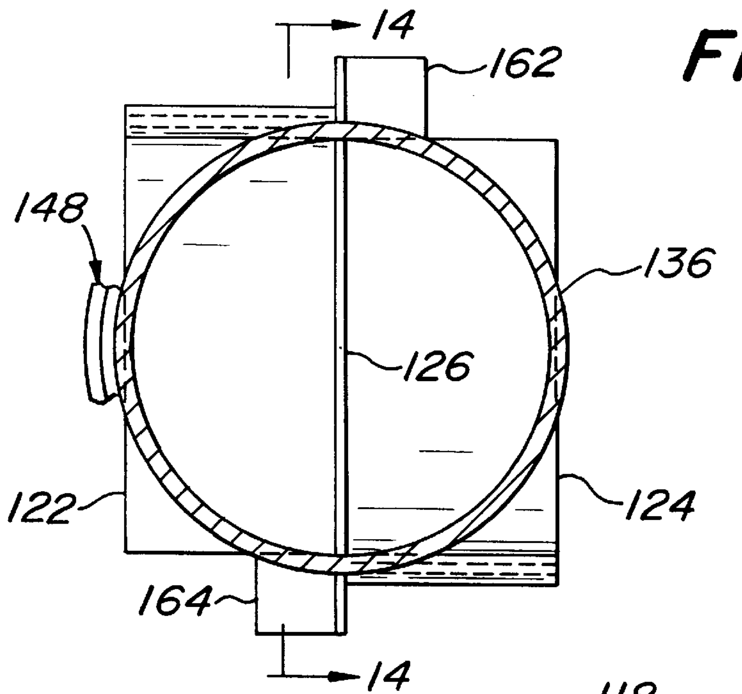


FIG. 12

FIG. 13

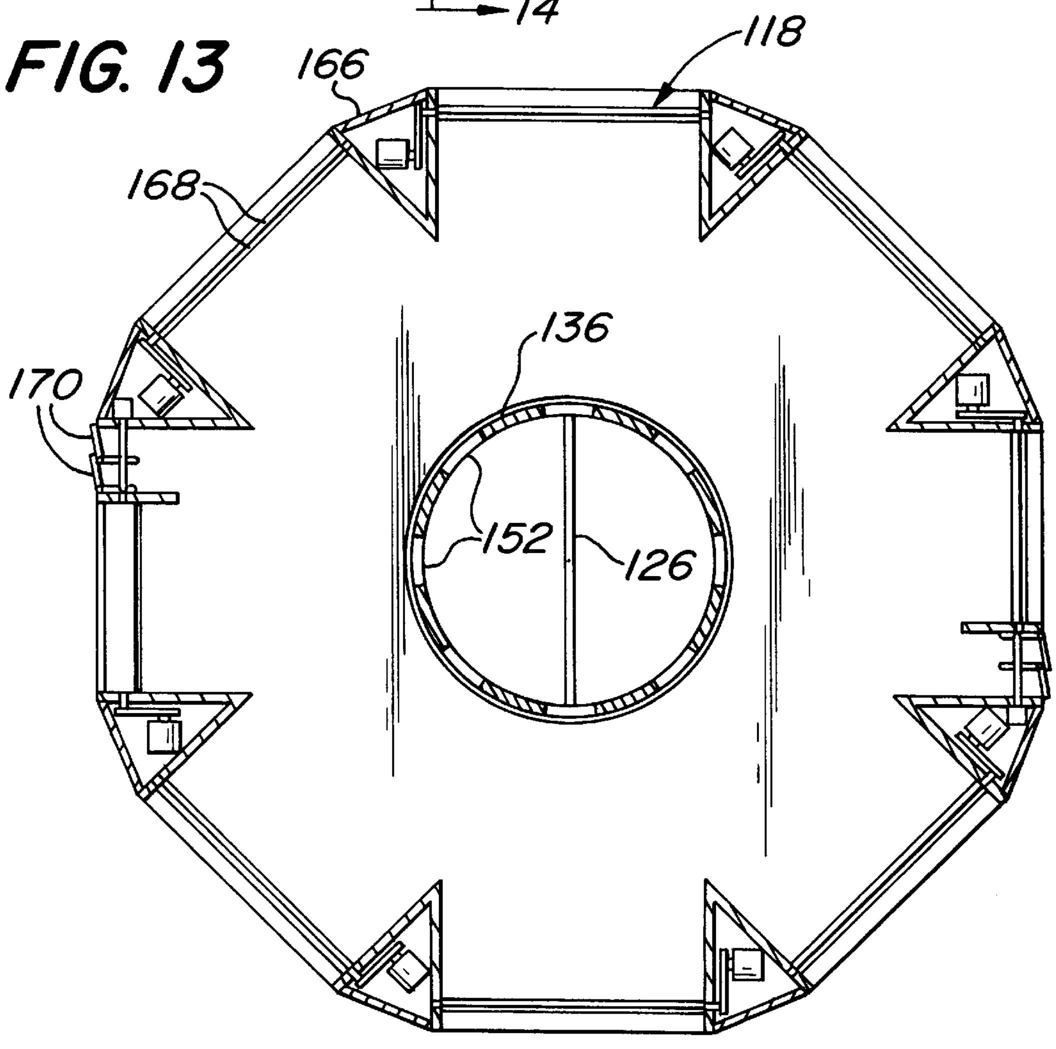


FIG. 14

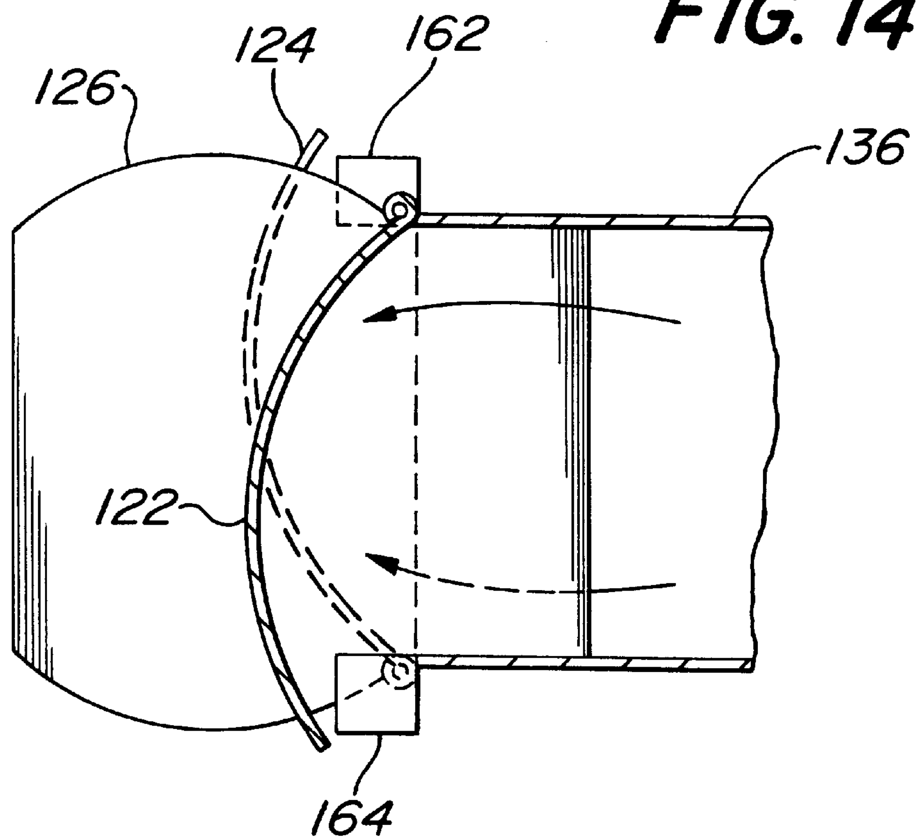
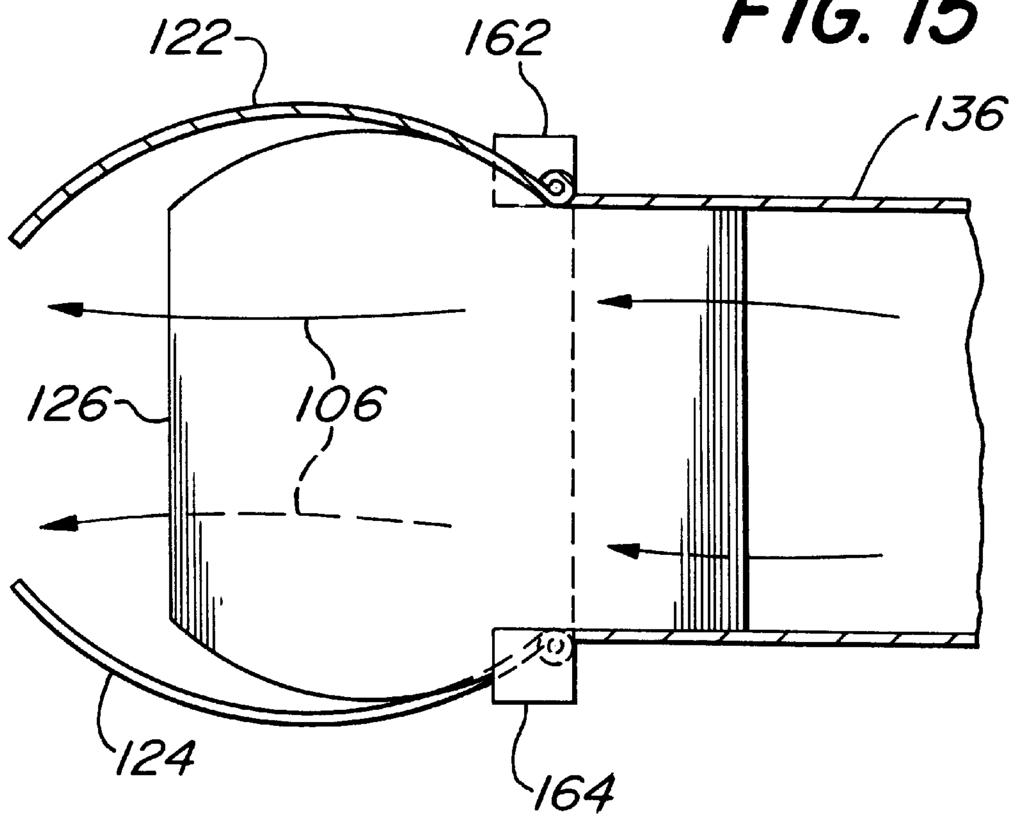


FIG. 15



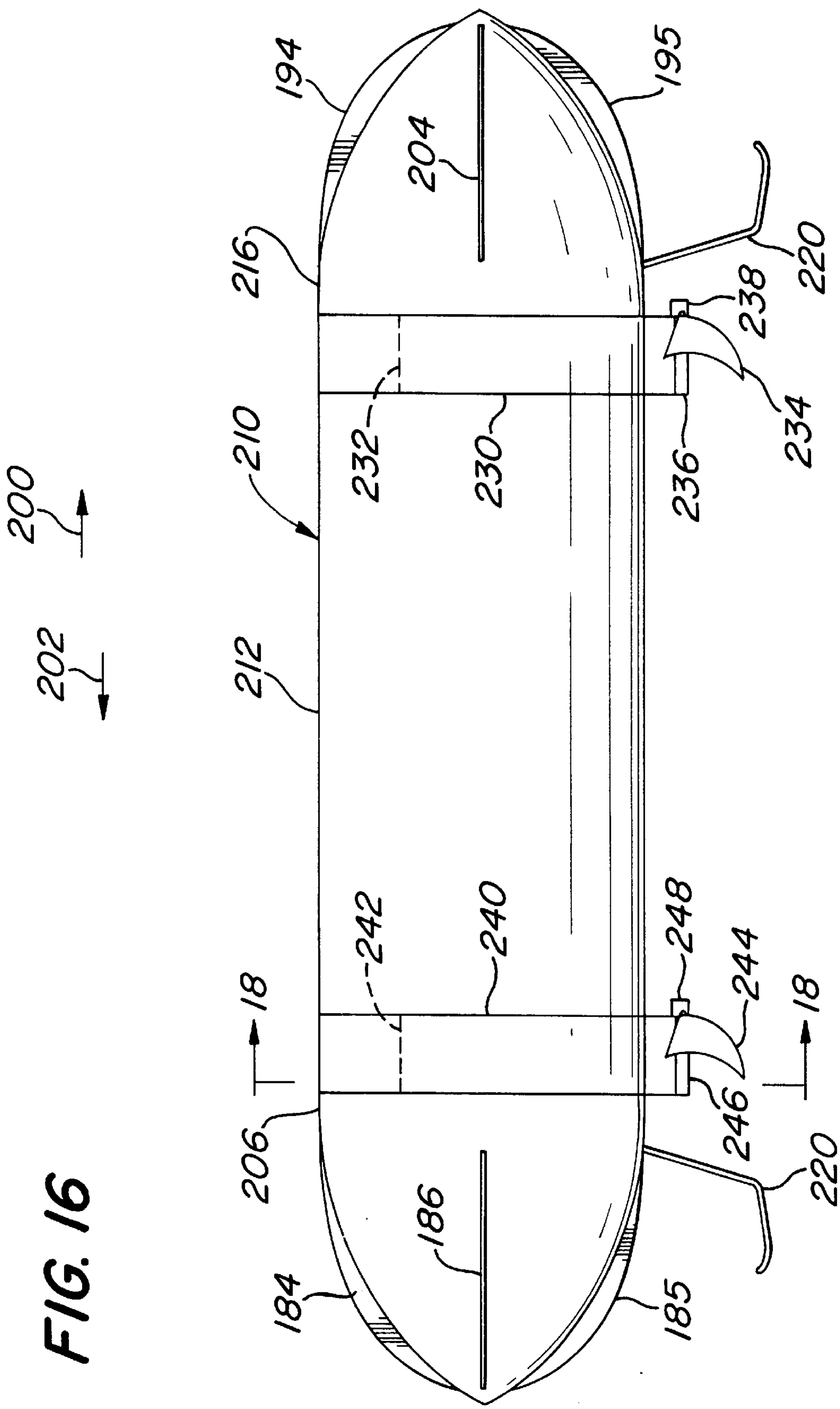


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FIG. 16

FIG. 17

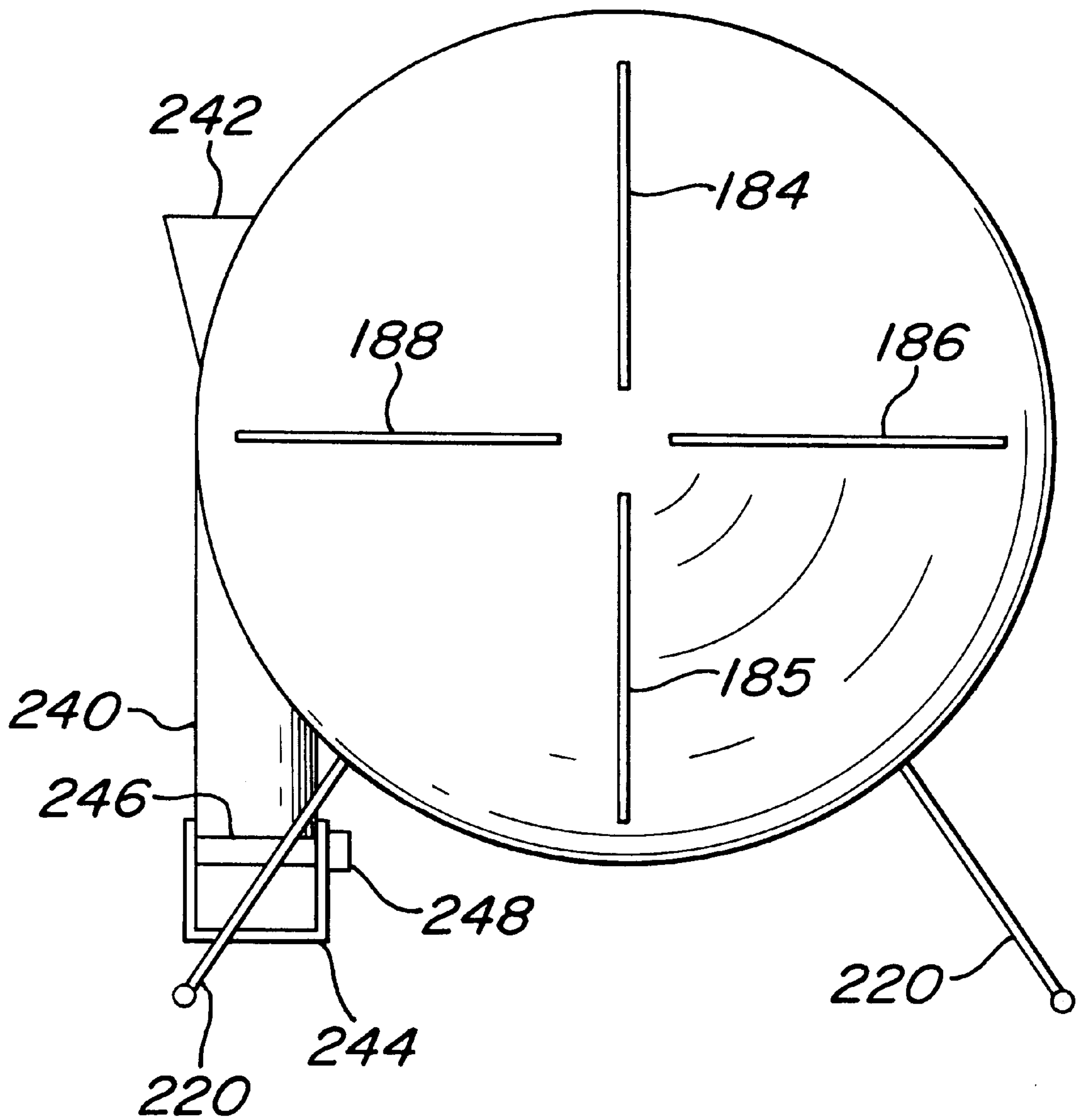
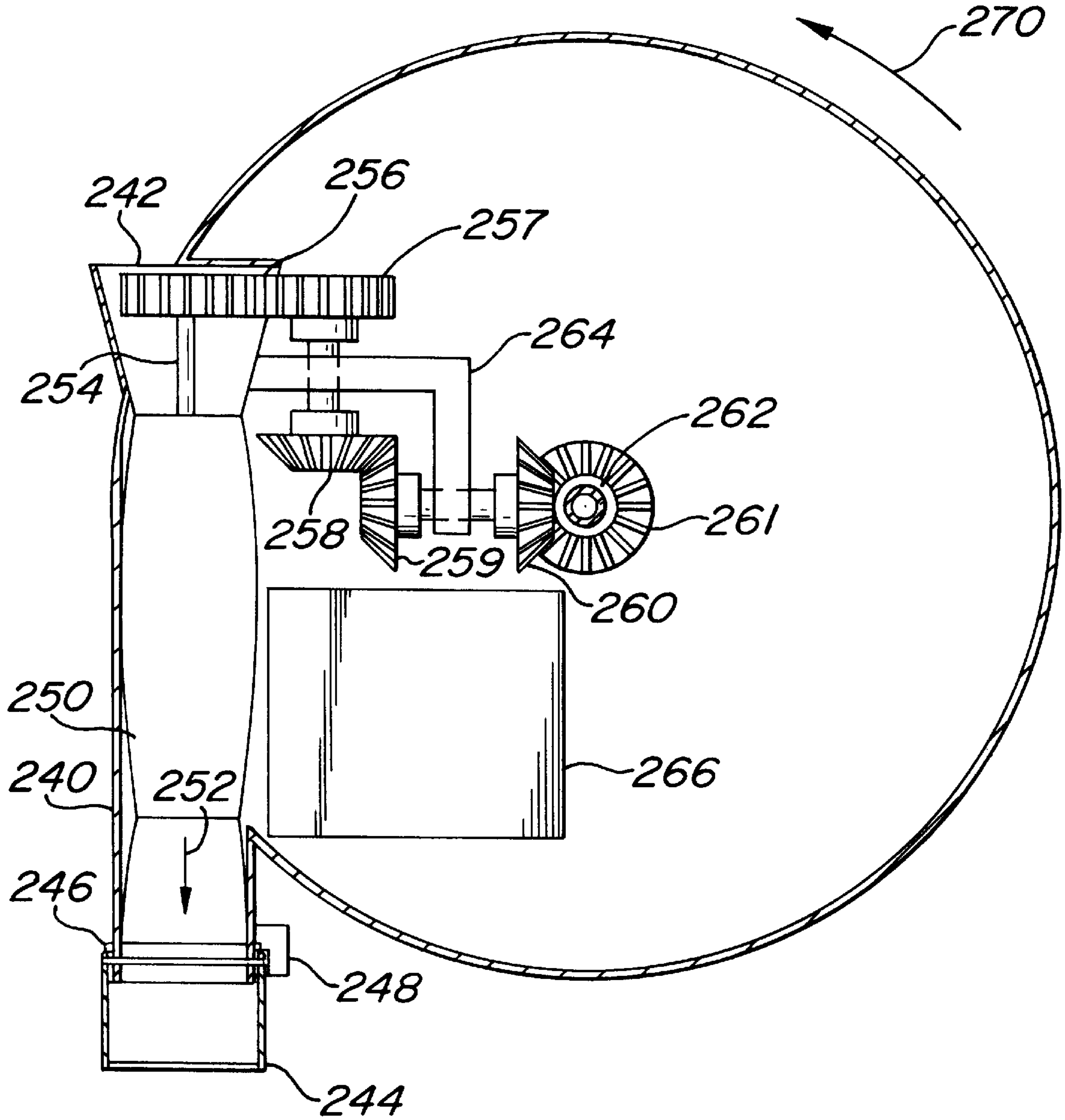


FIG. 18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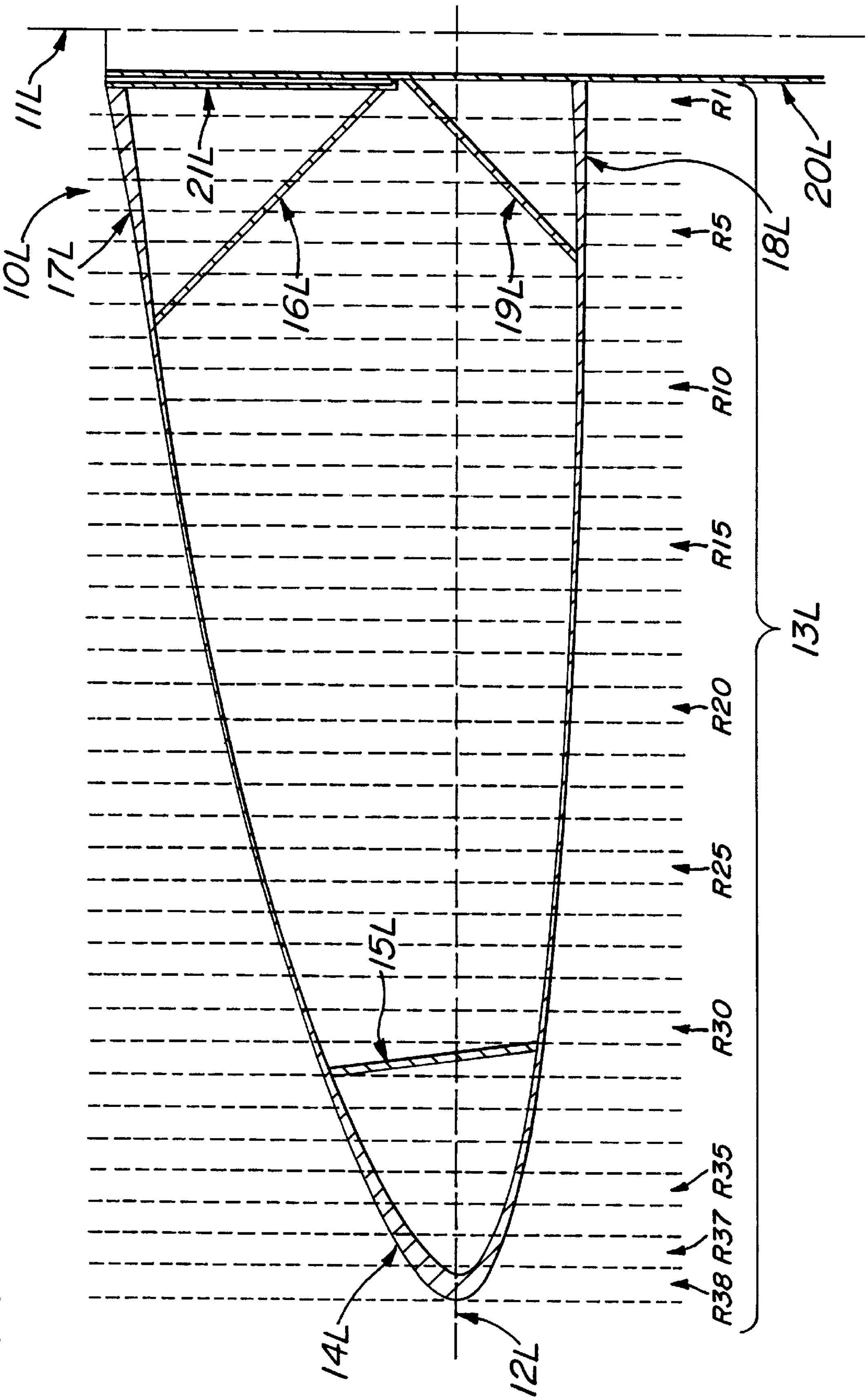
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FIG. 19

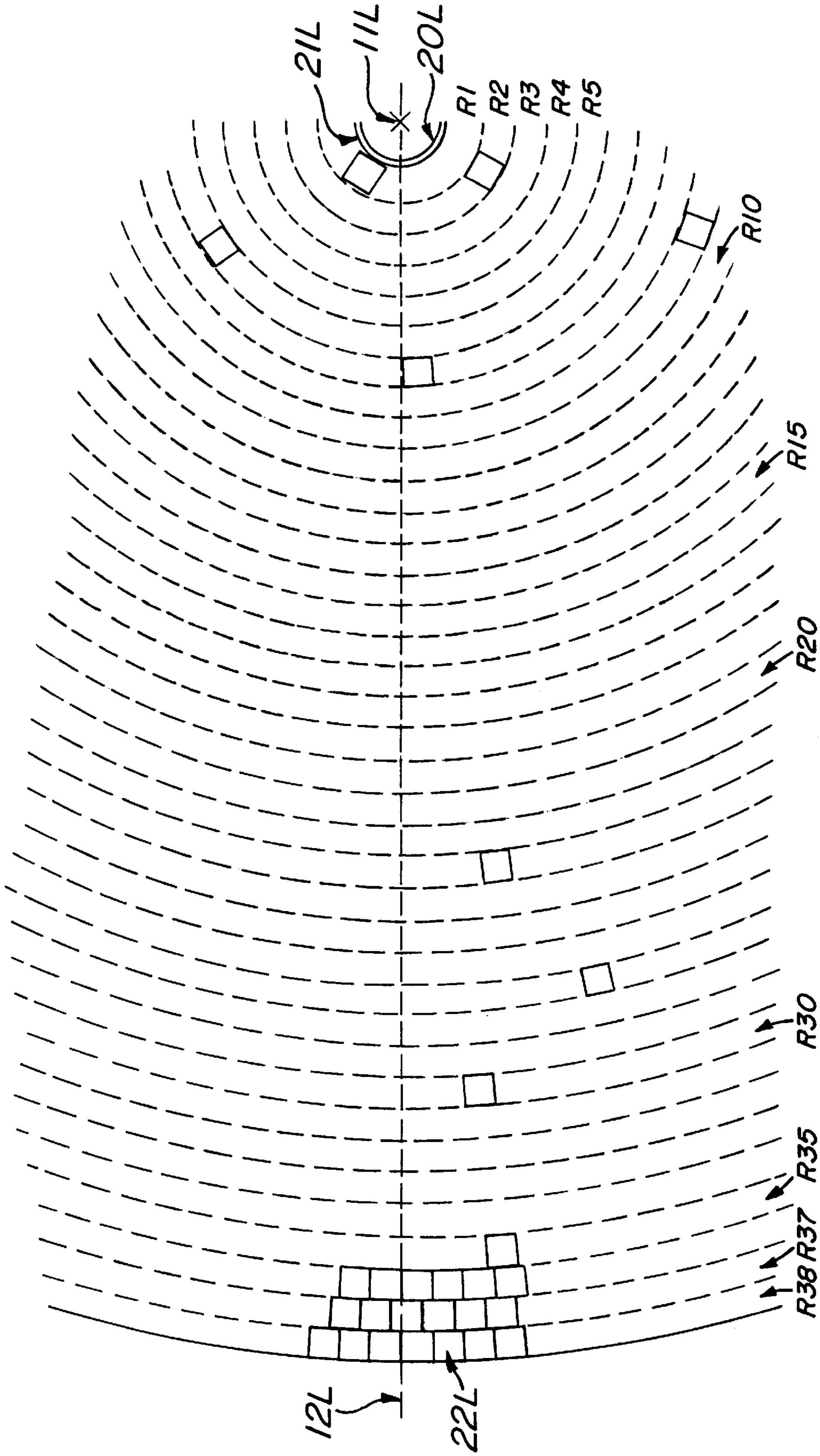

FIG. 20

EVACUATED ROTATING ENVELOPE AIRCRAFT

FIELD OF THE INVENTION

The present invention relates to a new and unobvious type of aircraft and methods associated with enabling aircraft flight. More particularly, the present invention is directed to a new and unobvious aircraft which utilizes in flight a partially evacuated rotating envelope to produce buoyancy wherein the centrifugal force of rotation acting on the envelope increases the structural rigidity enabling the use of lighter structural materials for the envelope.

BACKGROUND OF THE INVENTION

Man has been able to cause powered aircraft to fly through the atmosphere since the early part of the Twentieth Century. Much work has been done and continues to be done in developing improved and more versatile aircraft.

The most commonly used type of aircraft today requires enormous landing strips for take off and landing. However, over the years, much work has been done in attempting to develop suitable and improved vertical take off and landing (VTOL) aircraft. These have included helicopters as well as dirigibles, balloons and blimps.

Lighter-than-air aircraft such as dirigibles and the like which utilize helium or other lighter-than-air gases have the disadvantage of not only the cost of the lighter-than-air gas, the need to increase and decrease the volume of helium for ascent and descent, the substantial structure, including its weight, for containing the lighter-than-air gas and the very large structure sizes required to house gases which are only somewhat lighter than air.

Helicopters are a much heavier-than-air aircraft requiring rotating propeller or airfoil structures. Some attempt has also been made for providing vertical take off either by the means of propellers or rockets, sometimes mounted on wings which may be directed vertically for take off and horizontally for flight.

However, none of these prior art devices nor any combination of them teaches or suggests a new class of aircraft as disclosed and claimed herein.

SUMMARY OF THE INVENTION

The present invention creates a new category of aircraft or air transport vehicle. The present invention further includes new methods of achieving vertical take off and landing and flight in an economical, efficient and effective manner.

The present invention provides numerous advantages. An advantage of the present invention is that it provides an aircraft with vertical take off and landing (VTOL) capabilities thereby eliminating the need for enormous take off and landing runways. The VTOL capabilities of the present invention significantly reduce infrastructure requirements at ground-based air terminal facilities with consequent and substantial reductions in the environmental and economic impacts of such terminals.

Another advantage of the present invention is that its VTOL capabilities substantially improve the safety attributes of the aircraft as contrasted with most conventional aircraft since emergency landings may be safely conducted at vastly more locations.

Another advantage of the present invention is reduction in likelihood of sudden precipitous descent typically encountered by aircraft such as helicopters on the occurrence of a mechanical failure.

Another advantage of the present invention is that it provides an aircraft which is capable of lighter-than-air flight capabilities without the requirement of a lighter-than-air gas.

Another advantage of the present invention is that it is able to provide such an aircraft, which does not require a lighter-than-air gas, utilizes a vacuum or partial vacuum and is able to be constructed and operated as a light-weight vehicle by utilizing centrifugal force to provide structural rigidity.

Another advantage of the present invention is the ability to provide control in flight in at least certain embodiments utilizing the lift of buoyancy and airfoil characteristics in various combination depending upon the conditions of flight.

Another advantage of the present invention is that it provides an aircraft that is capable of both high speed, long distance, intercontinental operations as well as being a highly maneuverable VTOL aircraft thereby enabling a given volume of airspace to be safely occupied by a substantially larger number of aircraft.

Another advantage of the present invention is that it provides more efficient airspace utilization both at terminal locations as well as in areas between such terminal or airport locations thereby helping to reduce the growing problem of airspace congestion.

Another advantage of the present invention is that it provides an aircraft that is significantly more economical to manufacture and to operate and one that utilizes infrastructure and environmental resources more efficiently.

Another advantage of the present invention is that it provides an aircraft that is significantly more fuel efficient thereby reducing the cost of air transport as well as reducing consequent chemical and noise pollution of the atmosphere.

Briefly and basically, in accordance with the present invention, an aircraft is disclosed wherein lift is provided by means of a buoyant evacuated rotating envelope. The invention also contemplates a method of providing lift by evacuating an envelope wherein rigidity of the evacuated envelope is provided by rotating the envelope to provide centrifugal force or inertial force of rotation on material comprising the envelope. The terms centrifugal force and inertial force of rotation are used herein throughout interchangeably.

Further, in accordance with the present invention, the means for rotating the envelope is attached to the rotating buoyant evacuated envelope and rotates with the envelope. The means for rotating the envelope may be an engine (jet, turbojet, turbofan or even turboprop), which provides sufficient force to rotate the envelope against the force of air friction acting upon the external surface of the envelope.

Further, in accordance with the present invention, the shape, displacement and aspect ratio of the envelope may be changed dynamically during flight to optimize the envelope for varying flight requirements and conditions.

Further, in accordance with the present invention, means such as exhaust baffles or deflectors are provided for dividing the output air and exhaust of the engines into multiple flow streams with a purpose of creating a rotating torque force on the engines and the attached envelope.

Further, in accordance with the present invention, means such as pumps are provided for evacuating and/or pressurizing the envelope for the purpose of developing the desired amount of buoyancy and for maintaining the walls of the envelope under tension under various conditions.

Further, in accordance with the present invention, the means for rotating is selected to provide rotation necessary to provide a sufficient centrifugal force on the exterior material of the rotating envelope whereby the need for and weight of mechanical support structures to withstand the inward force of external atmospheric pressure may be reduced and/or minimized.

Further, in accordance with one embodiment of the present invention, the means for rotation of the envelope causes the envelope to rotate about an axis normal to the direction of lateral motion of the aircraft during flight thereby exposing the leading edges and surfaces of the envelope to aerodynamic heating caused by contact with atmosphere during only a portion of each rotation of the envelope. Rotation of the envelope allows the heat to be dissipated as the heated portion of the envelope rotates away from the leading edge during each revolution.

Further, in accordance with the present invention, lift for the aircraft in at least some embodiments may be supplemented by air foil lift (Bernoulli effect principle) due to lateral movement through the atmosphere, in addition to the buoyancy of the evacuated envelope.

Further, in accordance with the present invention, a payload compartment may be provided, mounted to said rotating envelope by bearings whereby the evacuated rotating envelope may be rotated without rotation of the payload compartment.

Further, in accordance with the present invention, the non-rotating payload compartment may be provided with lateral jets for enhancing lateral motion of the aircraft during flight.

Further, other variations will be apparent to those skilled in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of illustrating the invention, there are shown in the drawings forms which are presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIG. **1** is an elevation view of the present invention illustrating the rotating envelope in two different configurations, one being illustrated by a dotted line.

FIG. **2** is a cross-sectional view taken along the dotted section line labelled FIG. **2** of FIG. **1**.

FIG. **3** is a cross-sectional view, partially broken away, taken along line **3—3** of FIG. **2**.

FIG. **4** is a cross-sectional view taken along line **4—4** of FIG. **1**.

FIG. **5** is a cross-sectional view taken along line **5—5** of FIG. **3**.

FIG. **6** is a cross-sectional view illustrating the exhaust deflectors of FIG. **5** in a second and more open position.

FIG. **7** is a side elevation view of another embodiment of the present invention, utilizing an evacuated rotating envelope in the form of a cylinder.

FIG. **8** is a front elevation view of the embodiment shown in FIG. **7**.

FIG. **9** is a cross-sectional view of the forward portion of the second embodiment taken along **9—9** of FIG. **8**.

FIG. **10** is a cross-sectional view of the aft portion of the second embodiment taken along line **10—10** of FIG. **8**.

FIG. **11** is a cross-sectional view taken along line **11—11** of FIG. **7**.

FIG. **12** is a cross-sectional view, partially broken away, taken along line **12—12** of FIG. **10**.

FIG. **13** is a cross-sectional view taken along line **13—13** of FIG. **7**.

FIG. **14** is a cross-sectional view taken along line **14—14** of FIG. **12**.

FIG. **15** is a cross-sectional view showing the exhaust deflectors of FIG. **14** in a second and more open position.

FIG. **16** is a side elevation view of a third embodiment of the present invention, illustrating another embodiment of an evacuated rotating envelope in the form of a cylinder.

FIG. **17** is a rear elevation view of the embodiment shown in FIG. **16**.

FIG. **18** is a cross-sectional view taken along line **18—18** of FIG. **16**.

FIG. **19** is a cross-sectional view of an evacuated rotating disk embodiment of a rotating envelope illustrating possible reinforcing structures and an approach to analysis of forces on the structure.

FIG. **20** is a plan view of a portion of the rotating envelope of the embodiment of FIG. **19** illustrating an approach to analysis of forces on the structure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings in detail wherein like numerals indicate like elements, there is shown in FIG. **1** an aircraft **10** in accordance with the present invention. Aircraft **10** includes an envelope **12** which is adapted to be evacuated and rotated. Envelope **12** may be evacuated to assist in lift off, particularly vertical lift off and may be rotated so that the centrifugal force generated by such rotation applies an outward force to the envelope, thereby enhancing or increasing its structural rigidity and enabling envelope **12** to be constructed with a minimum of structural components and a minimum of weight.

Dotted line **14** shows envelope **12** with a changed and enlarged configuration to enable an increase in buoyancy as may be needed from time to time, particularly during vertical ascent or take off. Envelope **12** may at times contain a positive pressure in excess of ambient surrounding atmospheric pressure, such as for example when the craft is parked on the ground or even during certain conditions of flight where enhanced structural rigidity of the envelope may be desired and the air foil lift provided by envelope **12** is sufficient to maintain the altitude of the aircraft due to the aircraft's high speed of lateral motion.

Still most particularly referring to FIG. **1**, there is shown a non-rotating payload compartment **16**. Payload compartment **16** may carry people, weapons, goods or any other type of item needed to be transported by air. Although not shown, payload compartment **16** may be provided with windows or viewing ports. Preferably, payload compartment **16** may be equipped with an electronic external viewing system which may be more aero-dynamically effective, efficient and economical. Also shown in FIG. **1** is a plurality of lateral motion jet ports **18**. These may be integrally formed as a part of the payload compartment or may be a separate structure above or below the payload compartment. As illustrated in the presently preferred embodiment, the lateral motion jet ports are formed integrally with the payload compartment.

In addition to the lateral motion jet ports, payload compartment **16** may be equipped with one or more engines to provide additional lateral thrust thereby enhancing lateral velocity. One such engine is shown in dotted outline at **21**. This may be a jet engine or any other type of suitable engine. Additional such engines may be located around the payload compartment, preferably one being on each side or in each quadrant, but more or less may be utilized as desired. Further, these engines are optional.

Also shown in FIG. **1** is a plurality of light-weight landing gear **20**. Preferably, three such landing gear would be utilized, although any other suitable number may be utilized such as 4, 5, 6 or any other suitable number.

Also shown in FIG. **1** are moveable exhaust deflectors **22** and **24** along with an exhaust divider plate **26**. Exhaust deflector **24** is shown in dotted line because it is behind exhaust divider plate **26**.

Referring now more particularly to FIG. **2**, taken in conjunction with FIG. **1**, there is shown a cross-sectional view through the center of aircraft **10** showing the central core tube **28**, engine **30** and other structure. Engine **30** preferably may be a jet engine, a turbojet or turbofan engine, although any suitable engine such as a propeller engine may be feasible. Central core tube **28** has mounted therein a fuel tank **32** as the central core tube **28** is a convenient and stable location for such mounting. However, it is understood that other suitable locations may be utilized for the fuel tank, including an annular design located within the envelope or other suitable locations. Engine **30** is mounted to and rotates with central core tube **28** and envelope **12**, that is they corotate.

Central core tube **28** is preferably constructed of multiple telescoping sections which enables the change of shape and or aspect ratio of envelope **12** as illustrated in FIG. **1**. The aspect ratio may be considered to be the ratio of the diameter to the height of the envelope. Envelope **12** is mounted at the upper end to a telescoping enlarged upper core tube section **34**. Upper core tube section **34** sealably engages lower core tube section **36** at **38**. The movement of upper core tube section **34** on lower core tube section **36** may be controlled by hydraulic cylinders **40** or other suitable mechanical or electrical control means.

Two pumps **42** and **44** are mounted within central core tube **28**. Preferably, as illustrated in FIG. **2**, these may be mounted within lower core tube section **36** adjacent engine **30**, but other suitable mounting locations may be utilized. Pump **42** is an envelope vacuum pump which is used to pump air out of envelope **12** to create a vacuum or a partial vacuum within envelope **12**. Envelope pressure pump **44** is used to pump air into envelope **12**. These two pumps are managed to ensure that the light-weight low structural component envelope **12** is always under tension and is not in a condition where it may be collapsed by the pressure of the ambient atmosphere regardless of whether envelope **12** is rotating and regardless of any aerodynamic pressure which may be exerted on envelope **12** for any reason, including as a result of its lateral motion relative to ambient atmosphere.

Continuing to refer to FIG. **2**, while simultaneously also referencing FIGS. **3** through **6**, as well as FIG. **1**, non-rotating payload compartment **16** is shown to be mounted on upper bearings **46** and lower bearings **48**. Payload compartment **16** may be provided with a wall **60** separating payload compartment **16** from central core tube **28**. The upper portion of payload compartment **46** may be provided with an air plenum **50** integrally formed as a part of non-rotating payload compartment **16**, or this plenum may be an independent non-rotating structure. However, in a presently preferred embodiment, air plenum **50** would integrally form a part of non-rotating payload compartment **16**.

Central core tube **28** is provided with a plurality of openings **52** which enable exhaust gases from engine **30**, as shown by arrows **54**, to exit into air plenum **50** as shown by arrow **56** as well as to continue directly downward through central core tube **28** as shown by arrows **58**.

The downwardly directed exhaust gases as shown by arrows **58** are divided by an exhaust divider plate **26**. Exhaust divider plate **26** divides the exhaust into two equal streams such that each stream may be deflected in a different direction from the other by means of movable exhaust deflectors **22** and **24**. When movable exhaust deflectors **22** and **24** are positioned as shown in FIGS. **1** and **2**, central core tube **28** along with envelope **12**, as well as attached engine **30** and fuel tank **32**, are caused to rotate. The exhaust gases deflected in this manner may cause high speed rotation. Further, the amount of the deflection and the degree of rotation may be controlled both by the exhaust gas flow rate and the angle of deflectors **22** and **24**. Further, the opening of the exhaust deflectors in a manner similar to that shown in FIG. **6** allows the exhaust gases shown by arrows **58** to provide a substantial amount of vertical lift by the jet action of the exhaust gases' downward thrust, especially when the deflectors are open. The position of exhaust deflectors **22** and **24** may be controlled by suitable control means **62** and **64**, which may be any suitable type of control means including gears driven by an electric motor, pneumatic, hydraulic or any other suitable controllable drive means.

Exhaust deflectors **22** and **24** are shown in another position in FIG. **5** wherein, although rotation of the center core tube **28** is provided, the exhaust output is substantially obstructed to maximize deflection of exhaust gases into air or exhaust plenum **50**.

Referring now more particularly to FIG. **4** taken in conjunction with FIGS. **2** and **1**, the exhaust or air plenum **50** is shown with the openings **52** in central core tube section **36** feeding exhaust into plenum **50**. The outer circumference **66** of air plenum **50** is provided with a plurality of lateral motion jet ports **18**, each of which are controllably opened or closed by a plurality of vanes **68**. As may be best seen in FIG. **1**, in a presently preferred embodiment, two vanes would be utilized in each opening, however, it is understood that more or less vanes may be utilized depending upon the preference of the designer, and it is explicitly stated that a single vane could be utilized or it is contemplated that ten or more vanes could be utilized to controllably open and close each lateral motion jet port **18**.

In addition to the horizontally arranged controllable vanes **68**, a plurality of the lateral motion jet ports may be provided with controllable vanes **70** position in a vertical attitude to controllably direct the flow of exhaust gases in a direction counter to the direction of rotation of envelope **12** thereby providing a counter-rotation or stabilization force to maintain plenum **50** as well as payload compartment **16** non-rotating. Vanes **70** compensate for the fact that bearings **46** and **48** are not perfectly frictionless. Vertical vanes **70** may be controllably operated by a suitable motor drive **72** and vane **68** may be driven by a suitable controllable motor drive **74**. Both controllable motor drives **72** and **74** may be any suitable type of motor drive including electromechanical, electrical gear-driven, pneumatic, hydraulic or any other suitable drive to selectively control the position of the vanes.

The lateral motion jet ports provide a jet action to drive aircraft **10** in a particular direction. For example, if it were desired that aircraft **10** begin to move in the direction of arrow **76**, the vanes **68** of lateral motion jet port **18A** would be opened, preferably with all of the remaining vanes closed to prevent unwanted forces in other directions and to prevent aerodynamic drag. Of course, depending upon the amount of force needed to resist the rotation and overcome the friction of bearings **46** and **48**, vertical vanes **70** are opened just sufficiently to overcome the friction of these bearings and to maintain the payload compartment, as well as plenum **50**, in a stable non-rotating condition.

The rotating disc embodiment illustrated in FIGS. **1** through **6** includes four means of lift or vertically upward directed acceleration.

First, lift of the rotating, buoyant, evacuated envelope provides lift due to buoyancy. It is understood that the term "evacuated" includes partially evacuated as well as substantially or completely evacuated. This applies throughout, including use of the term in the claims unless the context of use clearly indicates otherwise. It is recognized that a perfect vacuum is not necessary and would be extremely difficult, if not impossible, in apparatus of the type disclosed.

Secondly, the exhaust from the engines as described previously, in particular with FIG. **6**, provides an upward force due to the reaction of the downwardly directed exhaust gases.

Thirdly, lift is provided as a result of frictional air flow generated by the upper and lower rotating surfaces of envelope **12** (or envelope **14** in the enlarged state), as may be best seen in FIG. **1** by the direction of the air flow arrows **78** and **80**. Air moves along the upper surface of the envelope and moves in an outward direction as a result of the frictional and centrifugal forces acting on it, substantially in the direction as shown by arrow **78**. As this surface air leaves the envelope at its outer edge, it continues to flow until its momentum is dissipated. The shape of the envelope results in the air that leaves the upper surface having a steeper downward angle as shown by arrow **78** than the upward angle of air that leaves the lower surface as shown by arrow **80**. The sum of these two air flows is a net downward air flow that provides an additional source of reaction lift for the aircraft.

A fourth means of lift is available when aircraft **10** is moving laterally through the atmosphere. When the aircraft is moving laterally, the air flow path over the upper surface of envelope **12** or **14** is longer than the air flow path over the lower surface of the envelope resulting in higher velocity air movement and lower pressure over the upper surface as compared with the lower surface of the envelope. This pressure difference provides an additional source of aerodynamic lift, sometimes referred to as air foil lift or lift in accordance with the Bernoulli effect principle.

The four sources of lift described above are not all necessarily used at the same time and in some cases, all four are not available. For example, during start up operations before the rotating evacuated envelope has reached full rotational speed and before it is fully evacuated, full envelope buoyancy is not available. Similarly, airfoil lift is not available if envelope **12** or **14** is not in lateral motion with regard to the ambient atmospheric environment, such as during a perfectly vertical take off in still air. Additionally, lift achieved through buoyancy is reduced in thinner atmospheres encountered at higher altitudes.

Requirements for lift are also variable. For example, payloads and fuel loads are variable. Additionally, gravitational effects are reduced at higher altitudes thereby reducing lift requirements. Combinations of buoyancy lift and air foil lift may be used for take offs that are not strictly vertical, but are accomplished in a relatively small area, as compared to winged aircraft. The rotating disk embodiment described with respect to FIGS. **1** through **6** may incorporate a comprehensive lift management control system that integrates and controls all lift sources and lift requirements at every instant of time.

Aircraft descent is primarily accomplished by making the aircraft heavier and this may be done by pumping air into envelope **12** by means of the envelope pressure pump **44**. Aircraft lift may also be reduced to assist in the descent process by reducing the rate of rotation of the envelope and by reducing the rate of lateral motion with respect to the ambient atmosphere.

The fact that multiple, complementary sources of lift are incorporated in the rotating disk embodiment means that no one of them must be sized to accommodate all lift requirements. This may provide a significant improvement in efficiency and economy as compared to alternative aircraft lift approaches.

Additionally, since the rotating disk embodiment incorporates multiple, complementary sources of lift, this built in redundancy factor adds to the safety margin of the vehicle. It is further noted that unique advantages in efficiency and economy are produced by the fact that one power source may serve all four power needs of the aircraft, although some of these may be provided by other power sources, such as additional engines for redundancy. The four power requirements include:

1. Power to rotate the buoyant, evacuated envelope;
2. Power to be used as an extra source of vertical thrust for special situations (such as "popping" the aircraft off the ground during a take off operation);
3. Power for lateral motion jet ports to provide lateral acceleration and braking; and
4. Power to operate the payload compartment counter rotation jet ports.

The rotating disk embodiment of FIGS. **1** through **6**, if optimized for very high speed lateral motion, also offers significant benefits in the area of aerodynamic heating. A major component of the vehicle that impinges on the atmosphere is the envelope **12** and this component rotates. Therefore, heat absorbed by each portion of the envelope **12**, while it is in the leading edge position is dissipated during the time that the portion is not in the leading edge position. Additionally, the rotating disk embodiment is not fully dependent on the action of an airfoil, or wing, for lift which also reduces aerodynamic heating.

The rotating disk embodiment also provides substantial platform stability resulting from the gyroscopic action of the rotating envelope.

An example of an evacuated rotating disk envelope aircraft, for purposes of illustration, and not by way of limitation, may be represented by the following general parameters concerning some of the major system components.

Envelope: (General shape per FIG. 1)	
Diameter -	30.0 m
Height -	5.53 m
Material -	Carbon fiber in plastic, metal or ceramic matrix (or equivalent); 0.09 cm thick; weighing approx. 900 g/m^2 (average)
Surface area -	1555 m^2
Displacement -	2160 m^3 2790 kg of air at sea level
Engine(s) thrust capacity -	1200 to 1700 kg (static)

-continued

Weight Distribution:		
Envelope (96% evacuation)	1450 kg	52%
Core Tube, Engine(s) & Fuel	530	19
Payload Compartment	445	16
Payload	365	13
	2790 kg	100%

Centrifugal Force:

Formula -

$$F = \frac{Pi^2 \times S^2 \times M \times R}{900}$$

Where:

F	=	Force in dynes (1 g = 980 dynes @ 1G acceleration)
S	=	Revolutions per minute (RPM)
M	=	Mass in grams
R	=	Radius in centimeters

Application of Envelope general design parameters:

Outward force acting on 1.0 cm^2 of Envelope material at periphery to be 1.50 times atmospheric pressure at sea level (sea level atmospheric pressure = 1.013×10^6 dynes per cm^2)

Therefore -

$$S^2 = \frac{900 \times F}{Pi^2 \times M \times R}$$

$$= \frac{900 \times 1.50 \times 1.013 \times 10^6}{Pi^2 \times 0.090 \times 1500}$$

$$S^2 = 1{,}026{,}385$$

$$S = 1{,}013 \text{ RPM}$$

Referring now to FIGS. **7** through **15**, there is shown another embodiment of the present invention which utilizes a rotating evacuated cylinder as the rotating evacuated envelope for the aircraft. Referring now, more particularly, to FIG. **7** there is shown a rotating evacuated envelope aircraft **90** which includes a rotating evacuated envelope in the form of a rotating evacuated cylinder **92**. Aircraft **90** is provided with a non-rotating payload compartment **96** on which there is formed or attached direction control vanes **94**, **95** and **104**. Direction control vane **105** is shown in the front elevation view of FIG. **8**. Direction control vanes **94**, **95**, **104** and **105**, formed or mounted on non-rotating payload compartment **96** are used to control and change the direction of the aircraft when it is moving forward (in the direction of arrow **102**) with respect to ambient atmosphere. Each opposing pair of vanes, such as **94** and **95** operate together. The vanes may be operated such that they rotate on an axis normal to the exterior surface of payload compartment **96**. Of course, variations in the number of vanes and the arrangement of the vanes is within the scope and spirit of the present invention. More or less vanes may be utilized.

Payload compartment **96** may preferably be provided with a weight distribution organized such that its center of gravity is considerably below the center line of aircraft **90** and may carry goods, people and/or weapons as described with respect to the previous embodiment. Although payload compartment **96** is not shown with viewing ports, it could be equipped with them if so desired. Further, external viewing by electronic means as described previously may be preferred as being more efficient and more economical.

As may be best seen in FIGS. **7** and **8**, aircraft **90** may be provided with relatively inexpensive and lightweight landing gear **100**, similar in nature to that provided in the previous embodiment.

Continuing to refer most particularly to FIG. **7**, a non-rotating attitude control section **98** is provided aft of rotating buoyant evacuated cylinder **92**. Non-rotating attitude control section **98** is provided with vertical and lateral jet motion ports **118**. Jet motion ports may also be directed between horizontal and vertical, and this is illustrated in the drawings. The vertical and lateral jet motion ports **118** will be described more fully hereinafter particularly with respect to FIG. **13**.

Continuing to refer to FIG. **7**, taken with FIG. **8**, there is shown an air intake **114**. Referring to FIG. **8**, there is also visible fuel tank **132** seen when viewing the forward section of core tube **134**. Reference may also be had to FIGS. **9** and **10** for a better view of this structure.

Continuing to refer to FIG. **7**, there is shown an exhaust divider plate **126** with moveable exhaust deflector **122** as well as moveable exhaust deflector **124** shown in dotted lines as it is located behind divider plate **126**.

Referring now to drawing FIGS. **7** through **15**, the air flow through the central core tube and its division into two flow streams by exhaust divider plate **126** and deflection by moveable deflectors **122** and **124** is similar to that described in detail with respect to the previous embodiment. Briefly, air enters at the front center air intake **114** and is caused to flow through a smaller forward section of core tube **134** as well as somewhat larger aft core tube section **136** which includes engine **130**. Engine **130** may be any suitable engine as described above with respect to engine **30**.

The exhaust from engine **130** is shown by arrows **154** and continues at least in part to be divided by divider plate or baffle **126** and deflected by moveable deflectors **122** and **124** as shown by arrows **108** and **110** to cause the central core tube with the attached engine and rotating cylindrical envelope **92** to rotate.

As described with respect to the previous embodiment, the position of exhaust deflectors **122** and **124** may be controlled by suitable control means **162** and **164**, which may be any suitable type of control means including gears driven by electric motors, pneumatic, hydraulic or other suitable controllable drive means as described above.

Exhaust deflectors **122** and **124** are shown in other positions in FIGS. **14** and **15**. In FIG. **15**, deflectors **122** and **124** are operated by their control devices **162** and **164**, respectively, to be substantially open resulting in maximum thrust caused by exhaust flow in the direction of arrows **106**. This also minimizes the air flow through openings **152** in core tube **136**.

In FIG. **14**, exhaust deflectors **122** and **124** are shown in a substantially closed or obstructed position, although there is still some exhaust flow there through for exerting some rotational force on core tube **136** and the structures attached thereto, such as rotating cylinder **92**. However, positioning deflectors **122** and **124** in a position similar to that shown in FIG. **14** substantially increases the exhaust gas flow through openings **152** into plenum **150** of non-rotating attitude control section **98**.

Referring now more particularly to FIG. **13** taken in conjunction with FIGS. **7** and **10**, the exhaust or air plenum **150** is shown as receiving exhaust through openings **152** and central core tube section **136**. The outer circumference **166** of air plenum **150** is provided with a plurality of vertical and lateral motion jet ports **118**, each of which are controllably opened or closed by a plurality of vanes **168** as may be seen in FIGS. **7** and **13**. Preferably two vanes may be used in each opening, however, this structure may be similar to that described with respect to FIG. **4**, and it is understood that more or less vanes may be utilized.

In addition to vanes arranged such that their longitudinal direction is in the direction of the circumference of aircraft **90**, a plurality of stabilization vanes **170** may be utilized to allow controllable amounts of exhaust flow to counteract rotation of the attitude control section **98**. This may be necessary because bearings **146** and **148** for mounting the attitude control section to core tube **136** cannot be made perfectly frictionless. Stabilization vanes **170** are similar to vanes **70** described with respect to the previous embodiment.

The non-rotating attitude control section **98**, as well as the payload section, is constructed and designed with its weight distribution organized such that the center of gravity is considerably below the center line of the aircraft, thereby insuring that landing will be on landing gear **100**. Further, by controlling vanes **168**, the exhaust gases through jet ports **118** may assist in landing and in vertical take off. When exhaust deflectors **122** and **124** are closed, maximum thrust is provided through selected jet port, those aimed in the direction of landing gear **100**, to provide maximum vertical thrust for vertical take off. Further, by controlling vanes **168**, the aircraft may be navigated, that is by providing a lateral thrust for turning the aircraft during flight. In the embodiment shown in FIG. **7**, maximum speed in the direction of arrow **102** is achieved during flight with deflectors **122** and **124** in a substantially open position, while being controlled such that sufficient rotational torque is provided on the center core tube and the rotating evacuated envelope **92** to prevent collapse of envelope **92** when evacuated. Struts or gussets **138** in FIG. **9** and **140** in FIG. **10** are provided to help support the end walls of cylinder **92** when it is evacuated.

As described with respect to the previous embodiment, the rotating evacuated envelope in the form of rotating cylinder **92** is evacuated by envelope vacuum pump **142**. Air is pumped into cylinder **92** by envelope pressure pump **144** as needed. As described previously, air may be pumped into the evacuated envelope for landing, as well as for maintaining altitude and other control during flight as well as for generally maintaining the degree of evacuation of the evacuated rotating envelope of the aircraft.

As with the previous embodiment, the non-rotating payload compartment **96** is provided with a wall **160** separating it from the central rotating core tube **134** as may be best seen in FIG. **9**. Also referring to FIG. **9**, payload compartment **96** is mounted on bearings **86** and **88**.

In operation, the embodiment of FIGS. **7** through **15** operates on the principle of the buoyancy of an evacuated envelope wherein the envelope is in the form of a cylinder and its structural rigidity is enhanced by rotating the cylinder at a sufficient rotational velocity thereby enabling the structure to be maintained in its evacuated condition with a minimum of structural weight. The aircraft may be utilized for vertical landing and take off due to the evacuation of the rotating cylinder which is complemented by the thrust provided by selected vertical jet ports **118**. Further, other jet ports **118** may be utilized for navigation and attitude control during flight. As previously described, the rotation of attitude section **178** may be stabilized by exhaust thrust provided by controllable opening of stabilization vanes **170**. Further, additional forward thrust may be provided by suitable engines, such as jet engines, turbojet or turbofan engines, on aircraft **90**. A possible jet engine for forward motion is shown in dotted lines **172** on FIG. **7**, mounted on the payload compartment. A similar engine would be mounted on the other side of the payload compartment, and this is not shown. Small jet engines may be mounted as shown in dotted lines at **174** on payload compartment **96** to stabilize the payload compartment against rotation. Other variations will be apparent to those skilled in the art.

Referring now to FIGS. **16**, **17** and **18**, there is shown another embodiment of the present invention which utilizes a rotating evacuated envelope wherein the evacuated envelope is rotated such that the centrifugal force reduces the need for structural components and accordingly the weight of such structural components. The rotating evacuated envelope aircraft **210** utilizes a rotating evacuated cylinder **212** as its rotating evacuated envelope. Aircraft **210** is provided with two non-rotating payload compartments **206** and **216**. Payload compartment **216** is provided with directional control vanes **194** and **195** as well as **204** and one opposite **204** (not shown). Directional control vanes **194**, **195**, and **204**, being shown, are used and operate in a manner similar to that described with respect to directional control vanes **94**, **95**, **104** and **105** in the previous rotating cylindrical embodiment. Payload compartment **206** is provided with similar directional control vanes **184**, **185**, **186** and **188**. There is another vane on the back side of FIG. **16**, opposite of vane **204**, which is not shown. As may be suggested by the shapes of non-rotating payload compartments **206** and **216**, aircraft **210** is adapted to fly in the direction of arrow **200** or arrow **202**.

Aircraft **210** is provided with inexpensive and lightweight landing gear **220** similar to that described with respect to the previous embodiments. Aircraft **210** is preferably provided with two non-rotating power units **230** and **240**. However, it is understood that a single power unit or more than two power units may be utilized. Power unit **230** is provided with an air intake **232** and power unit **240** is provided with an air intake **242**. Power unit **230** is provided with a rotatable exhaust deflector **234** mounted on a deflector rotation ring **236**. A controllable drive **238** is provided for exhaust deflector **234**. Similarly, power unit **240** is provided with a rotatable exhaust deflector **244** mounted on a deflector rotation ring **246** and operated by a controllable drive **248**.

The exhaust deflectors **234** and **244** are both shown in FIG. **16** to deflect the engine exhaust in a rearward direction, that is in the direction of arrow **202** thereby causing propulsion of aircraft **210** in the forward direction of arrow **200**. The exhaust deflectors **234** and **244** may be rotated on their respective deflector rotation rings **236** and **246** such that the engine exhaust may be directed to the right, to the left, in a forward direction or in any other intermediate direction. By directing the exhaust in the direction of forward direction shown by arrow **200**, the aircraft can be made to fly in the direction of arrow **202**. Further, by directing the deflector sideways, the aircraft **210** may be moved laterally, or by directing one deflector into the right and the other to the left, the aircraft may be caused to rotate or turn rapidly. Of course, the deflectors may be adjusted to any intermediate position for maneuvering or navigation.

The exhaust deflectors **234** and **244** are controllably operated by control drives **238** and **248**, which may be similar to the control drives described previously with respect to exhaust deflector drive **62** and **64**. The adjustment of the exhaust deflectors, as to the degree of opening, allows them to be positioned for maximum lateral thrust as shown in FIG. **16** or for maximum vertical thrust when fully opened or in any other intermediate position as may be dictated by flight, landing or take off requirements.

As described with respect to previous cylindrical embodiment, the payload compartments **206** and **216** may preferably have their weight distribution organized such that their centers of gravity are considerably below the central axis of the aircraft thereby insuring proper landing on landing gear **220** as well as stabilization in an appropriate orientation during flight without the expenditure of energy. Payload compartments **206** and **216** may carry goods, people, weapons or the like as previously described with respect to the other embodiments. Preferably, payload compartments **206** and **216** should be managed to be approximately equal weight when loaded. However, this may be adjusted by adjusting the output exhaust power of power units **230** and **240**.

The outside of each payload compartment **206** and **216** is provided with the vanes as previously described. These vanes, as described with respect to the previous embodiment are moveable such that each opposing pair is operated together and rotated about axis normal to the external surface of the payload compartment under each vane. The vanes are used to control and change the direction of the vehicle when it is moving with respect to ambient atmosphere. The vanes as well as structure of the air intake **242** and rotatable exhaust deflector **244** are further illustrated in FIG. **17**.

Referring now more particularly to FIG. **18**, there is shown a cross-sectional view through power unit **240**. There is shown in FIG. **18** an engine **250** which may be a turbojet, turbofan or any other suitable type of engine for producing an exhaust which exits in the direction of arrow **252**. The output drive of engine **250** is fed via shaft **254** and gears **256** through **261** on their associated shafts to transmit the output of engine **250** to rotate a center drive shaft **262**. Gears **256** through **261** may be appropriately journalled on the support structure, such as structure **264** and gear shaft which are of conventional structure. Furthermore, it is understood that any suitable type of drive may be utilized to transmit the output energy of engine **250** to drive the center shaft **262**. Evacuated rotating cylinder **212** is integrally connected to drive shaft **262** and rotates with drive shaft **262**. Gussets may be provided to reinforce the end walls of rotating evacuated cylinder **212** as was provided with respect to rotating evacuated cylinder **92**. As illustrated in FIG. **18**, fuel tank **266** is mounted offset from drive shaft **262** as one of the elements providing a center of gravity for the power unit offset from the center of aircraft **210**.

Referring most particularly to FIG. **18**, engine **250**, the gear train comprised of gears **256** through **260** and fuel tank **266**, are all shown to the left of the center shaft **262** about which the entire power unit is free to rotate. In a quiescent state with the engine **250** turned off, the weight of engine **250**, the gear train and fuel tank **266** would cause them to rotate counter clockwise approximately 45 degrees and come to rest at a point where their combined center of gravity would be directly below center shaft **262**. However, during normal, power-on operation, the resisting force exerted by the power unit **240** and its contained components by the center shaft drive gear **261** causes engine **250**, the gear train and fuel tank to take the positions as shown in FIG. **18**. The rotating envelope **212** encounters frictional air resistance which impedes its free rotation. The direction of envelope rotation is indicated by arrow **270** in FIG. **18**. This frictional resistance to rotation is opposite to the direction of arrow **270** and is communicated from the outside surface of envelope **212** to the envelope and to the connected center shaft **262** and to the attached center shaft drive gear **261**. However, it is understood that engine **250** and its associated air intake and other components may be located on the other side and the direction of envelope rotation would be reversed.

As described with respect to the previous embodiment, the non-rotating payload compartments and power units will be isolated from the center rotating shaft **262** by suitable bearings.

In operation, rotating evacuated envelope aircraft **212** operates in principle similar to the other embodiments. Exhaust deflectors **234** and **244** may be opened widely for a vertical take off. Evacuated rotating cylinder **212** is also provided with an evacuation pump and a pressure pump. Accordingly, for take off, rotating cylinder **212** is evacuated by the evacuation pump and lift is accordingly provided both by the buoyancy of the evacuated rotating cylinder **212** as well as the vertically downward directed exhaust of power units **230** and **240**.

Once suitable altitude is reached, the exhaust deflectors may be positioned as shown in FIG. **16** to produce a substantial thrust forcing aircraft **210** to fly in the forward direction of arrow **200**. Sharp turns or maneuvers may be made by adjusting the direction of exhaust ports **234** and **244** by rotation on their respective deflector rotation rings **236** and **246**. Further, for navigation and attitude control, the deflector vanes located on the payload compartments may be used and adjusted for optimum flight conditions. Further, lateral movement of the craft may be accomplished by appropriate rotation and adjustment of the exhaust deflectors **234** and **244**.

Referring now to FIGS. **19** and **20**, there is shown additional information relating to an evacuated rotating envelope aircraft having a rotating envelope in the form of a rotating disk. Shown therein are possible locations of reinforcement of the disk or envelope of such a model as well as a presently preferred embodiment. However, it is understood that this is only an example of a presently preferred embodiment and is subject to change and is not intended in any way to limit the claimed invention. In accordance with the segmenting of the structure into radial concentric rings as shown in FIGS. **19** and **20** in the following chart, there is provided an analysis of forces acting on the external envelope while it is rotating in the evacuated state.

The envelope chosen for the purposes of this model is approximately 30 meters in diameter in the horizontal plane and about 5.5 meters in height or thickness in a vertical direction at its axis of rotation. Since the envelope is symmetrical about its axis of rotation, the analysis considers only one side of the envelope with it being assumed that equivalent and opposite inertial forces are acting on the other side of the envelope.

The model is not intended to be exactly precise in all details but is aimed at providing a satisfactory degree of confidence concerning implementation feasibility. In accordance with conventional aircraft design practice, further detailed modeling, simulation and design in accordance with specific material selections for each portion of the envelope and each component of the operating aircraft is contemplated.

A side elevation cross section diagram of the half-envelope chosen for the model is shown in FIG. **19**. The envelope is represented by **10**L. The vertical axis of rotation and symmetry of the envelope is represented by the dotted and dashed line at **11**L. The horizontal median of the envelope is the dashed line at **12**L. The inside core tube of the aircraft is represented by **20**L, and the outside core tube is represented by **21**L. The core tube may be approximately 1.0 meter in diameter for the purposes of this model.

A plan view of the model is shown in FIG. **20**. Here also can be seen the axis of rotation **11**L, the inside core tube **20**L, the outside core tube **21**L and a top view of the horizontal median line **12**L.

The horizontal median of the envelope **12**L is divided into **38** equal width segments as indicated at **13**L of FIG. **19** beginning at the outside of the core tube, each segment being 0.3947 meter wide. Each of these 38 segments can be visualized as an adjacent and concentric cylinder sharing a common center line which is the axis of rotation of the envelope **11**L. Each of these 38 cylinders intersects the material of the upper surface of the envelope dividing the upper envelope surface material into 38 adjacent and concentric rings each of which is numbered from Ring 38 at the outside edge of the envelope to Ring 1 as the innermost ring, which is adjacent to the outer core tube **21**L. Analysis of the forces acting on the material of the lower surface of the envelope may be done in a similar fashion.

Now referring to the chart below which is entitled "Metric for 30 Meter Diameter Model", a vertical column for each of the 38 rings to be analyzed can be seen.

Metric for 30 Meter Diameter Model

Row	Description	Ring 38	Ring 37	Ring 36
1	Degrees from Horizontal - upper surface	90	37	29
2	SIN of angle	1.000	0.602	0.485
3	COS of angle	0.000	0.799	0.875
4	Horizontal Width of Each Ring (meter)	0.3947	0.3947	0.3947
5	Number of .3947 m. Wide Segments in Each Ring	243.58	237.30	231.01
6	Segment Radial Height Along Surface (meter)	0.3947	0.4942	0.4513
7	Area of a Segment - (square meters)	0.1558	0.1951	0.1781
8	Mass of Material - (grams per square meter)	898	898	898
9	Mass of a Segment (grams)	139.9	175.2	160.0
10	Radius of Center of Ring - (meters)	15.30	14.91	14.51
11	Rate of Rotation (RPM)	1014	1014	1014
12	Segment Inertial Force - (dynes × 10^6)	2,414	2,944	2,617
13	Segment Inertial Force - (grams × 10^6 (@ 1 G))	2.463	3.004	2.671
14	Segment Inertial Force In Surface (grams × 10^6)	0.000	2.399	2.336
15	Seg. Inertial Force Surface Normal (grams × 10^6)	2.463	1.808	1.295
16	Atmos. Pressure on a Segment (grams × 10^6)	1.610	2.016	1.841
17	Atmos. Pres. Minus Normal Inert. Force (grams × 10^6)	−0.853	0.208	0.546
18	Cum. Seg. Inertial Force in Surface (grams × 10^6)	2.46	4.93	7.40

Row	Ring 35	Ring 34	Ring 33	Ring 32	Ring 31	Ring 30
1	25	22	20	19	18	17
2	0.423	0.375	0.342	0.326	0.309	0.292
3	0.906	0.927	0.940	0.946	0.951	0.956
4	0.3947	0.3947	0.3947	0.3947	0.3947	0.3947
5	224.73	218.45	212.16	205.88	199.60	193.31
6	0.4355	0.4257	0.4200	0.4174	0.4150	0.4127
7	0.1719	0.1680	0.1658	0.1648	0.1638	0.1629
8	898	898	898	898	898	898
9	154.4	150.9	148.9	148.0	147.1	146.3
10	14.12	13.72	13.33	12.93	12.54	12.14
11	1014	1014	1014	1014	1014	1014
12	2,457	2,335	2,237	2,158	2,080	2,003
13	2.507	2.382	2.283	2.202	2.122	2.044
14	2.272	2.209	2.145	2.082	2.018	1.955
15	1.060	0.892	0.781	0.717	0.656	0.598
16	1.777	1.737	1.714	1.703	1.693	1.684
17	0.717	0.844	0.933	0.986	1.037	1.086
18	9.88	12.37	14.88	17.42	19.98	22.59

-continued

Metric for 30 Meter Diameter Model

Row	Ring 29	Ring 28	Ring 27	Ring 26	Ring 25	Ring 24
1	17	16	16	15	15	14
2	0.292	0.276	0.276	0.259	0.259	0.242
3	0.956	0.961	0.961	0.966	0.966	0.970
4	0.3947	0.3947	0.3947	0.3947	0.3947	0.3947
5	187.03	180.75	174.46	168.18	161.90	155.61
6	0.4127	0.4106	0.4106	0.4086	0.4086	0.4068
7	0.1629	0.1621	0.1621	0.1613	0.1613	0.1606
8	898	898	898	898	898	898
9	146.3	145.5	145.5	144.8	144.8	144.2
10	11.75	11.35	10.96	10.56	10.17	9.78
11	1014	1014	1014	1014	1014	1014
12	1,938	1,863	1,798	1,725	1,661	1,589
13	1.978	1.901	1.835	1.761	1.695	1.622
14	1.891	1.828	1.764	1.701	1.637	1.573
15	0.578	0.524	0.506	0.456	0.439	0.392
16	1.684	1.675	1.675	1.667	1.667	1.660
17	1.106	1.151	1.169	1.211	1.229	1.267
18	25.24	27.94	30.71	33.56	36.50	39.55

Row	Ring 23	Ring 22	Ring 21	Ring 20	Ring 19	Ring 18
1	14	14	13	13	13	13
2	0.242	0.242	0.225	0.225	0.225	0.225
3	0.970	0.970	0.974	0.974	0.974	0.974
4	0.3947	0.3947	0.3947	0.3947	0.3947	0.3947
5	149.33	143.05	136.76	130.48	124.20	117.92
6	0.4068	0.4068	0.4051	0.4051	0.4051	0.4051
7	0.1606	0.1606	0.1599	0.1599	0.1599	0.1599
8	898	898	898	898	898	898
9	144.2	144.2	143.6	143.6	143.6	143.6
10	9.38	8.99	8.59	8.20	7.80	7.41
11	1014	1014	1014	1014	1014	1014
12	1,525	1,461	1,391	1,327	1,263	1,199
13	1.556	1.491	1.419	1.354	1.289	1.224
14	1.510	1.446	1.383	1.319	1.256	1.192
15	0.376	0.361	0.319	0.305	0.290	0.275
16	1.660	1.660	1.653	1.653	1.653	1.653
17	1.283	1.299	1.333	1.348	1.363	1.377
18	42.72	46.04	49.54	53.25	57.20	61.44

Row	Ring 17	Ring 16	Ring 15	Ring 14	Ring 13	Ring 12
1	12	12	12	12	11	11
2	0.208	0.208	0.208	0.208	0.191	0.191
3	0.978	0.978	0.978	0.978	0.982	0.982
4	0.3947	0.3947	0.3947	0.3947	0.3947	0.3947
5	111.63	105.35	99.07	92.78	86.50	80.22
6	0.4035	0.4035	0.4035	0.4035	0.4021	0.4021
7	0.1593	0.1593	0.1593	0.1593	0.1587	0.1587
8	898	898	898	898	898	898
9	143.0	143.0	143.0	143.0	142.5	142.5
10	7.01	6.62	6.22	5.83	5.43	5.04
11	1014	1014	1014	1014	1014	1014
12	1,131	1,067	1,004	940	873	810
13	1.154	1.089	1.024	0.959	0.891	0.826
14	1.129	1.065	1.002	0.938	0.875	0.811
15	0.240	0.226	0.213	0.199	0.170	0.158
16	1.646	1.646	1.646	1.646	1.640	1.640
17	1.406	1.420	1.433	1.447	1.470	1.483
18	66.02	71.03	76.53	82.65	89.53	97.36

Row	Ring 11	Ring 10	Ring 9	Ring 8	Ring 7	Ring 6
1	11	11	10	10	10	10
2	0.191	0.191	0.174	0.174	0.174	0.174
3	0.982	0.982	0.985	0.985	0.985	0.985
4	0.3947	0.3947	0.3947	0.3947	0.3947	0.3947
5	73.93	67.65	61.37	55.08	48.80	42.52
6	0.4021	0.4021	0.4008	0.4008	0.4008	0.4008
7	0.1587	0.1587	0.1582	0.1582	0.1582	0.1582
8	898	898	898	898	898	898
9	142.5	142.5	142.1	142.1	142.1	142.1
10	4.64	4.25	3.85	3.46	3.07	2.67

-continued

Metric for 30 Meter Diameter Model						
11	1014	1014	1014	1014	1014	1014
12	746	683	617	554	491	428
13	0.762	0.697	0.630	0.566	0.501	0.437
14	0.748	0.684	0.620	0.557	0.493	0.430
15	0.145	0.133	0.109	0.098	0.087	0.076
16	1.640	1.640	1.635	1.635	1.635	1.635
17	1.495	1.508	1.526	1.537	1.548	1.559
18	106.38	116.94	129.54	144.87	164.01	188.68

Row	Ring 5	Ring 4	Ring 3	Ring 2	Ring 1
1	9	9	9	9	8
2	0.156	0.156	0.156	0.156	0.139
3	0.988	0.988	0.988	0.988	0.990
4	0.3947	0.3947	0.3947	0.3947	0.3947
5	36.23	29.95	23.67	17.38	11.10
6	0.3996	0.3996	0.3996	0.3996	0.3986
7	0.1577	0.1577	0.1577	0.1577	0.1573
8	898	898	898	898	898
9	141.6	141.6	141.6	141.6	141.3
10	2.28	1.88	1.49	1.09	0.70
11	1014	1014	1014	1014	1014
12	364	300	237	174	111
13	0.371	0.307	0.242	0.178	0.113
14	0.366	0.303	0.239	0.176	0.112
15	0.058	0.048	0.038	0.028	0.016
16	1.630	1.630	1.630	1.630	1.626
17	1.572	1.582	1.593	1.603	1.610
18	221.77	268.59	340.14	463.25	725.57

Row 1 indicates the average angle of each of the 38 rings in terms of degrees from a horizontal plane with this angle decreasing from 90 degrees at Ring 38 to 8 degrees at Ring 1. Rows 2 and 3 respectively compute the sine and cosine of this angle for use in subsequent calculations.

Row 4 notes that the horizontal, or radial, width of each Ring is 0.3947 meters for all rings.

Each ring is divided into a number of 0.3947 meter wide adjacent segments around its circumference in the plane of the median line **12**L. Examples of several of these square segments are shown in FIG. **20**, one of them being labeled **22**L. The number of segments in a ring varies from 243.58 in the large, outer ring, Ring 38, to 11.10 segments in the smallest ring, Ring 1 adjacent to the core tube as shown on Row 5 of the chart.

At Row 6 the radial height along the surface is computed for each ring considering the angle of each ring as noted in Row 1. The radial height along the surface for Row 38 is set at 0.3947 m. Row 7 computes the area of a segment in each ring in square meters and Row 9 computes the mass of a segment in each ring based on the mass of the material of which the envelope is constructed as shown on Row 8.

In preparation for calculating the inertial force acting on a segment in each ring due to its rotation, Row 10 indicates the radius of the center of each ring in meters and Row 11 notes the rate of rotation as being 1014 revolutions per minute which is of course the same for all rings and segments.

Row 12 indicates the inertial force acting on a segment in each ring expressed in millions of dynes. This force is converted to millions of grams on Row 13 assuming the earth's gravitational environment.

The inertial force acting on a segment in each ring is then broken into two components: Row 14 expresses the inertial force component that is in the plane of the surface for a segment in each ring and Row 15 indicates the inertial force acting normal to the plane of the surface for a segment in each of the rings.

Row 16 indicates the pressure of the external atmosphere acting inwardly on a segment in each ring considering that the area of a segment depends upon its angle to the horizontal as expressed in Row 1. The atmospheric pressure acting on a segment is shown in millions of grams assuming earth's standard gravitational environment at sea level.

Row 17 subtracts the surface normal inertial force acting outwardly on a segment from the force due to atmospheric pressure acting inwardly on a segment and displays the result for each of the rings. The result indicates that the surface normal inertial force acting outwardly exceeds the force due to atmospheric pressure acting inwardly at standard conditions at sea level by about half an atmosphere at Ring 38. However the force due to atmospheric pressure is greater than the surface normal inertial force and is increasingly so as rings closer to the axis of rotation are examined for the set of conditions concerning envelope material mass and rate of rotation assumed for this model.

Row 18 computes the cumulative in surface component of inertial force for a segment in each ring and may be used to determine the tensile strength required in the envelope material at each ring of the model. The calculations in Row 18 account for the fact that the in surface inertial forces generated in the x number of segments in Ring y must be sustained by the smaller number of segments in Ring y-1.

It may be seen by comparing Row 18 with Row 16 that the cumulative in surface force of tension due to inertia greatly exceeds, by more than two orders of magnitude, the force due to atmospheric pressure as rings closer to the axis of rotation are examined. Therefore, without any adjustments of envelope material thickness, material strength or envelope internal reinforcements, the profile of the upper surface of the envelope would be very nearly flat and straight.

Preferably, in accordance with this model, the material of the envelope may not be uniform in thickness, mass and tensile strength per segment from its outer margin at ring 38 to its inner edge at Ring 1. Referring to FIG. **19**, a thickening of the envelope material near the core tube at locations **17**L and **18**L is preferred to accommodate the accumulation of the in surface inertial forces in lower numbered rings.

As an example: the accumulation of the inertial forces of rotation at Ring 1 is quite large and if these forces were to be sustained by high tensile strength carbon fiber with a tensile strength rating in the range of 3.16 G Pa, then the carbon fiber would have to be about 1.0 centimeter thick at Ring 1 assuming a design safety factor of 100%.

In addition to increased tensile strength, these strengthened areas may also provide increased strength in the shear dimension to insure the convex shape of the envelope exterior surface while it is evacuated. Subject to design considerations and specific materials selected for each portion of the envelope, preferably internal mechanical reinforcement structures may be provided in the form of truncated cones such as those shown at **15**L, **16**L and **19**L. The convex external envelope shape is easily maintained during periods when the envelope is inflated.

The outer edge of the envelope may also be thickened and hardened as indicated at **14**L to provide additional strength to sustain external aerodynamic forces resulting from high speed lateral motion. Further, please note that the thickened areas **14**L, **17**L and **18**L indicated in FIG. **19**, are not shown to scale but are instead shown to be much thicker than they would actually be for the purposes of clarity of illustration for this model.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

I claim:

1. An aircraft wherein lift is provided by means of a buoyant, at least partially evacuated, rotating envelope, including a motor for causing said envelope to rotate, wherein the envelope's resistance to inward force of ambient atmospheric pressure is provided at least in part by centrifugal force acting outwardly on the envelope as a result of the envelope's rotation.

2. An aircraft in accordance with claim **1** wherein said motor for causing said envelope to rotate is attached to said rotating buoyant evacuated envelope and rotates with said envelope.

3. An aircraft in accordance with claim **2** wherein said motor for rotating said envelope provides sufficient force to rotate said envelope against the force of air friction acting on the external surface of said envelope.

4. An aircraft in accordance with claim **1** wherein shape, displacement and aspect ratio of said envelope is selectively changed dynamically during flight to optimize said envelope for varying flight requirements and conditions.

5. An aircraft in accordance with claim **1** including evacuating means and pressurizing means for evacuating and pressurizing said envelope.

6. An aircraft in accordance with claim **1** wherein the shape of said envelope is capable of being dynamically changed while the aircraft is in flight.

7. An aircraft in accordance with claim **1** wherein a lifting force is provided to the aircraft by means for evacuating said envelope to provide a lighter-than-air buoyant envelope.

8. An aircraft in accordance with claim **1** wherein a lifting force is provided by said envelope which is shaped in the form of an airfoil which is caused to move in lateral motion through the atmosphere producing lift.

9. An aircraft in accordance with claim **1** wherein said rotating envelope is in the form of a disk.

10. An aircraft in accordance with claim **1** wherein said rotating envelope is in the form of a disk mounted on a central core tube, said central core tube having an axis of rotation coincident with the axis of rotation of said disk, said central core tube being adapted to elongate to enable expansion of said disk in the direction of its axis.

11. An aircraft in accordance with claim **1** including at least one pump adapted and connected to evacuate air from said envelope or pump air into said envelope wherein the pressure inside said envelope is varied to accommodate differing flight conditions.

12. An aircraft wherein lift is provided by means of a buoyant, evacuated, rotating envelope, including an engine for rotating said envelope, and including means for dividing output air and exhaust of said engine into multiple flow streams for the purpose of creating a rotating torque force on the engine.

13. An aircraft in accordance with claim **12** wherein said means for dividing the output air and exhaust issuing from said engine into multiple flow streams includes deflection means mounted in the output air and exhaust of said engine.

14. An aircraft wherein lift is provided by means of a buoyant, evacuated, rotating envelope, including means for rotating said envelope to provide a centrifugal force on exterior material of said rotating envelope whereby the need for and weight of mechanical support structures to withstand the inward force of external atmospheric pressure is reduced.

15. An aircraft wherein lift is provided by means of a buoyant, evacuated, rotating envelope, including means for rotating said envelope about an axis normal to the direction of lateral motion of the aircraft during flight thereby exposing the leading edges and surfaces of said envelope to aerodynamic heating caused by contact with atmosphere during only a portion of each rotation of said envelope.

16. An aircraft wherein lift is provided by means of a buoyant, evacuated, rotating envelope, including an engine for rotating said envelope, said engine and envelope being connected together such that they corotate.

17. An aircraft wherein lift is provided by means of a buoyant, evacuated, rotating envelope, wherein lifting forces are provided by one or more engines which are structured and adapted to direct air thrust in a downward direction.

18. An aircraft wherein lift is provided by means of a buoyant, evacuated, rotating envelope, wherein lifting forces for the aircraft are provided by said envelope being caused to rotate such that reaction forces realized from air flow leaving the surface of said rotating envelope produce a momentum of downward air flow which is greater than the momentum of upward air flow.

19. An aircraft in accordance with any of claims **7**, **8**, **17** or **18** wherein the amount of lift produced is selectively varied dynamically during flight of the aircraft.

20. An aircraft wherein lift is provided by means of a buoyant, evacuated, rotating envelope, including a non-rotating payload compartment mounted by means of bearings to said rotating envelope.

21. An aircraft in accordance with claim **20** wherein said payload compartment is provided with means for counteracting rotation of said payload compartment.

22. An aircraft in accordance with claim **20** wherein said non-rotating payload compartment is provided with jets for enhancing lateral movement of the aircraft during flight.

23. An aircraft wherein lift is provided by means of a buoyant, evacuated, rotating envelope;

said rotating envelope being in the form of a disk mounted on a central core tube, said central core tube having an axis of rotation coincident with the axis of rotation of said disk, said central core tube being adapted to elongate to enable expansion of said disk in the direction of its axis; and,

a non-rotating payload compartment mounted to said central core tube and provided with means for reducing friction between said central core tube and said non-rotating payload compartment.

24. An aircraft wherein lift is provided by means of a buoyant, evacuated, rotating envelope;

said rotating envelope being in the form of a disk mounted on a central core tube, said central core tube having an axis of rotation coincident with the axis of rotation of said disk, said central core tube being adapted to elongate to enable expansion of said disk in the direction of its axis; and,

a jet engine mounted within said central core tube, a divider plate mounted in an exhaust flow path of said jet engine and one or more exhaust deflector plates mounted in said exhaust flow path for causing said envelope and core tube to rotate.

25. An aircraft wherein lift is provided by means of a buoyant, rotating envelope;

means for at least partially evacuating said envelope;

a non rotating payload compartment; and,

means for rotating said envelope to provide a centrifugal force on material comprising said envelope whereby the need for and weight of mechanical structures to withstand the inward force of external atmospheric pressure is reduced.

26. An aircraft in accordance with claim **25** wherein said means for rotating said envelope is attached to said rotating buoyant evacuated envelope and rotates with said envelope.

27. An aircraft in accordance with claim **26** wherein said means for rotating said envelope provides sufficient force to rotate said envelope against the force of air friction acting on the external surface of said envelope.

28. An aircraft in accordance with claim **25** wherein shape, displacement and aspect ratio of said envelope may be changed dynamically during flight to optimize said envelope for varying flight requirements and conditions.

29. An aircraft in accordance with claim **25** wherein said means for rotating said envelope includes an engine for rotating said envelope and means for dividing engine output air and exhaust of said engine into multiple flow streams for the purpose of creating a rotating torque force on the engine.

30. An aircraft in accordance with claim **29** wherein said means for dividing the output air and exhaust issuing from said engine into multiple flow streams includes deflection means mounted in the output air and exhaust of said engine.

31. An aircraft in accordance with claim **25** including pressurizing means for pressurizing said envelope.

32. An aircraft in accordance with claim **25** wherein said means for rotating said envelope rotates said envelope about an axis normal to the direction of lateral motion of the aircraft during flight thereby exposing the leading edges and surfaces of said envelope to aerodynamic heating caused by contact with atmosphere during only a portion of each rotation of said envelope.

33. An aircraft in accordance with claim **25** wherein said means for rotating said envelope includes an engine, and said engine for rotating said envelope and said envelope are connected together such that they corotate.

34. An aircraft in accordance with claim **25** wherein the shape of said envelope may be dynamically changed while the aircraft is in flight.

35. An aircraft in accordance with claim **25** wherein a lifting force is provided by said envelope which is caused to move in lateral motion through the atmosphere producing lift.

36. An aircraft in accordance with claim **25** wherein lifting forces are provided by one or more engines which are structured and adapted to direct air thrust in a downward direction.

37. An aircraft in accordance with claim **25** wherein lifting forces for the aircraft are provided by said envelope being caused to rotate such that reaction forces realized from air flow leaving the surface of said rotating envelope produce a momentum of downward air flow which is greater than the momentum of upward air flow.

38. An aircraft in accordance with any of the claims **35** through **37** wherein the amount of lift produced is selectively varied dynamically during flight of the aircraft.

39. An aircraft in accordance with claim **25** wherein said non-rotating payload compartment is mounted by means of bearings to said rotating envelope.

40. An aircraft in accordance with claim **39** wherein said payload compartment is provided with means for counteracting rotation of said payload compartment.

41. An aircraft in accordance with claim **39** wherein said non-rotating payload compartment is provided with jets for enhancing lateral movement of the aircraft during flight.

42. An aircraft in accordance with claim **25** wherein said rotating envelope is in the form of a disk.

43. An aircraft in accordance with claim **25** wherein said rotating envelope is in the form of a disk mounted on a central core tube, said central core tube having an axis of rotation coincident with the axis of rotation of said disk, said central core tube being adapted to elongate to enable expansion of said disk in the direction of its axis.

44. An aircraft in accordance with claim **43** including said non-rotating payload compartment mounted to said central core tube and provided with means for reducing friction between said central core tube and said non-rotating payload compartment.

45. An aircraft in accordance with claim **43** wherein said means for rotating said envelope is a jet engine mounted within said central core tube, and a divider plate mounted in an exhaust flow path of said jet engine and one or more exhaust deflector plates mounted in said exhaust flow path for causing said envelope and core tube to rotate.

46. A process for reducing the amount of leading edge heating caused by an aircraft as claimed in claim **1** traveling through ambient atmosphere at a speed sufficient to generate significant leading edge heating, comprising the steps of:

providing said rotating envelope in the form of a rotatable disk shaped airfoil;

causing said rotatable disk shaped airfoil to travel laterally through the atmosphere wherein leading edge heating occurs on the periphery of the rotatable disk shaped airfoil only during a portion of each rotation of said airfoil where said portion is in the direction of flight; and,

providing a cooling period for said portion of said airfoil previously subjected to heating for the remainder of each rotation.

* * * * *

US006050520A

United States Patent [19]

Kirla

[11] **Patent Number: 6,050,520**

[45] **Date of Patent: Apr. 18, 2000**

[54] **VERTICAL TAKE OFF AND LANDING AIRCRAFT**

[76] Inventor: **Stanley J. Kirla**, 81 River Rd., Deep River, Conn. 06417

[21] Appl. No.: **09/157,730**

[22] Filed: **Sep. 21, 1998**

[51] **Int. Cl.**[7] **B64C 15/00**

[52] **U.S. Cl.** .... **244/23 A**; 244/23 C; 244/12.2; 244/10

[58] **Field of Search** .... 244/23 A, 12.2, 244/12.3, 17.19, 23 C, 65, 67, 10, 19

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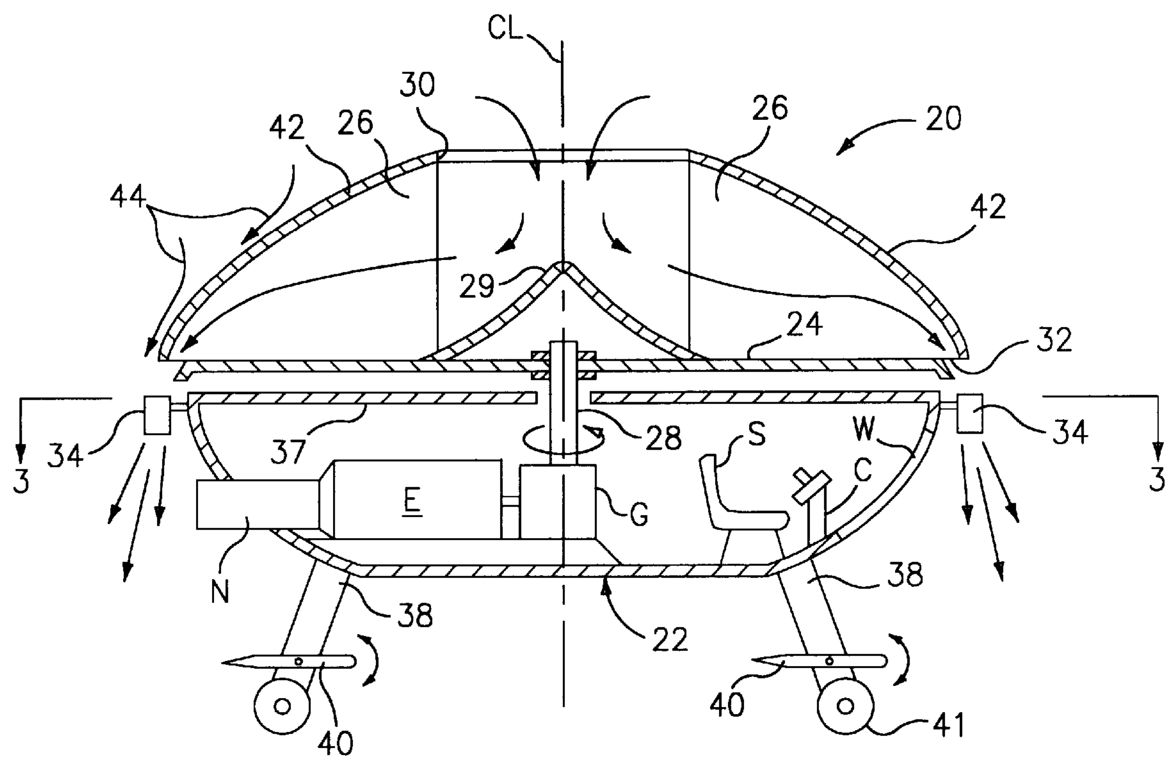
Primary Examiner—J. Woodrow Eldred
Attorney, Agent, or Firm—C. G. Nessler

[57] **ABSTRACT**

An aircraft for vertical take off and landing is comprised of a rotor assembly mounted on a rotating drive shaft extending from the top of a cabin. The rotor assembly is comprised of a truncated-cone top, a spaced apart circular bottom, and internal vanes running radially, between the top and bottom, forming an air impeller. In operation, air is drawn through the central air intake of the top and discharged through an annular nozzle around the circumference of the rotor assembly. As the top rotates, additional air is rammed through scoops mounted at an angle to radii of the top, on the surface of the top. The torque applied to the cabin, due to rotation by the engine of the rotor assembly, is countered by the reaction force generated by a plurality of tabs extending from the cabin sidewall into the airstream flowing downwardly from the nozzle.

11 Claims, 4 Drawing Sheets



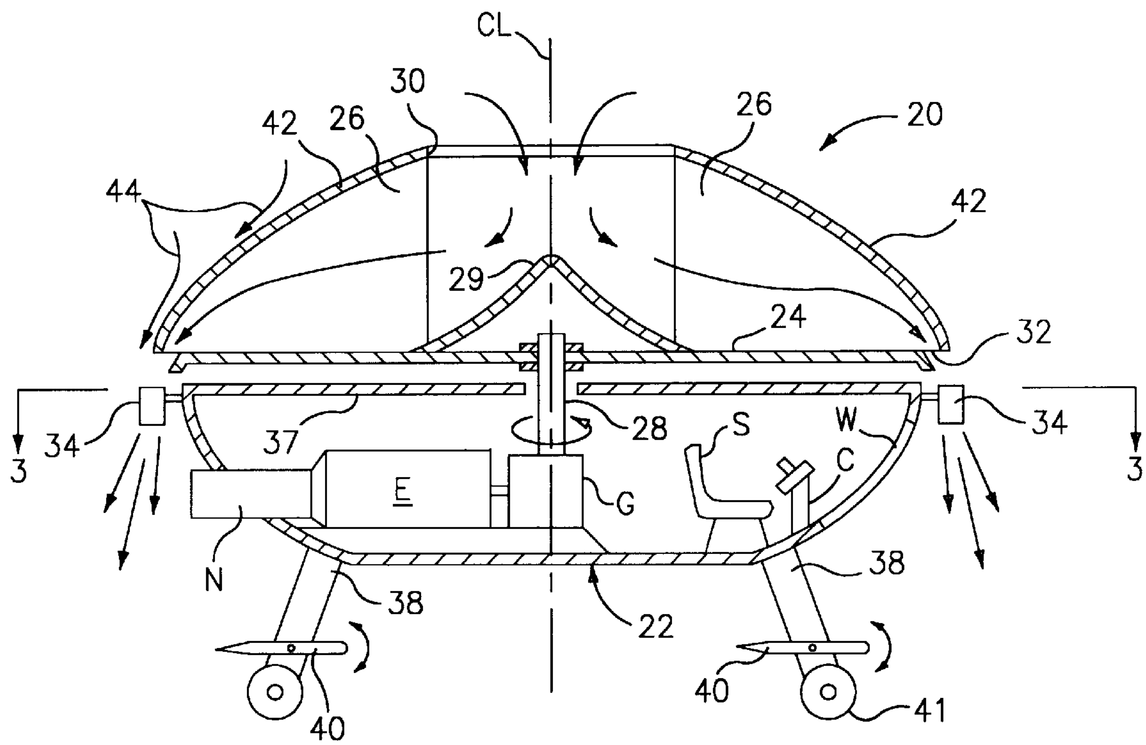

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FIG. 1

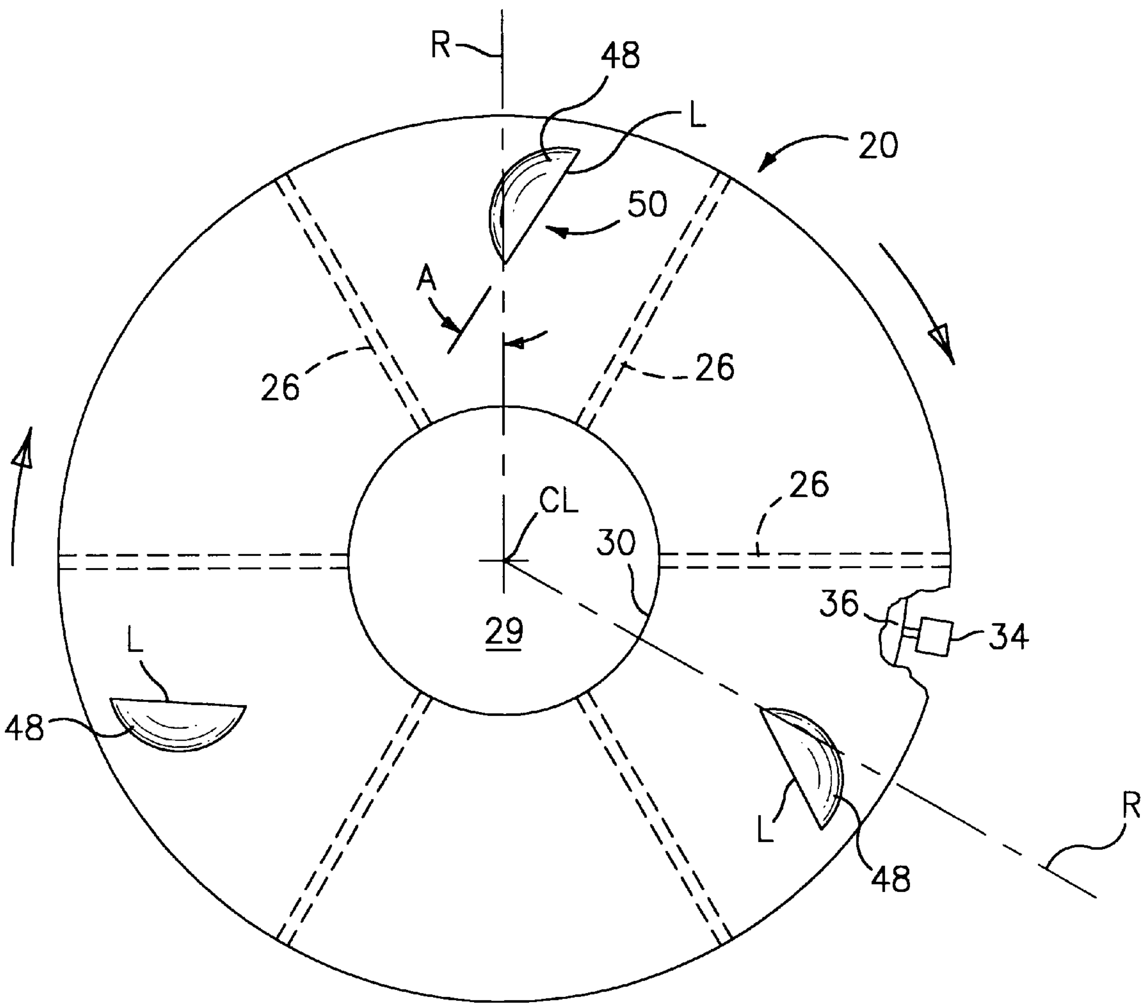

FIG. 2

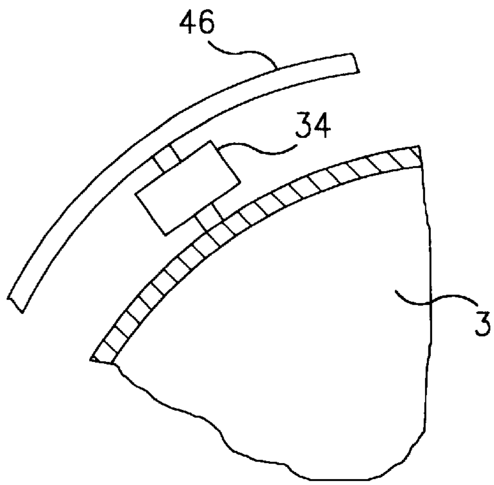

FIG. 6

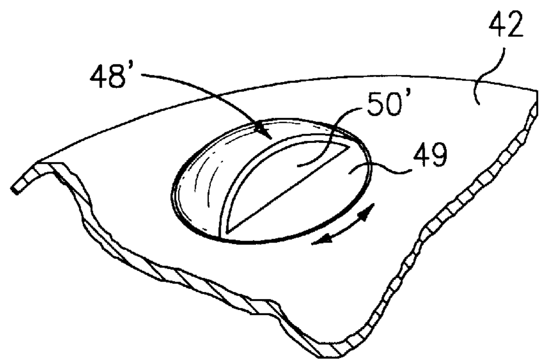

FIG. 5

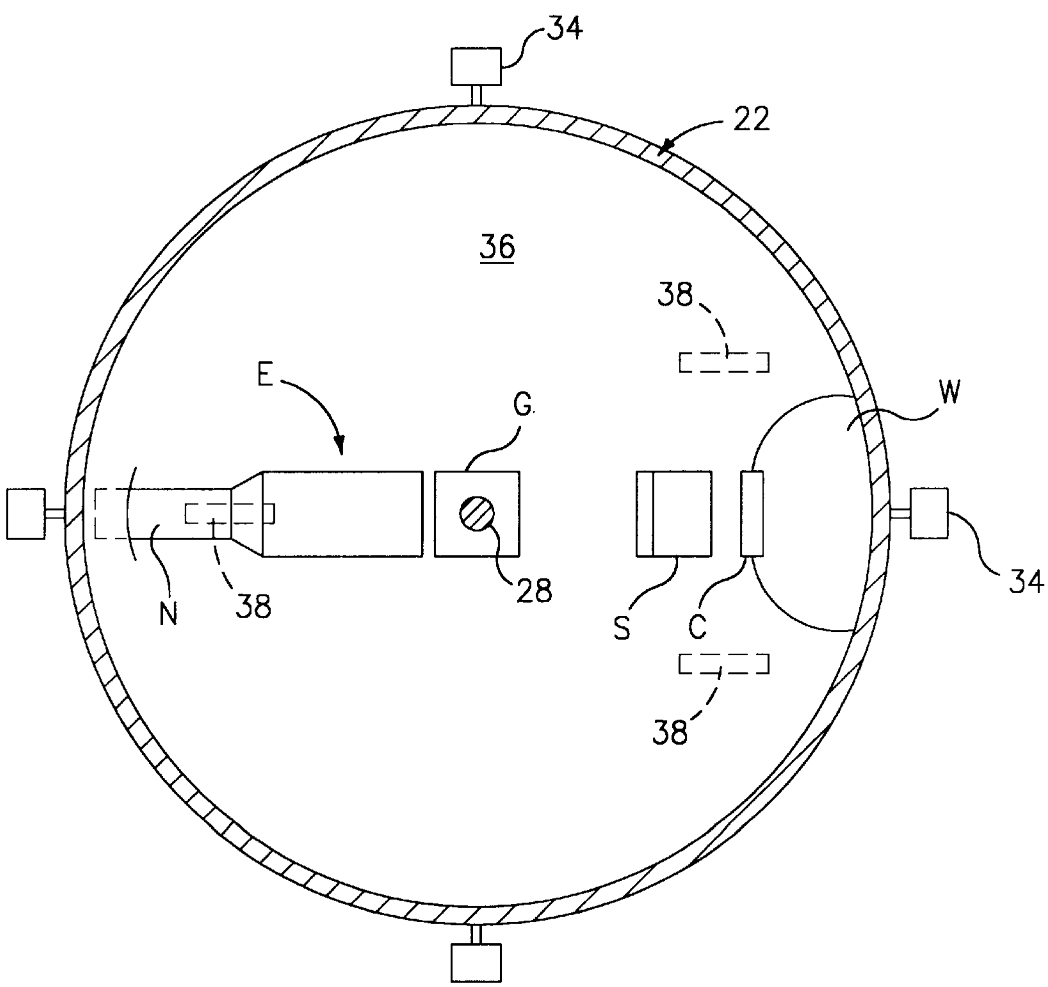

FIG. 3

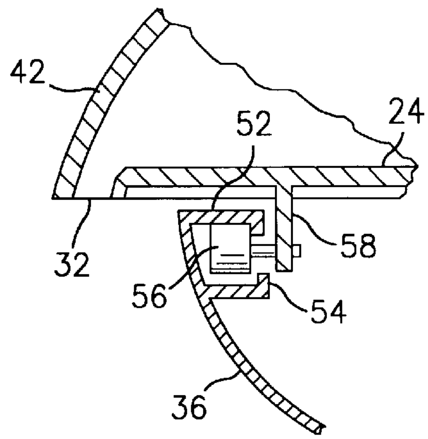

FIG. 8

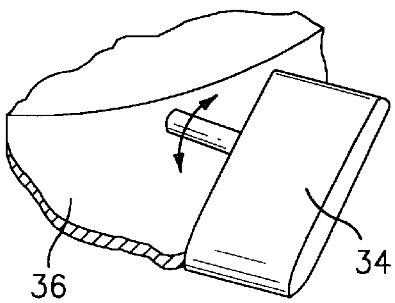

FIG. 7

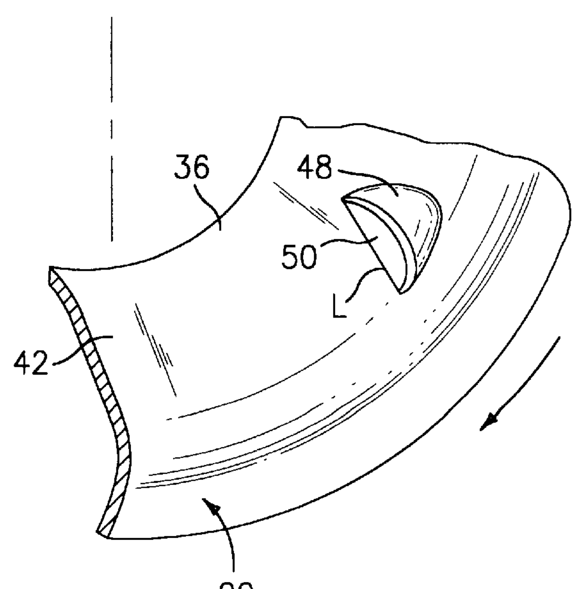

FIG. 4

VERTICAL TAKE OFF AND LANDING AIRCRAFT

TECHNICAL FIELD

The present invention relates to flying machines, in particular to powered aircraft which are able to hover and take off and land more or less vertically.

BACKGROUND

Conventional helicopters of the type pioneered by Igor Sikorsky are well known for their ability to take off and land more or less vertically, and to hover in a stationary spot. Helicopter type aircraft are proven, and of great utility through their ability to take off and land vertically. They have enabled saving of many lives and accomplished otherwise impossible tasks. However, the blades in an ordinary helicopter are vulnerable to foreign object damage when the machine comes too close to stationary objects, such as trees and the like. And the rotor and blade systems in the now-familiar types of helicopters tend to involve numerous moving parts, making them complex to fabricate and maintain. Thus, there have long been efforts to develop other types of vertical take off and landing aircraft.

One of the avenues that has been pursued has been to make circular or toroidal shaped aircraft with internal air moving systems. For instance, U.S. Pat. No. 2,927,746 to Mellen describes a disc shape aircraft with a central impeller that causes air to flow radially across the top of the aircraft and downwardly from the periphery. U.S. Pat. No. 2,718,364 of Crabtree describes another circular aircraft, where there is an internal propeller which forces air downwardly through an opening in the center of the machine. U.S. Pat. No. 2,997,254 to Mulgrave describes a disc shaped aircraft where an internal radial fan discharges air dowwardly from a nozzle around the periphery of the craft. Beck, Jr. in U.S. Pat. No. 5,170,963 describes a vertical take off and landing aircraft having a ducted fan which discharges air radially outward over airfoils placed around the periphery of the disc shaped craft. Flow over the airfoils also induces downward air flow, across the top surface of the craft, adding lift. U.S. Pat. No. 3,104,853 to Klein describes an embodiment of a vertical take off and landing machine, wherein a downwardly curved, open centrifugal impeller flows air downwardly. Vanes around the periphery of the craft counter the tendency of the cabin part of the aircraft to rotate in reaction to the impeller. The present invention represents a continuation of the evolution of concepts and ideas of the prior inventors.

SUMMARY

An object of the invention is to provide a powered aircraft capable of more or less vertically taking off and landing, and hovering. A further object of the invention is to provide a vertical take off and landing type of aircraft with lifting means which are less vulnerable to damage than are the blades and rotor systems of conventional types of helicopters.

In accordance with the invention, an aircraft is comprised of a cabin and a rotor assembly mounted on a rotatable shaft extending vertically up from the cabin. The shaft is rotated by a prime mover, such as a gas turbine engine, in the cabin. The rotor assembly is comprised of a truncated-cone shape top having a central air intake opening, a circular bottom spaced apart from the top, and vanes running vertically between the top and the bottom; the combination forming a closed impeller. A downward-facing annular nozzle is formed between the circular outer edges of the top and bottom. During operation, the rotor assembly spins, drawing air through the central opening and blowing it downwardly through the nozzle. Since the spinning of the rotor assembly imparts a torque to the cabin, means for countering the torque are provided on the cabin. Preferably, the means comprise a plurality of variable orientation tabs affixed to the exterior of the cabin. Air blowing from the nozzle impinges on the tabs, to thereby impart to the cabin a reaction force which counters the torque.

In a preferred embodiment, the aircraft has a plurality of scoops on the upper surface of the top, spaced around the top near its outer circumference. Each scoop has an opening facing toward the direction in which the rotor assembly is adapted to rotate. Rotation of the rotor assembly causes air to be rammed into the scoop opening, and the air is then exhausted through the nozzle, significantly enhancing the lift that the top assembly generates. The scoops are either fixedly oriented so their openings lie at an angle to a radius of the top, or their orientation is adjustable. In another aspect of the invention, a plurality of struts extends from the bottom of the craft, to facilitate the landing of the craft on a surface. There are pivotable airfoils attached to the struts, to assist in controlling the orientation of the craft during flying.

The smooth exterior design of the craft and absence of exposed blades enables an improved aircraft of the present invention to fly faster than more conventional helicopters. Compared to conventional helicopters, there will be a reduction in the high maintenance costs which are commonly associated with the blades and blade control mechanisms; the new craft will be relatively quite, will have less vibration, fewer components, and good stability due to gyroscopic effects of the rotor assembly. The circular or saucer like shape also engenders improved fuselage strength.

The foregoing and other objects, features and advantages of the invention will become more apparent from the following description of preferred embodiments and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a vertical partial cross section of an aircraft.

FIG. **2** is a top view of the aircraft of FIG. **1**, showing the rotor assembly.

FIG. **3** is a top cross sectional view of the cabin (or lower) part of the aircraft of FIG. **1**.

FIG. **4** shows a fixed air scoop which is on the top surface of the rotor assembly of the aircraft of FIG. **1**.

FIG. **5** shows an air scoop which has a variable orientation.

FIG. **6** shows a segment of the outside edge of the cabin housing of an aircraft, illustrating a protective ring for the flow-directing tabs at the cabin periphery.

FIG. **7** shows in detail of a movable tab at the periphery of the cabin, for changing the direction of air flowing from the rotor assembly and for imparting counter-torque to the cabin.

FIG. **8** shows a vertical cross section fragment of the periphery of an aircraft embodying circumferential roller bearings which carry the thrust load between the rotor assembly and cabin.

DESCRIPTION

The invention is described conceptually and various elements are shown schematically. Thus, it will be understood that the proportions between the various elements may vary in actuality from what is shown in the drawings. In will be also understood that various bearings, supporting structure, controls, and like things are not detailed, as they are within the ordinary skill of artisans concerned with aircraft and associated machinery.

The aircraft is comprised of a cabin **22**, above which is mounted the rotor assembly **20**. FIG. **1** shows a partial vertical cross section and FIG. **2** shows a top view of the preferred embodiment of the aircraft invention. FIG. **3** shows a top cross-sectional view of the cabin. The rotor assembly is mounted at the upper end of rotatable shaft **28** which extends vertically upwardly from the cabin. During operation, the rotor assembly spins (in the clockwise direction looking down on the top as indicated by the arrow in FIG. **2**), to induce lift as will be described.

Rotor assembly **20** is comprised of a closed impeller for moving air which lifts the aircraft. Six radial vanes **26** run between the curved top **42** and the flat circular bottom **24** of the assembly. More or fewer, and curved rather than straight, vanes may be used. The top has the shape of a flattened truncated curved cone, with the open base facing downwardly. See FIG. **1**. Around the periphery of the rotor assembly, the annular opening of nozzle **32** is formed between the outer circular edges of top **42** and bottom **24**. At the center of top **42** of the rotor assembly is air inlet opening **30**. The opening **30** has a diameter of about one-third of the outside diameter of the craft. Mounted at the center of bottom **24**, beneath the opening **30**, is curved cone shaped airflow fairing **29**.

When the rotor assembly spins with shaft **28** about the centerline CL of the machine, air is drawn downwardly through opening **30**, thrust radially outwardly by action of the vanes **26**, and then discharged downwardly through the nozzle **32**, as represented by arrows in FIG. **1**. As illustrated by arrows **44** in FIG. **1**, the downward discharge of air from nozzle **32** tends to induce flow of air outwardly and downwardly, across the exterior surface of the top, to thereby lower pressure at the top of the craft, and induce lift. Likewise, lower pressure above the top of the rotor assembly, which is caused by the drawing of air into the intake opening, abets lift.

As shown by FIG. **2**, there are at least three air scoops **48**, equally spaced apart around the periphery of the top **42**. FIG. **4** shows a typical fixed air scoop **48**. It is formed as a bulbous protrusion rising from the surface of the top **42**, and has an opening **50** generally facing in the direction in which the top rotates during use. When looking down directly on the top, the opening **50** has a length L which lies at a preferred angle A of about 30 degrees to a radius R of the top, which radius lies in a plane perpendicular to the axis of spinning of the top, i.e., the length axis of the shaft **28**, and which radius runs through the innermost point of the length of the scoop. See FIGS. **2** and **4**. The innermost edge on of the scoop opening, that nearest the center of the top, is about two thirds of the way along the radius length. The length L of the opening **50**, i.e., the nominal length of the front edge of the scoop, runs at the preferred 30 degree angle, to terminate near the periphery or outside circumference of the top. The front edge of the scoop may in other instances be somewhat curved. In such a case, the straight line which defines the mean path of the front edge of the scoop would be made to lie along angle A. Preferably, when looking directly at the scoop opening, along the surface of the top, the opening shape is approximates that of a chordal segment of a circle, as can be envisioned from FIG. **4**. During rotation of the top, air is rammed into each scoop, to be then acted on by the outer ends of the vanes **26** and discharged from the circumferential nozzle opening **32**.

Experiments show that during rotation of the rotor assembly the scoops thereby substantially augment the air flow through the central inlet opening, increasing the amount of air which is discharged through the nozzle at any given rotational speed. Experiments on the small-scale rotor assembly described below indicate that lift is increased by up to 75 percent when 3 scoops as described are used, compared to when the top has no scoops. Different numbers of scoops may be used, and they need not be confined to the preferred proportions and location. The height of the scoop opening may be varied, as may the shape. Scoops may be alternatively constructed in a manner such that they can be flattened or retracted into the surface of the top during flying operation, to the extent such may be desired during high speed lateral movement of the craft.

As illustrated by FIG. **5**, another embodiment of scoop **48'** is comprised of a circular base piece **49**, rotatably captured on the surface of the top **42**. With suitable servomechanism and controls, the orientation of the opening **50'** of the scoop **48'** may be varied from the preferred 30 degree angle A which characterizes a fixed scoop.

The cabin **22** is comprised of a housing **36** from which extend downwardly three legs **38**. The legs have wheels **41** at their lower extremities, for supporting the craft on the surface of the earth when it is not flying. Alternately, skids may replace the wheels. As shown in FIG. **1**, in cross section the aircraft exterior is defined by the exterior surfaces of the top and the cabin housing; and, the shape is generally the shape of a conventional lift-generating airfoil, where the front-to-back distance over the top is greater than the same distance along the bottom. Thus, in lateral motion, lifting due to the craft shape is present.

Contained within the cabin **22** and mounted on the floor of the housing **36** is prime mover E, such as a gas turbine engine. The exhaust from the gas turbine issues from nozzle N which projects through the sidewall of the cabin, to thus propel the craft laterally and assist in its vertical upward motion. The nozzle N is fitted with unshown flow vectoring and flow reversing means, known in the art on vertical take off and landing fixed wing aircraft, to control the direction in which the exhaust gases are directed. One or more ducted fans or propellers, driven by any type of prime mover, may be alternately used.

The rotary shaft output of the gas turbine is connected to reducing gear and transmission G, schematically illustrated, to drive rotary vertical shaft **28** and thereby spin the rotor assembly **20**. The cabin housing is comprised of a roof **37**. The operator is provided with a seat S and control pendant C. A window W in the side wall of the cabin housing **36** provides the operator with external visibility. Fuel tanks and engine controls will be understood to be within the cabin, and they are not shown.

Around the periphery of the upper edge of the circumferential sidewall of the cabin housing **36** are four or more adjustable tabs **34**. See FIGS. **1**, **2**, **3** and **7**. The tabs **34** are positioned so they lie just below the nozzle **32** of the rotor assembly. As illustrated by FIG. **7**, the tabs are adjustably pivotable, so that some of the downwardly flowing air issuing from the nozzle **32** can be deflected at a desired angle to the vertical. The resultant reaction force on the each tab, due to the deflecting of the air stream, is imparted as a moment to the cabin. By appropriate selection of the number and size of tabs **34**, and suitable adjustment of the angular orientation of the tabs, the torque imparted to the cabin by the prime mover when it drives the rotor assembly can be thus be countered by the reaction force on the tabs. Thus, the operator may cause the cabin window to face along a constant desired bearing, or to slowly rotate in a desired direction. FIG. **6** shows how a ring **46** may be optionally run around the periphery of the craft, outboard of the tabs **34**, to protect them against possible damage should the craft contact a fixed object. As suggested, fewer or more than four tabs may be used. In certain craft, such as small craft run at constant rotor assembly speed, some or all of the tabs may be at a fixed angle to the air flow.

Extending downwardly from beneath the cabin housing are struts **38** which have wheels **41** at their lowermost extremes. As illustrated by the dashed lines in FIG. **3**, the struts are arranged in a tricycle gear arrangement. In accord with known principles, the wheels may be rotatable and steerable, to enable flexible movement of the craft when it is setting on a flat surface, such as an airport apron or runway. Just above the wheel of each strut is an essentially horizontally disposed airfoil **40**. See FIG. **1**. As indicated by the arrow near airfoil **40**, each airfoil is rotatable about a pivot point on the struts. Thus, during forward flying motion of the craft, the angular orientation of the airfoils can be varied together or separately, to change the attitude of the craft, to roll the craft, and to provide some lift.

A portion of the exhaust gas from the gas turbine engine, or air otherwise moved by it or an alternative prime mover, may also be externally discharged in a tangential direction from the cbain sidewall, and/or vertically downward from the cabin housing at various locations, to augment or substitute for the desired actions of the tabs **34** and the airfoils **40** which has been described.

It is preferred that the rotor assembly be supported only by means of the shaft **28**, as described. However, an alternate construction is within contemplation, wherein the shaft may be used principally for rotation only, and the upward thrust of the rotor assembly on the cabin is absorbed by a multiplicity of peripheral roller bearings **56**, as shown in FIG. **8**. With reference to that fragmentary Figure, a circumferential skirt **58** runs around the underside of the bottom **24** of the rotor assembly. A series of roller bearings are mounted on shafts running radially outward from the skirt. A channel comprised of upper flange **52** and lower flange **54** runs around the interior of the top of the housing **36** of the cabin.

A feature of the invention is that due to the compression of the air within the impeller, the air is heated. The air within heats the top of the rotor assembly, which top is the top of the aircraft, desirably assisting anti-icing effects.

A subscale prototype rotor assembly like that shown in FIG. **1** was constructed of aluminum sheet metal and tested. It had an outside diameter of about 16.5 inch, an inlet hole **30** of 5.5 inch diameter, an impeller peak height of about 3 inches, and a circumferential nozzle **32** with a gap opening of about 0.625 inch. Rotation at about 500 rpm produced about one pound of lift. When three scoops of the fixed 30 degree angle type described above were added, each scoop having an opening of about 3 inch length and ⅜ inch height, the lift was increased to about 1.5 pound. The present concept would desirably be embodied in a larger experimental craft, for instance one having an outside rotor assembly diameter of about 16.5 foot and an inlet opening **30** of about 5.5. foot diameter, and an interior peak height (near the opening) of about 3 foot. It is believed that such a rotor assembly would be capable of providing lift for a craft weighing as much as 2000 pounds. Such a craft may be constructed of lightweight metal alloys and engineered composite materials.

Although this invention has been shown and described with respect to a preferred embodiment, it will be understood by those skilled in this art that various changes in form and detail thereof may be made without departing from the spirit and scope of the claimed invention.

I claim:

1. An aircraft suited for vertical flying motion comprising:

a cabin, containing a prime mover for powering a rotatable rotor assembly, wherein the prime mover imparts a torque to the cabin during flying operation;

a rotatable shaft, extending upwardly from the cabin, driven by the prime mover;

a rotor assembly, mounted above the cabin, connected to the shaft, and adapted to rotate in a desired direction relative to the cabin; comprising a truncated cone shaped top having a central inlet opening; a circular bottom spaced apart from the top; and, rotor vanes, running radially between the top and the bottom of the rotor assembly, from vicinity of the central inlet opening to vicinity of the outer circumferences of said top and bottom;

wherein, the exterior circular edges of the top and the bottom form a downward facing annular nozzle for discharge of air from within the rotor assembly;

the combination of top, bottom and vanes forming an air-moving impeller so that when the top assembly is rotated, air is flowed through the inlet opening of the top, radially outward past the vanes, and then downward through said nozzle; and,

means for countering said torque, on the cabin.

2. The aircraft of claim **1** wherein the means for countering said torque comprises a plurality of tabs spaced apart around the periphery of the cabin, lying along the flow path of air discharged from said nozzle.

3. The aircraft of claim **2** further comprising a circumferential ring, running around the cabin, outboard of said tabs.

4. The aircraft of claim **1** further comprising a plurality of air scoops mounted on the surface of the top; each scoop having an opening facing in the desired direction in which the rotor assembly is adapted to rotate; the length of each scoop opening running across the top so that the outermost end thereof is near the periphery of the top and so that the innermost end thereof lies nearer to the central inlet opening of the top; wherein rotation of the rotor assembly causes air to be rammed through the scoop opening and into the interior of the impeller.

5. The aircraft of claim **4** wherein the length of the opening of each scoop runs at an angle to the radius of the top which runs through the innermost end of the scoop length.

6. The aircraft of claim **5** wherein the length of each scoop opening is fixedly oriented at an angle to said radius.

7. The aircraft of claim **6** having three equally spaced apart scoops; each scoop having an opening length oriented at a 30 degree angle to said radius.

8. The aircraft of claim **5** wherein each scoop is rotatably adjustable upon the surface of the top, so the orientation of the length of the opening of each scoop may be varied relative to said radius.

9. The aircraft of claim **1** further comprising struts extending downwardly from the bottom of the cabin; and, airfoils pivotably mounted on the struts, for changing the orientation of the aircraft during forward motion flight.

10. An aircraft suited for vertical flying motion comprising:

a cabin, containing a prime mover for powering a rotatable rotor assembly, wherein the prime mover imparts a torque to the cabin during flying operation;

a rotatable shaft, extending upwardly from the cabin, driven by the prime mover;

a rotor assembly, mounted above the cabin, connected to the shaft, and adapted to rotate in a desired direction relative to the cabin; comprising a truncated cone shaped top having a central inlet opening; a circular bottom spaced apart from the top; and, rotor vanes, running radially between the top and the bottom of the rotor assembly, from vicinity of the central inlet opening to vicinity of the outer circumferences of said top and bottom;

wherein, the exterior circular edges of the top and the bottom form a downward facing annular nozzle for discharge of air from within the rotor assembly;

the combination of rotor assembly top, bottom and vanes forming an air-moving impeller so that when the top assembly is rotated, air is flowed through the inlet opening of the top, radially outward past the vanes, and then downward through said nozzle;

means for countering said torque, comprising a plurality of tabs spaced apart around the periphery of the cabin and lying along the flow path of air discharged from said nozzle; and,

a multiplicity of air scoops mounted on the surface of the top, each scoop having an opening facing toward the desired direction in which the rotor assembly is adapted to rotate, so that rotation of the rotor assembly causes air to be rammed into the scoop opening.

11. The aircraft of claim **10** further comprising struts extending downwardly from the bottom of the cabin; and, airfoils pivotably mounted on the struts, for changing the orientation of the aircraft during forward motion flight.

* * * * *

US006179247B1

(12) **United States Patent**
Milde, Jr.

(10) **Patent No.: US 6,179,247 B1**
(45) **Date of Patent: Jan. 30, 2001**

(54) **PERSONAL AIR TRANSPORT**

(76) Inventor: **Karl F. Milde, Jr.**, 752 Union Valley Rd., Mahopac, NY (US) 10541

(*) Notice: Under 35 U.S.C. 154(b), the term of this patent shall be extended for 0 days.

(21) Appl. No.: **09/352,522**

(22) Filed: **Jul. 13, 1999**

Related U.S. Application Data

(63) Continuation-in-part of application No. 09/247,163, filed on Feb. 9, 1999.

(51) **Int. Cl.**[7] **B64C 15/00**; B64C 29/00; F02B 73/00

(52) **U.S. Cl.** .... **244/23 A**; 244/23 C; 60/716

(58) **Field of Search** .... 244/12.2, 23 A, 244/23 C; 60/716, 717, 718

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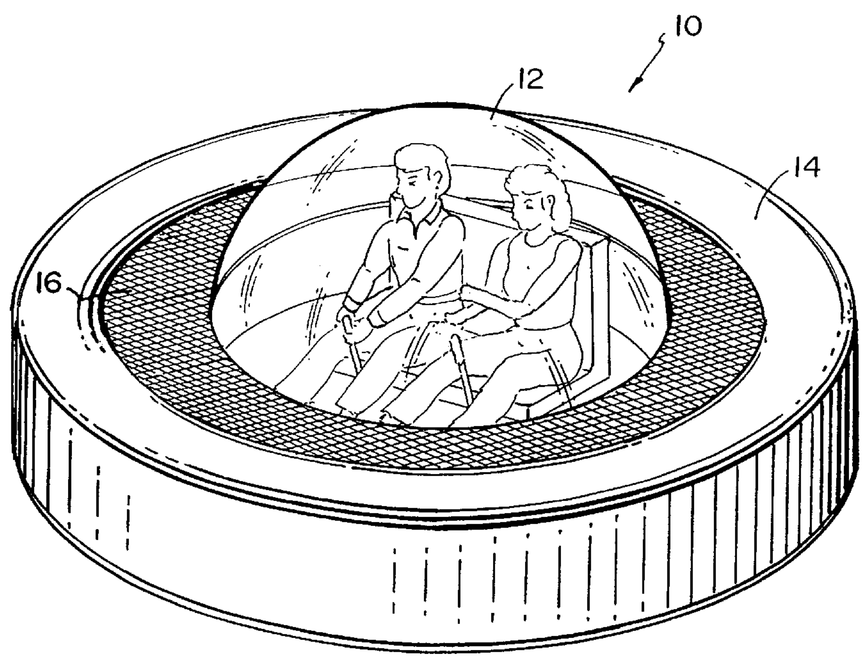
Primary Examiner—Robert P. Swiatek
(74) *Attorney, Agent, or Firm*—Milde, Hoffberg & Macklin, LLP

(57) **ABSTRACT**

A wingless personal air transport (PAT) comprises two main sections: First, a substantially horizontal circular inner platform is provided with its outer extremity having a first diameter D1. This inner platform has a seat for carrying at least one person and a shroud forming a smooth upper surface extending outward and downward to its outer extremity. Second, a substantially horizontal annular outer platform is arranged coaxially with the inner platform. This outer platform has a central opening with a second diameter D2 and a shroud forming a substantially smooth upper surface extending inward and downward into its central opening. The second diameter D2 is greater than said first diameter D1. Preferably there are at least five thrusters arranged in the space between the inner and outer platforms to provide a downward thrust of air. Also preferably, a clear plastic hemispherical bubble is arranged on top of the inner platform to protect the passengers and provide for the smooth flow of air.

37 Claims, 12 Drawing Sheets



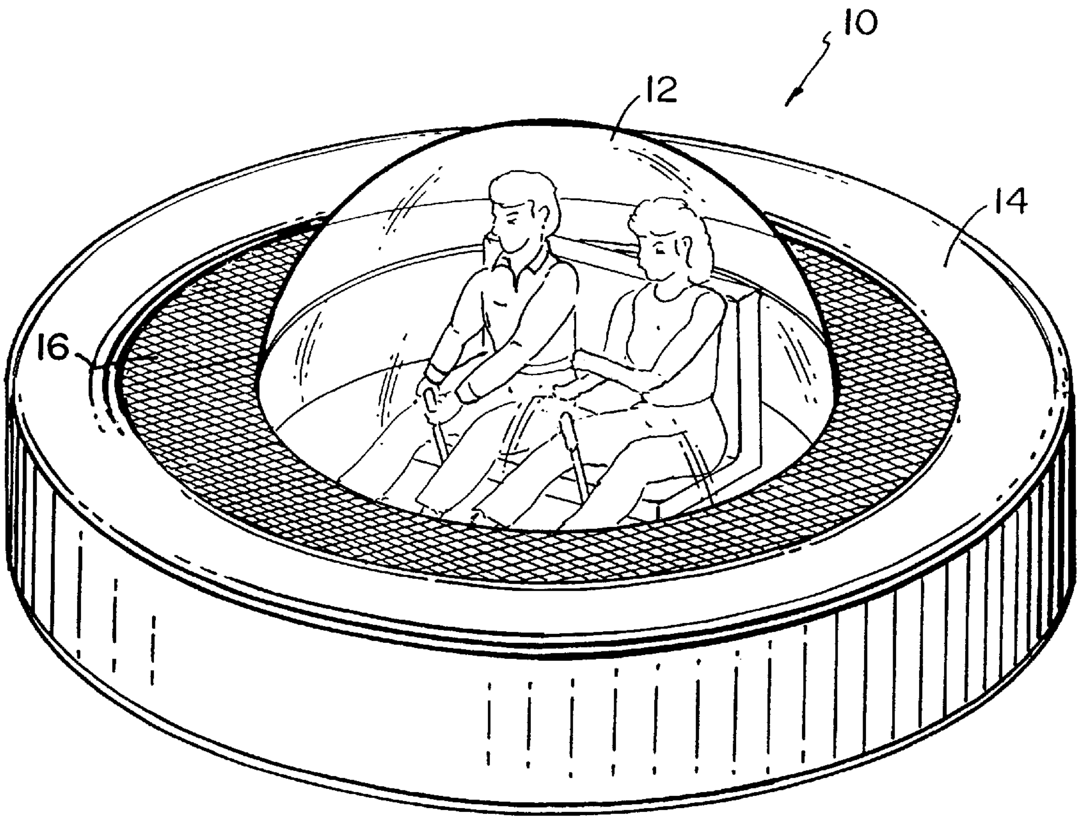


FIG.1

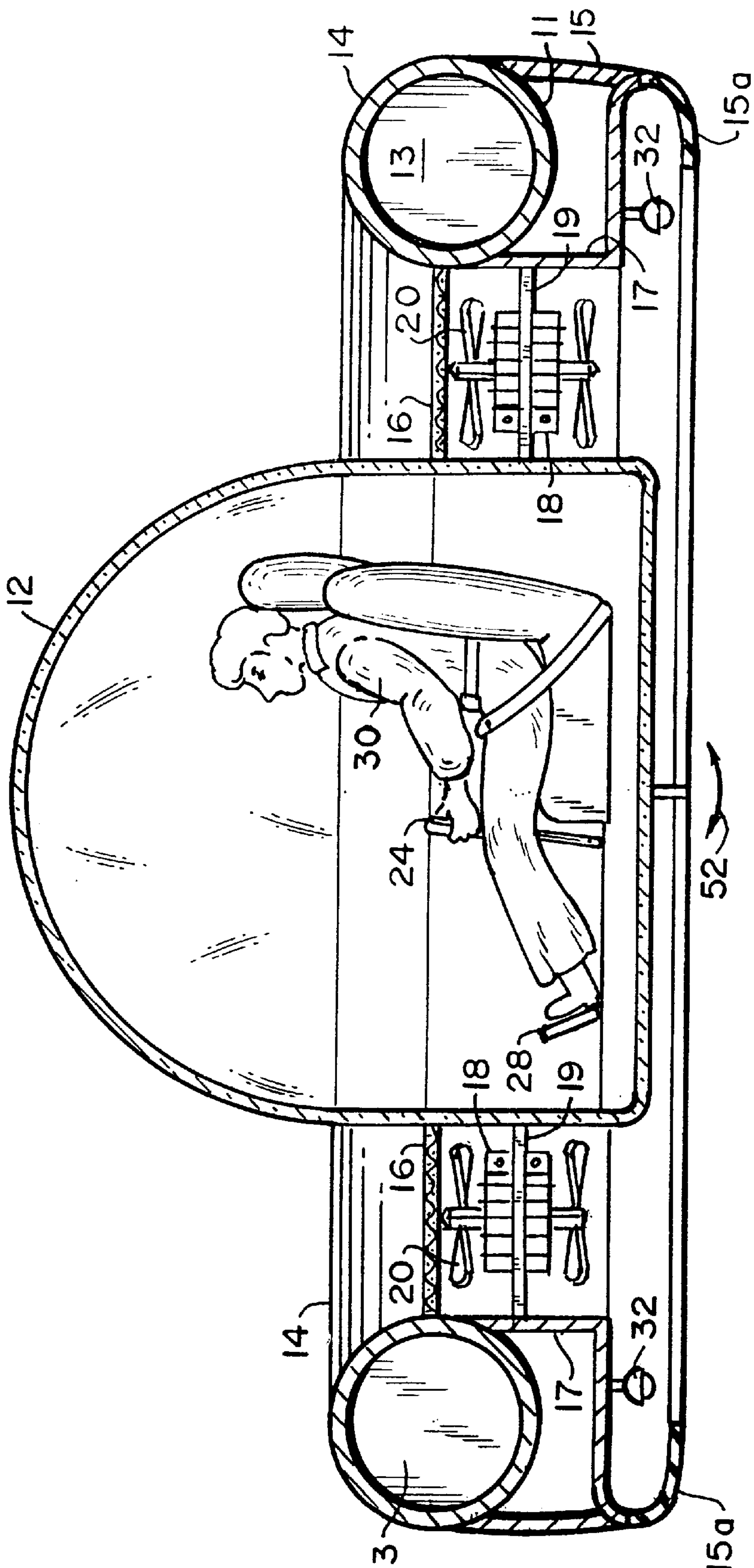

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FIG.2

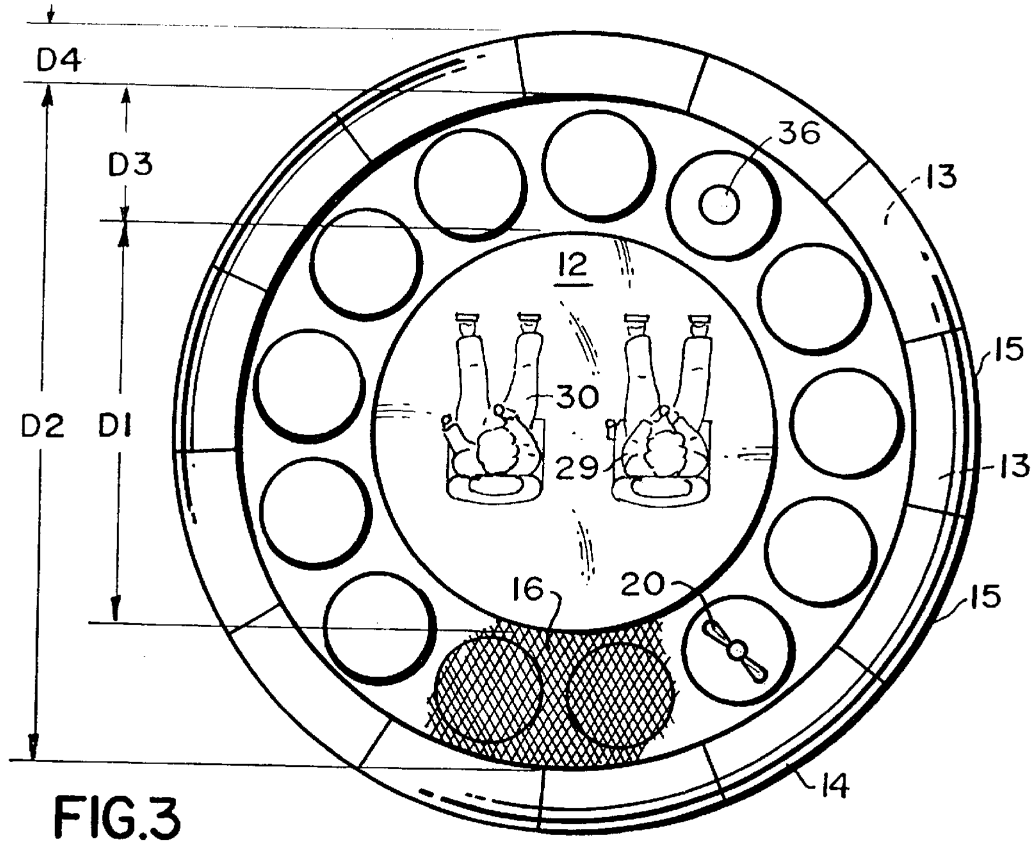
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FIG.3

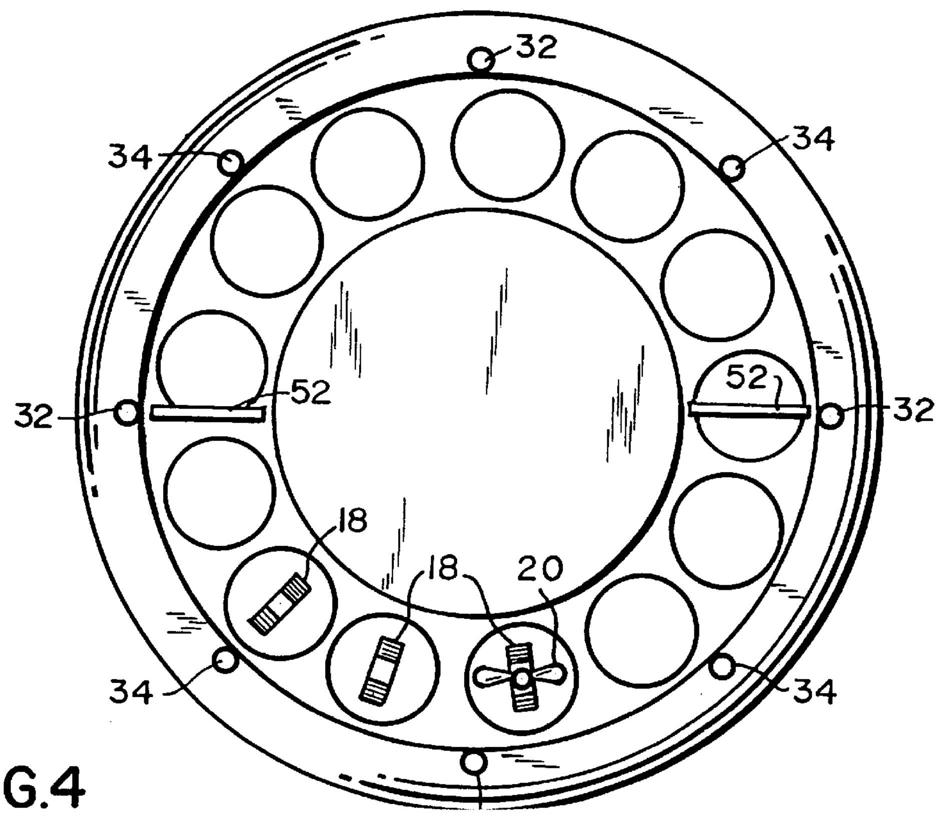
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FIG.4

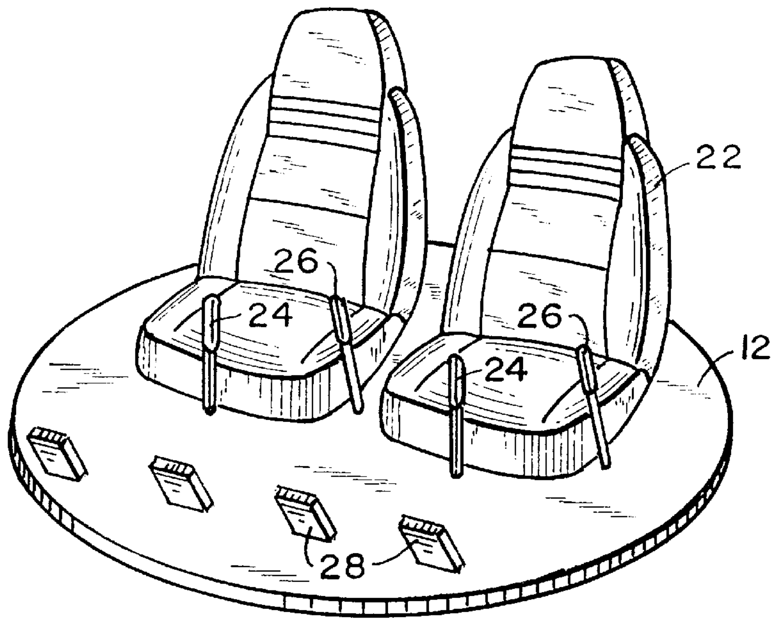
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FIG.5

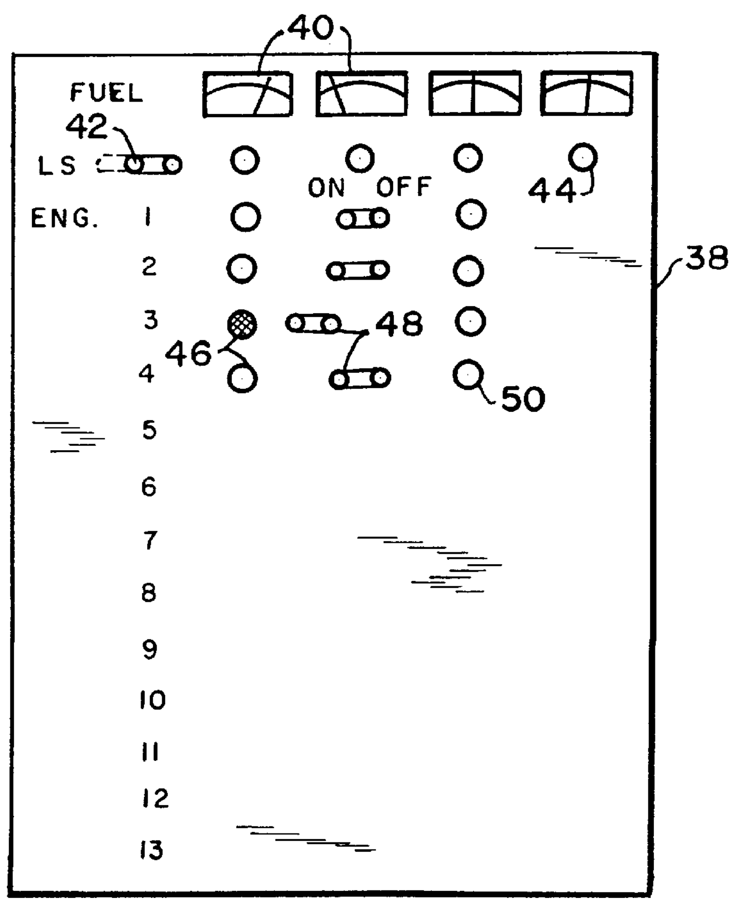
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FIG.6

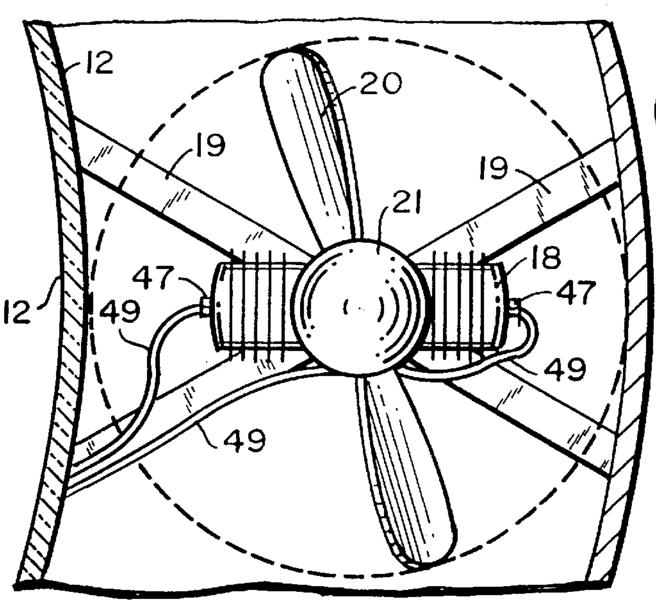

FIG.7

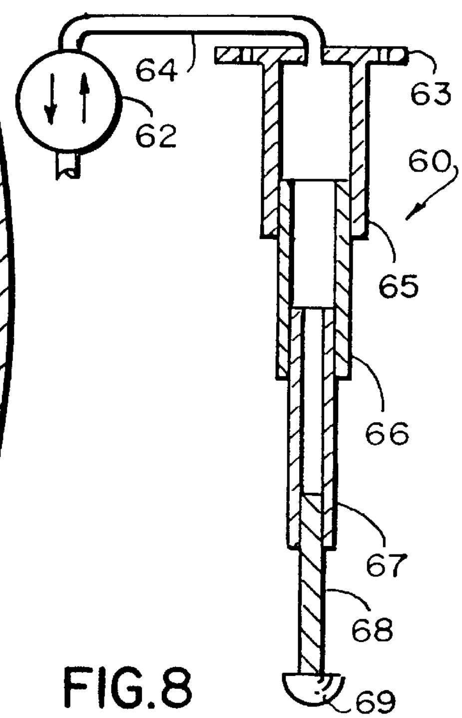

FIG.8

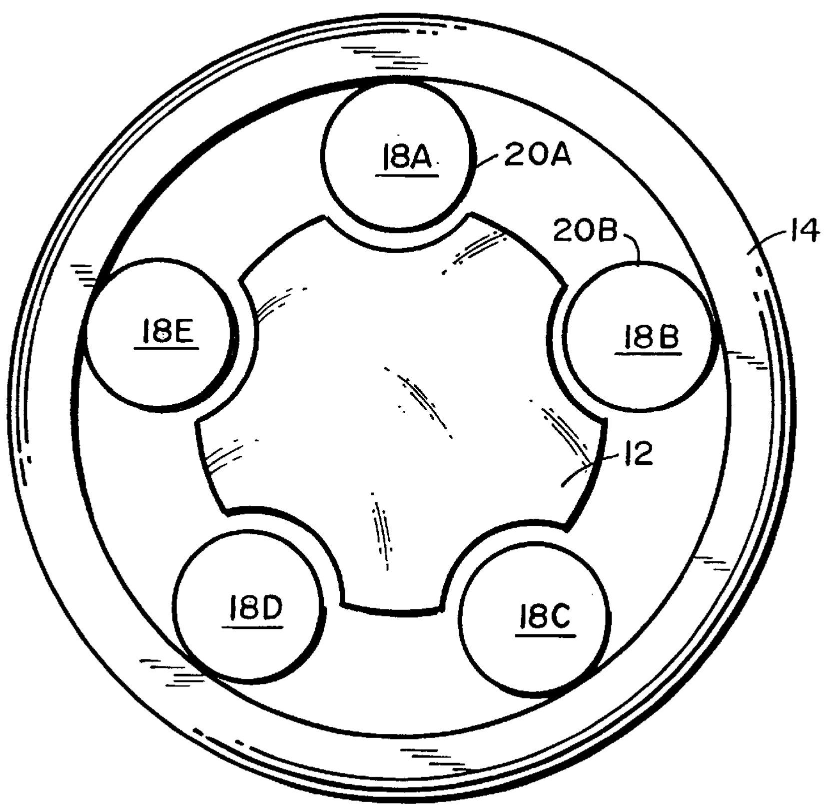

FIG.9

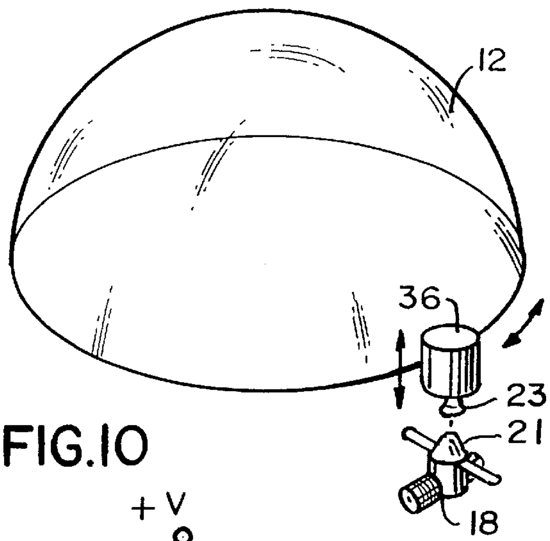

FIG.10

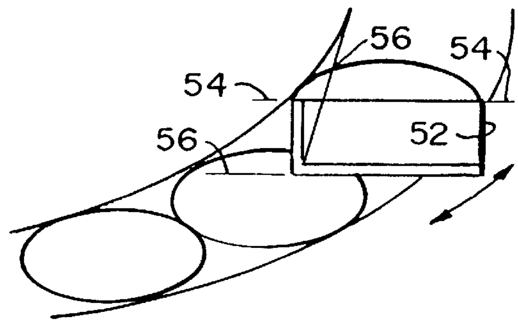

FIG.11

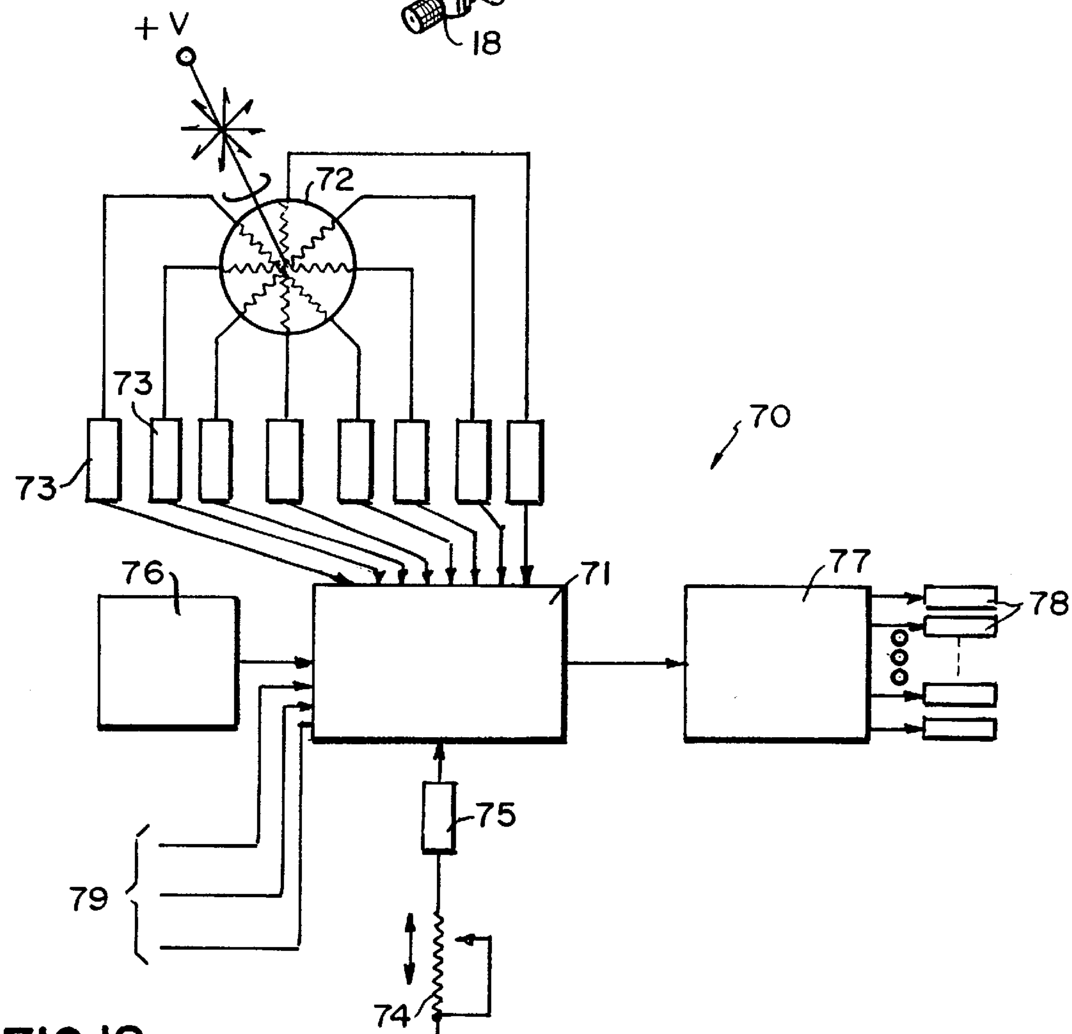

FIG.12

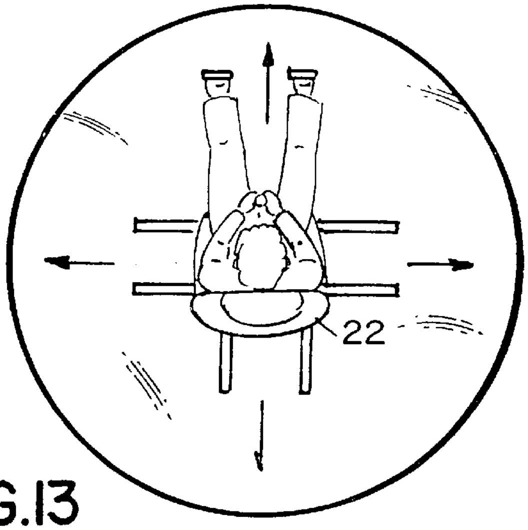

FIG.13

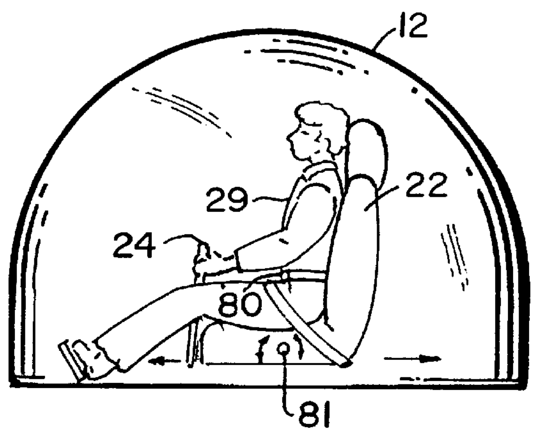

FIG.14

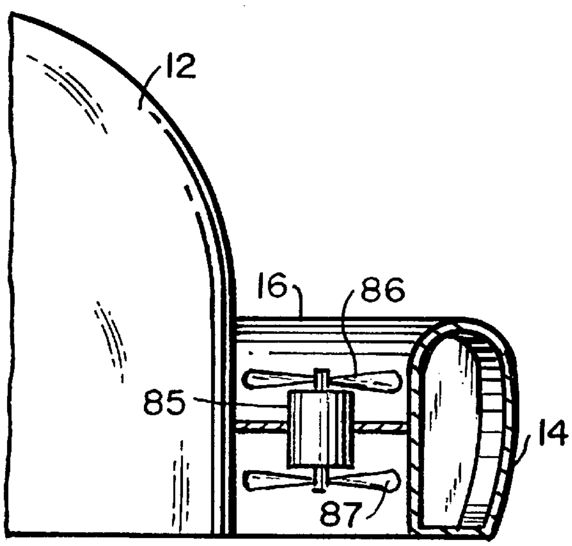

FIG.15

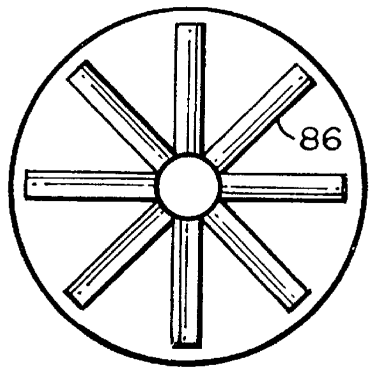

FIG.16

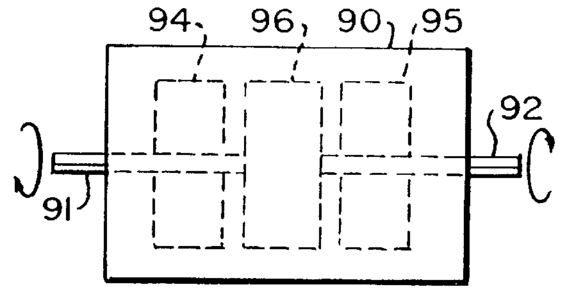

FIG.17

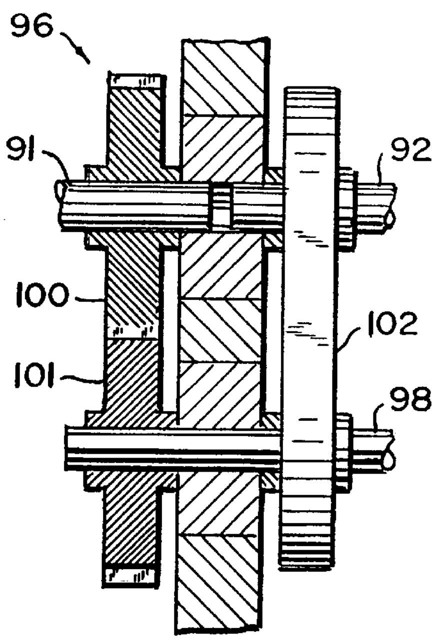

FIG.18

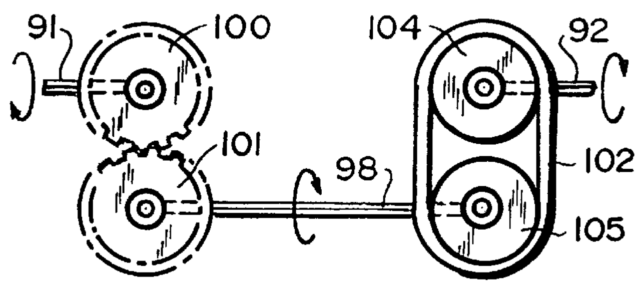

FIG.19

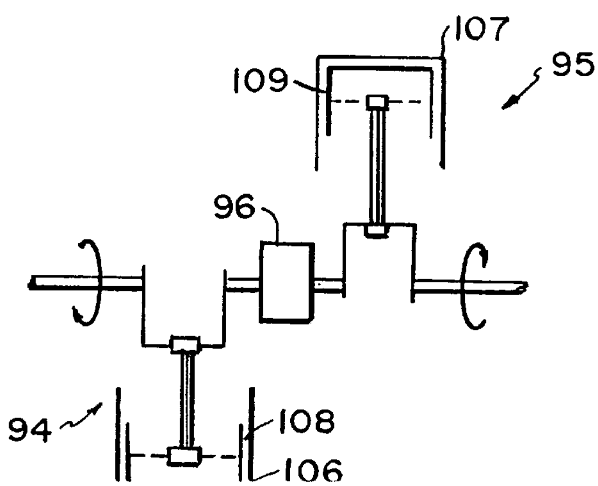

FIG.20

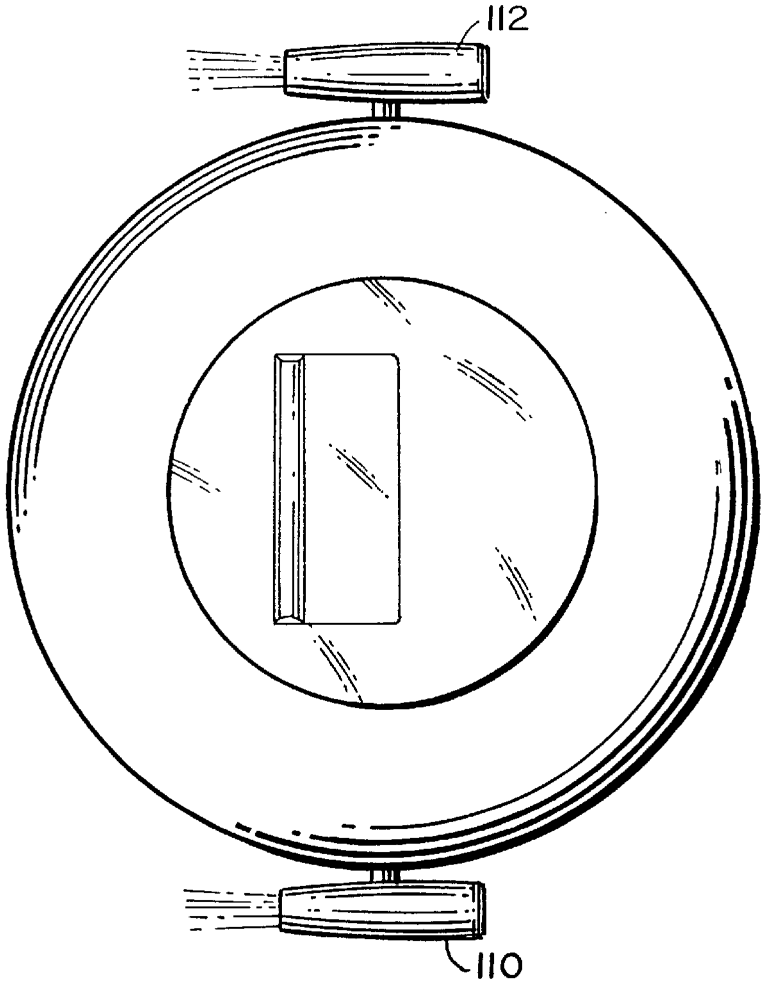

FIG.21

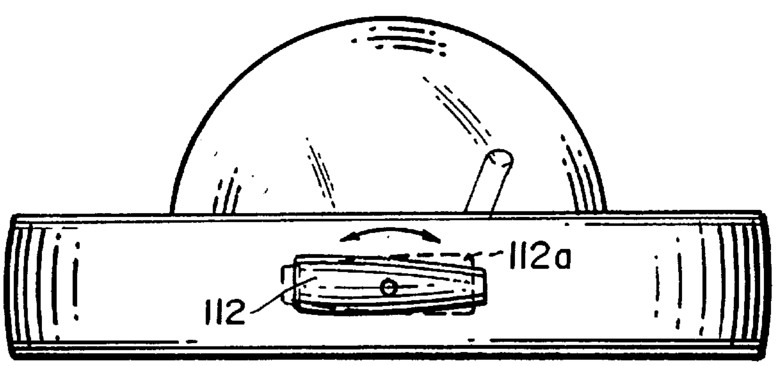

FIG.22

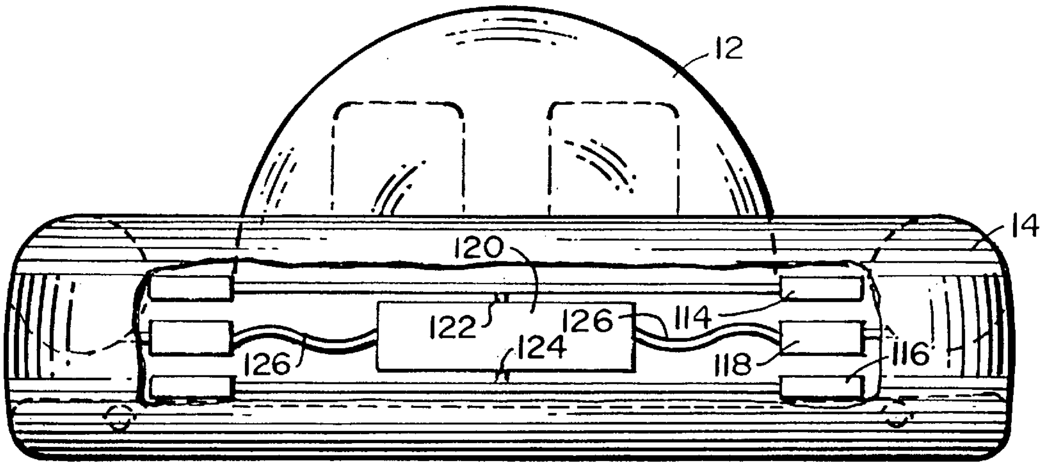

FIG.23

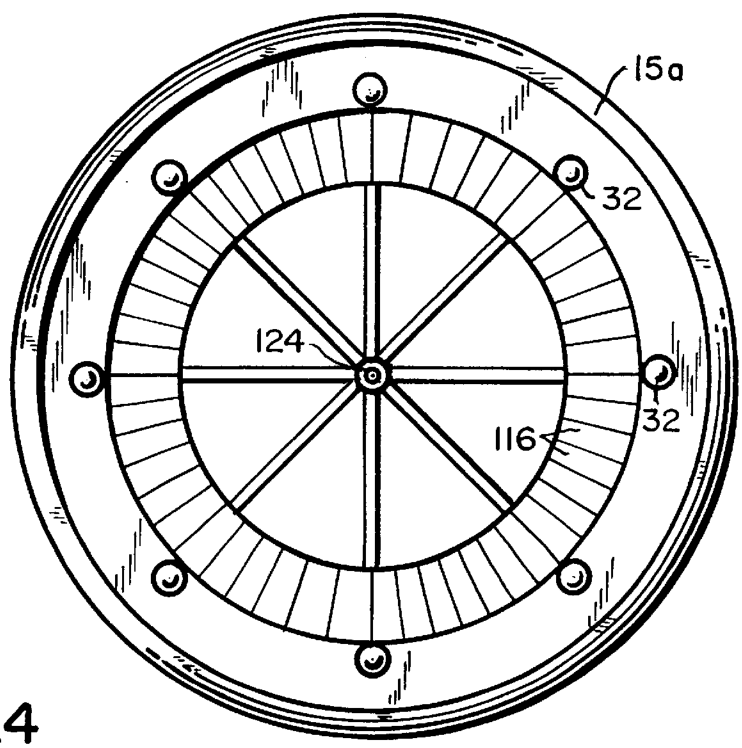

FIG.24

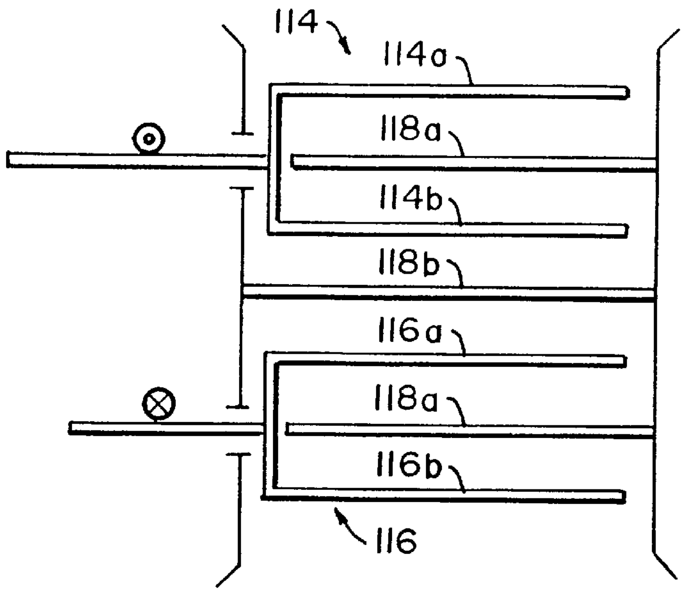

FIG.25

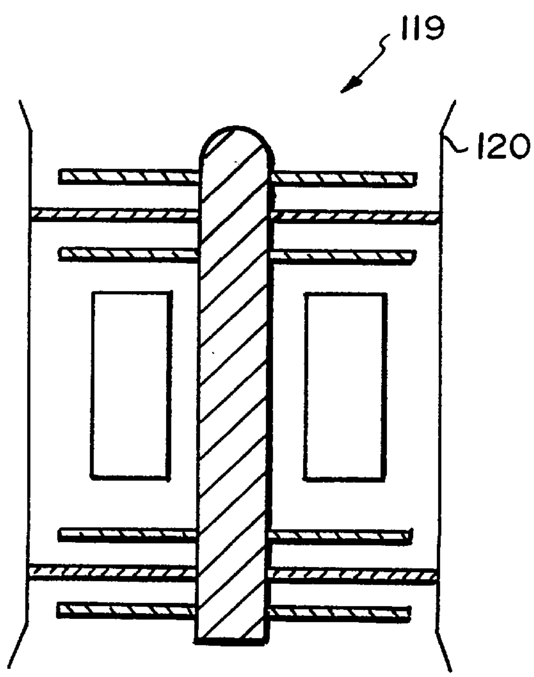

FIG.26

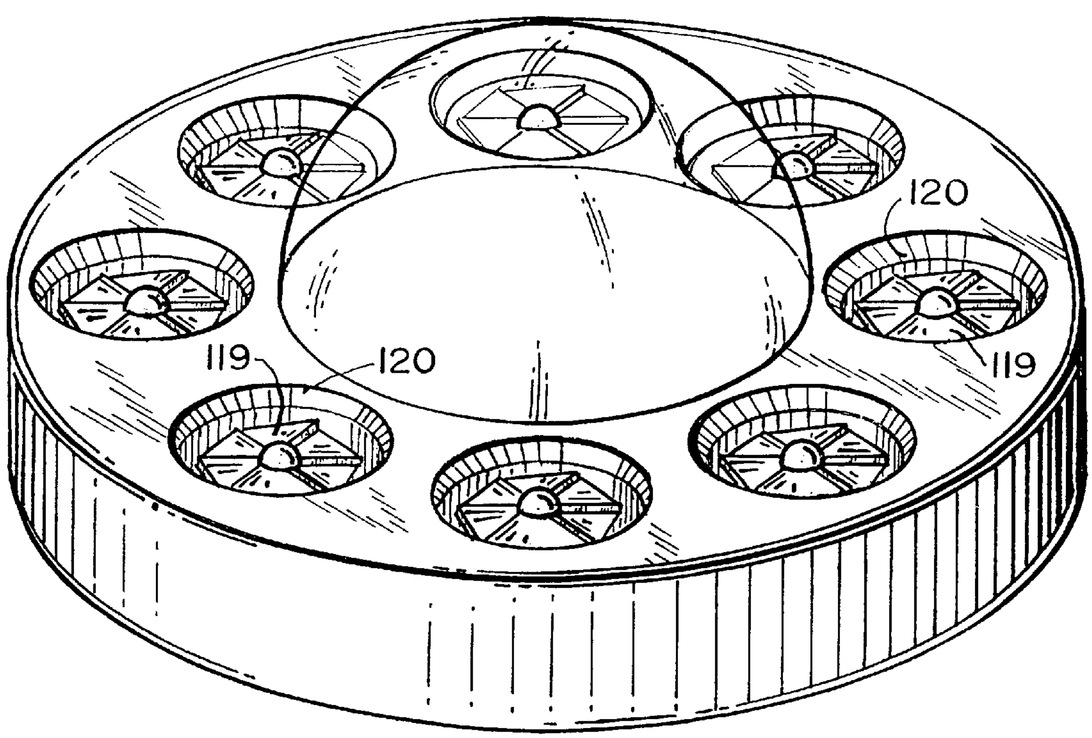

FIG. 27

PERSONAL AIR TRANSPORT

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of U.S. patent application Ser. No. 09/247,163, filed Feb. 9, 1999 for "PERSONAL AIR TRANSPORT".

BACKGROUND OF THE INVENTION

The present invention relates to a personal air transport or "PAT" which is capable of taking off and landing vertically as well as hovering, if desired. The PAT can maneuver, forward and back as well as side to side, and is capable of traveling forward at a reasonable speed.

Small vertical take-off and landing (VTOL) aircraft have been constructed in various configurations. The most well known is the helicopter which operates with powered rotor blades arranged above the craft body that rotate about a substantially vertical axis, and a powered tail rotor that rotates about a substantially horizontal axis. The pitch of the tail rotor blades is controlled in the cockpit by two pedals—one for the right foot and one for the left—which permit the operator to rotate the craft about the vertical axis or to hold it in a fixed, stable orientation by pressing on the right or left pedal, as desired. The pitch of the upper rotor blades is controlled by two levers: an up-down lever which changes the pitch if all blades at once and a directional "joystick" that selectively changes the pitch of the blades as they rotate through a 360° arc. The joystick is used to tilt the craft and thus impart lateral motion.

Another craft which is capable of VTOL utilizes shrouded rotor blades for extra lift. Instead of arranging the lifting blades in open air, as in the case of a helicopter, they are placed in a vertical "wind tunnel". As air is drawn in, it passes over a smooth upper rim of the tunnel, reducing the air pressure on this rim in accordance with Bernoulli's Principal. Such a shroud thus not only prevents the air from exiting outward, horizontally from the rotor blades, it also adds lift by this application of Bernoulli's Principal, thereby adding a multiple of about 1.5 to the static thrust as compared to an unshrouded set of rotor blades.

VTOL craft which utilize shrouded rotor blades are therefore considerably more efficient and require less energy to remain airborne. Aircraft of this type are known from the U.S. Pat. Nos. 3,614,030; DES 292,194; 5,213,284 and 5,881,970.

For one reason or another, none of these aircraft designs has risen to the level of commercial practicality.

SUMMARY OF THE INVENTION

It is a principal object of the present invention to provide a personal air transport ("PAT") which is capable of vertical take-off and landing (VTOL) and which is exceedingly safe to fly, notwithstanding engine failure.

It is a further object of the present invention to provide a PAT, capable of VTOL, which is exceedingly simple and easy to control and easy to operate.

It is a further object of the present invention to provide a PAT, capable of VTOL, which requires a minimum of energy to remain airborne.

These objects, as well as other object which will become apparent from the discussion that follows, are achieved, in accordance with the present invention, by providing a stable, shrouded platform with a plurality N of engines distributed around a circle substantially equidistant from each other, with each engine arranged to provide upward thrust along a substantially vertical axis. If the number N of engines is made greater than or equal to five, the PAT can retain its stable orientation in space and continue to fly even in the event of an engine failure.

Preferably, the number N is made equal to at least 10. In the preferred embodiment of the present invention, disclosed herein, where the craft is about 10 feet wide, N=13.

The present invention takes advantage of the fact that small yet powerful internal combustion (IC) engines, as well as jet engines, are available commercially. The power-to-weight ratio of such engines is comparable to that of larger air-cooled IC engines used for full sized aircraft.

Because of its reduced noise and reduced exhaust pollutants as compared to a two-cycle engine, it is advantageous to select a four-cycle IC engine. The somewhat lower power to weight ratio of this engine is offset by the greater torque that is available at lower RPM.

Also, for reasons of balance and reduced vibration, it is advantageous to select a twin cylinder reciprocating engine with opposed pistons or possibly even a Wankel engine. The two cylinder IC engine has the additional advantage, over a single cylinder engine, that it will continue to operate, even though one of the two cylinders may temporarily cease producing power.

Finally, it is advantageous to select a glow plug engine over a spark plug ignited engine because a spark plug ignition system is considerably more complex and prone to failure as compared to a glow plug.

In a preferred embodiment of the present invention the engine drives a propeller having a diameter in the range of 12–20 inches. This dictates that the engine should have a cubic inch displacement in the range of 1.0 to 3.0.

Preferably a muffler system is provided to substantially muffle the noise of the various engines. Such a system may include a single large muffling "ring" which surrounds the PAT and receives the exhaust from all engines.

As a particular example, the PAT may be powered by thirteen one or two-cylinder, four cycle engines available commercially from Echo Inc., 400 Oakwood Road, Lake Zurich, Ill. 60047. Such an engine may deliver over 50 pounds of static thrust when outfitted with a multiple blade, 20 inch propeller with a 6 inch pitch.

At full power, ten of these engines can lift over 500 pounds without a shroud. In a shrouded configuration ten such engines can lift about 1.5 times this weight or 750 pounds.

Assuming a craft weight of 225 pounds and a full tank (20 gallons) of fuel weighing 125 pounds, the craft will be able to lift a payload of about 400 pounds.

Add three more engines and thirty percent more power, and the craft becomes a nimble flyer which can rapidly rise off the ground and fly horizontally in any desired direction.

Control of the PAT is effected in two ways:

(1) Small moveable paddles which enable the craft to rotate about its central vertical axis under control of the operator, and

(2) Individual throttle control of each engine, thus controlling the engine speeds.

All of the engine speeds are controlled as a single group to cause the craft to rise, fall or hover. The speed of each engine is also controlled separately in a manner to be described hereinbelow to cause the craft to tilt in any desired direction and thus to move horizontally.

Preferably, the engine throttles are controlled by servomotors which, in turn, are controlled electronically. A first throttle lever is used by the operator to increase or decrease the speeds of all engines at once. A joystick is used to control the relative speeds of the engines and thus the tilt of the craft.

As in the case of a conventional helicopter, pedals are provided to enable the operator to rotate the craft. These pedals mechanically actuate two "paddles" or flaps arranged beneath the engines on opposite sides of the craft, in the downwash of the driven air, to rotate the craft about its vertical axis.

The PAT according to the invention is preferably configured as follows:

A substantially horizontal circular inner platform is arranged at the center of the craft to carry the craft passengers. The inner platform carries a seat for at least one person and has a preferably transparent, hemispherical enclosure arranged as a "bubble" over the passenger seat for protecting the passengers of the craft and providing a smooth surface for the flow of air. The enclosure extends downward to the circular outer extremity of the inner platform which has a diameter D**1**.

A substantially horizontal annular outer platform is arranged coaxially and surrounds the inner platform. The outer platform has a central opening with a second diameter D**2**, this second diameter being greater than the first diameter. The annular outer platform has a shroud forming a substantially smooth upper surface extending inward and downward into the space between the inner platform and outer platform.

At least one thruster is arranged in the space between the inner and outer platforms for forcing air downward to lift and propel the craft. Such a thruster may comprise a single engine, centrally arranged on the inner platform, for driving fan blades disposed in the space between the inner and outer platforms which rotate about the central vertical axis of the craft. Alternatively, the thrusters may comprise a plurality of engines arranged in the space between the inner and outer platforms, such as internal combustion reciprocating engines, internal combustion Wankel engines or even jet engines.

In the preferred embodiment of the invention, the engines are started one-by-one by a single electric motor which moves in a circle and engages the spinner or hub of each respective engine. As each engine is rotated to start it, electric power is applied to the engine glow plug or spark plug. Once the engine has started, both the mechanical power of the starter is removed and thereafter applied to the next engine in succession.

For movement on land, the PAT is preferably outfitted with casters, allowing the craft to be rolled by hand into a garage or the like.

The PAT is also provided with a flexible dust skirt, enabling it to hover on sand or water, if desired. This skirt collapses when the engines are switched off, allowing the craft to lower itself onto the casters.

In a preferred embodiment, telescoping "stilts" are provided to absorb the landing shock. These stilts are retracted when the craft is flying and while the craft is being rolled on its casters.

For stability, it is advantageous to have the center of gravity of the passengers (and luggage) disposed gravitationally below the level at which the engines lift the craft. Also, in addition to, or instead of, the system for selectively varying the speeds of the engines, thereby to tilt the craft and cause it to move in the horizontal direction, it is advantageous to provide means by which the passenger(s) can shift their weight laterally. This causes the craft to tilt as well, and thus to move horizontally.

Finally, if desired, the passenger seat(s) can be made to pivot forward and backward so that the passenger(s) can remain substantially level, even though the PAT craft may tilt forward (for traveling forward) or backward (for traveling backward).

These and other features and advantages will become apparent from the discussion that follows when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of the personal air transport (PAT) according to a preferred embodiment of the present invention.

FIG. **2** is a cross-sectional view of the PAT of FIG. **1** showing the relative positions of the major components.

FIG. **3** is a top view of the PAT of FIG. **1**.

FIG. **4** is a bottom view of the PAT of FIG. **1**.

FIG. **5** is a detailed view of the cockpit of the PAT of FIG. **1**.

FIG. **6** is a detailed view of a portion of the control panel of the PAT of FIG. **1**.

FIG. **7** is a detailed view of an engine of the PAT of FIG. **1**.

FIG. **8** is a detailed view of a landing "stilt" of the PAT of FIG. **1**.

FIG. **9** is a diagram of a PAT showing the minimum number of engines for fail-safe operation.

FIG. **10** is a detailed view of the starter mechanism of the PAT of FIG. **1**.

FIG. **11** is a detailed diagram of a craft rotator flap or "paddle", used for rotating the PAT about its central vertical axis.

FIG. **12** is a diagram of the electronic circuit for actuating the throttle servos of the engines.

FIG. **13** is a top view of a portion of the PAT showing an alternative embodiment for balancing and steering the craft according to the invention.

FIG. **14** is a side view of the cockpit portion of the PAT shown in FIG. **13**.

FIG. **15** is a detailed diagram showing a particular design of a thruster for the PAT of FIG. **1**.

FIG. **16** is a top view showing the propeller blades of the thruster of FIG. **15**.

FIG. **17** is a representational diagram of an engine or prime mover which rotates two coaxial shafts in opposite directions.

FIG. **18** is a detailed diagram of a mechanism used in the engine of FIG. **17** for connecting the oppositely rotating shafts.

FIG. **19** is a representational diagram illustrating the operation of the mechanism of FIG. **18**.

FIG. **20** is a representational diagram of a reciprocating engine of the type shown in FIG. **17**.

FIG. **21** is a top view of a PAT according to the invention having two external thrusters.

FIG. **22** is a side view of a PAT having external thrusters as shown in FIG. **21**.

FIG. **23** is a side elevational view of a PAT having two counter-rotating propeller blades.

FIG. **24** is a bottom view of the PAT of FIG. **23** showing one of the propeller blades.

FIG. **25** is a representational diagram showing an alternative embodiment of the blade configuration for the PAT of FIG. **23**.

FIG. **26** is a representational diagram of a jet engine arranged in the space between the inner and outer platforms.

FIG. **27** is a perspective view of the PAT according to a preferred embodiment of the present invention which incorporates jet engines.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the personal air transport (PAT) will now be described with reference to FIGS. **1–27** of the drawings. Identical or similar elements in the various figures are identified with the same reference numerals.

FIG. **1** is an illustration of the PAT **10** in flight. The craft comprises a circular inner platform **12** having a clear plastic bubble in the shape of a hemisphere. The inner platform supports two passenger/operators **29** and **30** on seats **22** within the bubble as well as the controls, indicated by the joystick **24**. The bubble is provided with a door (not shown) for the passengers.

Surrounding and connected to the inner platform **12** is an annular outer platform **14**. Like the inner platform, the outer platform has a smooth, rounded upper surface extending inward and downward toward the annular region **16** between the two platforms. As indicated in FIG. **1**, this region is covered by a protective screen but air is drawn downward into the space by engines **18** and propellers **20** (FIG. **2**) and exhausted out the bottom. Each engine may drive a single, mutliblade propeller, or may drive two propellers, as shown, one above and one below the engine, in the same direction of rotation. As the air passes over the upper surfaces of the inner and outer platforms it reduces the pressure on these surfaces, in accordance with Bernoulli's Principal, increasing the lift or upward thrust produced by the engines. This increased lift, coupled with the effect of the shrouds surrounding the propellers which prevent air from exiting in any direction except downward, adds a factor of about 1.5 to the upward thrust as compared to an engine and propeller situated in free space. Thus, if an engine **18** and its associated propeller(s) can produce an upward thrust of 50 pounds in free space, each engine in the PAT will generate about 75 pounds of lift.

Referring to FIGS. **2** and **3**, it may be seen that the outer platform **14** comprises an upper annulus **11** which encloses a plurality of fuel tanks **13** (e.g., thirteen, one per engine) arranged symmetrically about the circle, an outer shroud **15** and an inner shroud **17**. These shrouds as well as a dust-catching skirt **19**, are configured to prevent the air forced downward by the propellers **20** from recycling upward and entering the driven airstream again.

The outer platform **14** also includes an exhaust muffling system (not shown) for the engines, whereby all engine exhaust is supplied to a single muffler and then released downward into free space.

Referring to FIG. **3**, there are shown the two passengers **29** and **30** sitting in the center of the craft on the inner platform. Thirteen engines and propellers **20** surround the inner platform and these, in turn, are surrounded by the outer platform **14**.

In the upper right quadrant of the diagram there is indicated an electric starter motor **36**. More will be said about this starter motor in connection with FIG. **10**.

FIG. **4** shows the reverse (bottom) side of the PAT. As may be seen, the engines **18** are opposed two cylinder engines, preferably four-cycle in operation. Surrounding the engines and attached to the outer platform are four casters **32** interspersed by four landing "stilts" (shock absorbers) **34**. More will be said about these landing stilts (LS) in connection with FIG. **8**.

FIGS. **3** and **4** illustrate the respective size (diameters) of the inner and outer platforms. The inner platform has an outer diameter D1 whereas the outer platform has an inner diameter D2>D1. The difference D2 minus D1 or D3 is slightly greater than the diameter of the propeller **20**.

In the preferred embodiment of the invention, illustrated in FIGS. **1–4**, the outer diameter D1 is 6 feet, the inner diameter D2 is between 8 and 9 feet and the overall diameter D4 is 10 feet. The space D3 for the propellers is therefore approximately in the range of 1 and 1.5 feet. The Echo twin-cylinder reciprocating engine, referred to above, may operate with 16 to 20 inch propeller(s) having a six inch pitch.

FIG. **5** illustrates the cockpit controls for the craft. Joystick **24** is used in its conventional way to orient the craft front to back and side to side. This control adjusts the relative speeds of the engines to cause the craft to tilt. For example, pushing the joystick forward causes the rearward engines of the craft to increase in speed and (if desired) the front engines to decrease their speed slightly, thereby increasing the relative lift in the back and causing the craft to tilt forward. This forward tilt results in the craft moving forward in the horizontal direction.

The control arms **26** are throttle controls which operate all engines simultaneously and in unison. If this arm or lever is pulled upward, the engines speed up, causing the craft to rise. If this lever is pushed down, the craft will sink. At one particular setting of the lever **26** the craft will hover.

The joystick **24** and lever **26** operate variable resistors in an electrical circuit that produces the proper pulse code modulated (PCM) signals for the engine throttle servos. Each engine is controlled by its own individual servo which rotates the throttle spindle of the engine. The electronic circuit for this function will be explained in connection with FIG. **12**.

Pedals **28** operate flaps or "paddles" on opposite sides of the craft, as shown in FIGS. **2**, **4** and **11**. These flaps move in opposite directions in the airstream to rotate the craft. The rotator flaps **52** are pivoted about an axis **54** and are operated by cables **56** mechanically connected to the pedals **28**. Pressing the right pedal causes the craft to rotate clockwise; pressing the left pedal causes it to rotate counter-clockwise.

FIG. **6** shows a portion of the instrument panel **38** relating to engine control and operation. The usual navigation instruments (gyro and magnetic compass) have been omitted for reasons of clarity.

The top row of gauges **40** shows the fuel level in four separate tanks: front, rear, left side and right side. While there may be more fuel tanks (e.g., one per engine as noted above) it is assumed that the fuel levels in four tanks around the periphery of the craft are representative of the fuel levels in all tanks.

The next line, marked "LS", relates to the landing stilts of the craft. This landing gear will be described in detail in connection with FIG. **8**. At the left, on this line, is a single switch **42** for raising and lowering all landing stilts as a group. To the right of the switch are four lights **44** which indicate whether each respective landing stilt is in the extended (landing) position.

If all four lights are not illuminated upon landing when the switch **42** is placed in the "gear down" position, the operator may retract the gear and land the craft directly on the casters **32**.

The remaining rows on the instrument panel are numbered **1**, **2**, **3** . . . **12**, **13**. These numbers specify an engine number on the craft. For each engine there is provided a starter button **46** for the starter motor, an on/off switch **48** for the engine ignition or glow plug(s) and an over-heat temperature light **50**. These controls enable the operator to start each respective engine and to monitor it during flight. Engines are switched off by moving the throttle lever **26** to the "off" position, thereby preventing both fuel and air from entering the engines.

FIG. **7** is an illustration of a single engine **18** and its associated propeller **20** and spinner hub **21**. In this case the engine is a twin piston and cylinder type internal combustion engine. The opposed cylinders are outfitted with glow plugs **47**. A suitable voltage (e.g. 1.5 volts) is selectively applied to the glow plugs, via the control panel switch **48** discussed above, through wires **49** which are permanently connected to the plugs. The engine **18** is attached to the craft **12**, **14** by means of bracket members **19**. An "X" configuration of these brackets is shown, but any suitably robust arrangement will suffice. Engine exhaust is ported to the exhaust muffler system (not shown) in the outer platform **14**.

FIG. **8** shows a telescoping landing stilt **60** which is preferably attached to, and extends downward from the outer annular platform **14**. The landing stilt is pneumatically operated by an air pump **62**, that is capable of pumping air in either of two directions. This air is conveyed to or from the landing stilt **60** via a tube **64** connected to the attachment bracket **63**. When air is pumped in, the telescoping elements **65**, **66**, **67** and **68** extend downward and provide a pneumatic spring and shock absorber for landing. When air is pumped out of the system the telescoping elements retract. A small pad or "foot" **69** ensures that the landing stilt secures a firm footing on the ground.

FIG. **9** illustrates the advantage of having at least five separate engines **18** on the PAT craft. Assuming that each engine drives at least one propeller **20**, preferably mounted coaxially with the engine drive shaft, it may be seen that five engines **18**A, **18**B, **18**C, **18**D and **18**E, spaced equidistantly around the inner platform **12** are the minimum number required for fail-safe operation. If one of these engines fails, the remaining four will be able to lift and support the craft without causing it to flip over.

If two engines fail, and if they are not adjacent each other, the craft will also continue to fly or, if there is insufficient lift, to at least hover or descend slowly while maintaining a level platform.

FIG. **9** shows only five propellers **20**A, **20**B, etc., one for each engine. It would, of course, also be possible for each engine to drive two or more propellers about a common axis or even about multiple axes by providing a suitable mechanical linkage. For example, five engines arranged equidistantly as shown in FIG. **7** could drive a total of ten propellers arranged in a circle in the manner shown in FIG. **3**.

FIG. **10** illustrates how the engines **18** may be started using an electric starter motor **36**. This starting motor has a chuck **23** which engages the spinner hub **21** of each engine **18**. The starter motor **36** is arranged on a ring or a track that surrounds the inner platform **12** and is caused to move around the platform **12** stopping at each engine, in turn, to start it.

If an engine fails in flight, the starter may be incremented to this engine and lowered onto the engine for starting.

FIG. **12** is a block diagram of the electronic circuit **70** used to control the thirteen servos that operate the throttles of the thirteen engines. The joystick **24** selectively varies the resistance of a star-shaped array of resistors **72** which receive a constant voltage V at this center point. The output voltages of the various resistors are converted to digital numbers in a series of analog-to-digital converters **73**.

Similarly, the throttle lever **26** adjusts the resistance of a single variable resistor **74** causing the input voltage V to vary. The output voltage is then converted to a digital number by an analog-to-digital converter **75**.

The outputs of the A/D converters **73** and **75** are read by a microcomputer **71** which also receives a vertical reference signal from a gyroscopic device **76**. The gyroscopic device maintains a stable horizontal platform and outputs a reference signal indicating the angular deviation of the PAT craft from the horizontal. Stated another way, the device **76** continuously informs the microcomputer which way vertically "down".

Other inputs **79** to the microcomputer **71** may comprise GPS generated information defining the craft's position on the globe (latitude and longitude); altimeter generated information regarding the craft's altitude above sea level and above ground; and compass generated information as to the direction of true north.

The microcomputer calculates the throttle values required to orient the craft in the manner selected by the joystick **24** and the throttle lever **26**. In so doing, the microcomputer insures that the craft will not be tilted so far in any direction, for example more than 30° from the horizontal, as to dangerously reduce the lift or tumble over.

The throttle values determined by the microcomputer are passed, either sequentially or in parallel to a demultiplexer and translator **77**, which produces pulse code modulated (PCM) signals for the thirteen throttle servos **78**.

FIGS. **13** and **14** illustrate how the PAT craft may be controlled by shifting the weight of the passenger(s). As is best seen in FIG. **13**, the passenger seat may be moved in the horizontal direction, either forward or back, to the right or to the left, or a combination of these movements, to change the position of the center of gravity of the craft.

Normally, the center of gravity or CG of a seated person is located approximately at the position of the person's navel, or at the point where the seat belt passes across the person's torso. If this CG point is moved horizontally from a central position on the craft, the craft will tilt. This tilting may be used, either in addition to, or instead of the individual engine throttle control described above, to maneuver the craft horizontally.

FIG. **14** shows the position of the CG **80** at substantially the center of the craft. FIG. **14** also shows a pivot point **81** either through the bottom of, or beneath the seat **22** about which the passenger **29** may be tipped forward or backward. In this way, the passenger can remain substantially level even though the craft is tilted sharply forward when traveling in the forward direction.

FIG. **15** shows an alternative embodiment of a circular thruster for the personal air transport. In this case, the thruster comprises an engine **85** mounted within the annular region **16** between the inner platform **12** and the outer platform **14**. The engine **85** rotates two propellers **86** and **87** either in the same direction or, preferably, in opposite rotational directions. The propellers are preferably multi-blade propellers for increased efficiency, as illustrated, in top view, in FIG. **16**.

The engine drives the propellers at speeds up to 7500 RPM or 125 revolutions per second. Such propellers may have a maximum diameter of about 21 inches to maintain the tip speed below about 0.7 times the speed of sound or 700 feet per second.

The maximum tip speed at 125 revolutions per second is: 700/125=5.6 feet (circumference)

The diameter is therefore 5.6/π=1.78 feet×12=21.36 in.

With a six inch or ½ foot pitch, the blades operating at 125 revolutions/second can move air at 62.5 feet per second.

FIG. **17** illustrates and engine **90** which drives counter rotating shafts **91** and **92**. The engine comprises a first prime mover **94**, a second prime mover **95** and a central mechanism **96** which couples the two shafts **91** and **92** for counter rotation. This mechanism **96** is illustrated in FIGS. **18** and **19**. As illustrated there, the shafts **91** and **92** are both coupled mechanically to a separate shaft **98**. The shaft **91** is mechanically coupled to the shaft **98** via gears **100** and **101** which cause the shaft **98** to rotate in a direction opposite to that of the shaft **91**. In contrast, the shaft **92** is coupled to the shaft **98** via a pulley or chain **102**, causing the shaft **98** to rotate in the same direction as the shaft **92**. The pulley **102** surrounds two pulley wheels **104** and **105** of identical diameter.

Since the gear ratio of the gears **100** and **101** is 1:1 and the pulley operates with a ratio of 1:1, the shafts **91** and **92** rotate at the same speed, but in opposite directions.

The prime movers **94** and **95** in FIG. **17** are preferably internal combustion engines such as reciprocating piston engines or Wankel engines. In the former case, the cylinders **106** and **107** may be arranged in opposed relationship, as illustrated in FIG. **20**, so that the pistons **108** and **109**, respectively, will move in exactly opposite directions, thus reducing engine vibration due to imbalance of the reciprocating parts.

FIGS. **21** and **22** illustrate the addition of small thrusters **110** and **112** on opposite sides of the personal air transport. These thrusters, which may be small jet engines, rocket motors or shrouded motor driven propellers or fans, operate to speed the craft in the forward direction and, upon reversal of thrust by rotating the engines to the position shown in dashed lines **112***a*, the thrusters serve to rapidly break the forward motion of the vehicle in mid-air.

FIGS. **23** and **24** illustrate an alternative embodiment whereby two large fans are driven about a central vertical axis of the craft. A first fan **114** operates (rotates) in one direction while a second fan **116** rotates in the opposite direction. Fixed blades **118** redirect the air as it is forced downward at an angle by the blades **114**.

The engine **120** preferably comprises two separate engines and a central mechanism, as are shown in FIG. **17**, for counter rotating the fan blades **114** and **116** about the central shafts **122** and **124**, respectively.

The engines **120** receive fuel from the fuel tanks in the outer platform **14** via tubes **126**. These tubes also serve to transport liquid coolant from small radiators (not shown) within the airstream generated by the fans **114** and **116**.

FIG. **25** illustrates an alternative embodiment whereby the fans **114** and **116** may be composed of successive fan blades **114***a* and **114***b*, **116***a* and **116***b*, respectively. In between the rotating blades **114** and **116** are a series of fixed blades **118***a*, **118***b* and **118***c*. These blades are designed to provide the maximum upward thrust available in a configuration of this type.

In still another modification of the present invention, individual thrusters in the form of jet engines may be provided, as illustrated in FIG. **26**, with each engine in its own separate cylindrical channel **120** as illustrated in FIG. **27**. FIG. **27** shows the personal air transport having eight jet engines arranged in eight such channels.

Alternatively, thrusters of the type illustrated in FIG. **2** or in FIG. **15** can be disposed in individual, cylindrical channels.

There has thus been shown and described a novel personal air transport (PAT) which fulfills all the objects and advantages sought therefor. Many changes, modifications, variations and other uses and applications of the subject invention will, however, become apparent to those skilled in the art after considering this specification and the accompanying drawings which disclose the preferred embodiments thereof. All such changes, modifications, variations and other uses and applications which do not depart from the spirit and scope of the invention are deemed to be covered by the invention, which is to be limited only by the claims which follow.

What is claimed is:

1. A wingless, personal air transport (PAT) comprising, in combination:

(a) a substantially horizontal circular inner platform with its outer extremity having a first diameter D**1**, said inner platform having a seat for carrying at least one person and having a shroud forming a smooth upper surface extending outward and downward to said outer extremity; and

(b) a plurality N of independently powered thrusters distributed around a circle substantially equidistant from each other, each of said thrusters being attached to said inner platform, outside of said outer extremity, and arranged to produce upward thrust in a substantially vertical axis, wherein N≧5.

2. The PAT defined in claim **1**, wherein N≧10.

3. The PAT defined in claim **1**, further comprising a substantially horizontal annular outer platform arranged coaxially with said inner platform, said outer platform having a central opening with a second diameter D**2** and having a shroud forming a substantially smooth upper surface extending inward and downward into said central opening;

said second diameter D**2** being greater than said first diameter D**1** and forming a space between said inner and outer platforms;

wherein said thrusters are arranged in said space.

4. The PAT defined in claim **3**, wherein each of said plurality N of thrusters includes at least one internal combustion (IC) engine, each of said engines producing thrust by means of at least one propeller disposed in said space.

5. The PAT defined in claim **3**, further comprising an exhaust muffler system arranged in said outer platform for receiving and muffling the exhaust gases of all thrusters.

6. The PAT defined in claim **3**, further comprising a dust skirt arranged around the bottom of said outer platform for preventing air from escaping outward when said PAT is near the ground.

7. The PAT defined in claim **3**, wherein at least one fuel tank is provided in said outer platform.

8. The PAT defined in claim **1**, wherein at least one rotator flap is provided in the airstream provided by a thruster for rotating said craft about its central vertical axis.

9. The PAT defined in claim **1**, wherein said thrusters have throttles, and individual servos are provided for each thruster to control its respective throttle.

10. The PAT defined in claim **9**, further comprising a computer coupled to said servos, said computer adjusting the throttles of said thrusters to maintain said circular platform approximately level, notwithstanding the failure of one or more thrusters.

11. The PAT defined in claim **1**, further comprising a plurality of telescoping stilts disposed on the bottom of the craft for absorbing landing shock.

12. The PAT defined in claim **1**, wherein each of said thrusters includes an internal combustion, reciprocating engine.

13. The PAT defined in claim **1**, wherein each of said thrusters includes an internal combustion, Wankel engine.

14. The PAT defined in claim **1**, wherein each of said thrusters includes a jet engine.

15. The PAT defined in claim **1**, wherein the center of gravity of the craft, with passengers aboard, is below the level of said upward thrust.

16. In a wingless, personal air transport (PAT) comprising, in combination:

(a) a substantially horizontal circular inner platform with its outer extremity having a first diameter D**1**, said inner platform having a seat for carrying at least one person and having a shroud forming a smooth upper surface extending outward and downward to said outer extremity;

(b) a substantially horizontal annular outer platform arranged coaxially with, and surrounding said inner platform, said outer platform having a central opening with a second diameter D**2** and having a shroud forming a substantially smooth upper surface extending inward and downward into said central opening;

said second diameter D**2** being greater than said first diameter D**1**;

(c) thruster means arranged in the space between said inner and outer platforms for forcing air downward; and

(d) an enclosure disposed on said inner platform for protecting the passengers of the craft and providing a smooth surface for the flow of air to the space between the inner and outer platforms.

17. The PAT defined in claim **16**, further comprising a dust skirt arranged around the bottom of said outer platform for preventing air from escaping outward when said PAT is near the ground.

18. The PAT defined in claim **16**, wherein at least one engine fuel tank is provided in said outer platform.

19. The PAT defined in claim **16**, wherein at least one rotator flap is provided in the airstream between said inner and outer platforms for rotating said craft about its central vertical axis.

20. The PAT defined in claim **16**, wherein the center of gravity of the craft, with passengers aboard, is below the level of said means for forcing air downward.

21. The PAT defined in claim **16**, further comprising a plurality of telescoping stilts disposed on the bottom of the craft for absorbing landing shock.

22. The PAT defined in claim **16**, wherein said thruster means for forcing air downward include at least one engine driving coaxial, counter-rotating shafts and propeller blades, mounted for rotation about said shafts.

23. The PAT defined in claim **22**, comprising a plurality of said engines arranged in, and equally distributed around said space between said inner and outer platforms.

24. The PAT defined in claim **23**, comprising at least five of said thrusters arranged in, and equally distributed around said space between said inner and outer platforms.

25. The PAT defined in claim **16**, wherein said thruster means for forcing air downward comprises an engine centrally arranged on said inner platform, and fan blades, driven by said engine, disposed in the space between said inner and outer platforms and rotating about a central vertical axis of said craft.

26. The PAT defined in claim **25**, wherein said engine drives counter-rotating shafts and wherein said fan blades comprise two coaxial fans, each driven by one of said counter-rotating shafts, disposed in the space between said inner and outer platforms.

27. The PAT defined in claim **26**, wherein said engine includes a prime mover comprising, in combination:

(a) a first internal combustion engine having a first drive shaft extending therethrough;

(b) a second internal combustion engine having a second drive shaft extending therethrough, said first and second shafts being arranged on a common axis and said second engine being capable of producing substantially equal power to that of said first engine; and

(c) a transmission arranged intermediate said first and second engines and connecting said first and second shafts, said transmission requiring that said first and second shafts rotate in opposite directions,

whereby said first and second engines operate in synchronism with their respective drive shafts rotating in opposite directions.

28. The PAT defined in claim **27**, wherein said transmission requires that said first and second shafts rotate in opposite directions at the same speed.

29. The PAT defined in claim **26**, wherein said fan blades further comprise stationary fan blades disposed in the space between said inner and outer platforms.

30. The PAT defined in claim **16**, wherein said thruster means for forcing air downward comprises a plurality of thrusters arranged in, and equally distributed around the space between said inner and outer platforms.

31. The PAT defined in claim **30**, wherein said thruster means for forcing air downward comprises at least five of thrusters arranged in, and equally distributed around the space between said inner and outer platforms.

32. The PAT defined in claim **16**, wherein each of said thrusters includes an internal combustion, reciprocating engine.

33. The PAT defined in claim **16**, wherein each of said thrusters includes an internal combustion, Wankel engine.

34. The PAT defined in claim **16**, wherein each of said thrusters includes a jet engine.

35. The PAT defined in claim **16**, wherein said enclosure is hemispherical.

36. A prime mover comprising, in combination:

(a) a first internal combustion engine having a first drive shaft extending therethrough;

(b) a second internal combustion engine having a second drive shaft extending therethrough, said first and second shafts being arranged on a common axis and said second engine being capable of producing substantially equal power to that of said first engine; and

(c) a transmission arranged intermediate said first and second engines and connecting said first and second shafts, said transmission requiring that said first and second shafts rotate in opposite directions,

whereby said first and second engines operate in synchronism with their respective drive shafts rotating in opposite directions.

37. The prime mover defined in claim **36**, wherein said transmission requires that said first and second shafts rotate in opposite directions at the same speed.

* * * * *

US006270036B1

(12) United States Patent

Lowe, Jr.

(10) Patent No.: US 6,270,036 B1
(45) Date of Patent: Aug. 7, 2001

(54) BLOWN AIR LIFT GENERATING ROTATING AIRFOIL AIRCRAFT

(76) Inventor: **Charles S. Lowe, Jr.**, 2240 Berks Rd., Lansdale, PA (US) 19446

(*) 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.: **09/398,962**

(22) Filed: **Sep. 16, 1999**

Related U.S. Application Data

(63) Continuation-in-part of application No. 08/788,535, filed on Jan. 24, 1997, now Pat. No. 6,016,991.

(51) **Int. Cl.**[7] **B64C 15/00**; B64C 29/00
(52) **U.S. Cl.** .... **244/12.2**; 244/23 C
(58) **Field of Search** .... 244/12.2, 23 C, 244/23 R, 30, 29

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(57) ABSTRACT

A rotating airfoil aircraft utilizing blown air from a centrifugal fan located at its center to produce lift by causing airflow to travel over the upper surface of the airfoil and outwardly and downwardly from the lower surface of the airfoil. The airflow over the upper surface produces lift by causing a reduced pressure in the blown air current and the downwardly directed air produces an upward lift. This lifting force is used in connection with other lift produced by various factors including the airfoil traveling laterally through ambient air and, particularly during takeoff and landing, by means of the downward exhaust of an engine such as a jet engine. The rapidly rotating airfoil aircraft provides an advantage of providing the leading edge an opportunity to cool during a major portion of each rotation, thereby reducing the effective degree of leading edge heating caused during lateral flight.

17 Claims, 8 Drawing Sheets

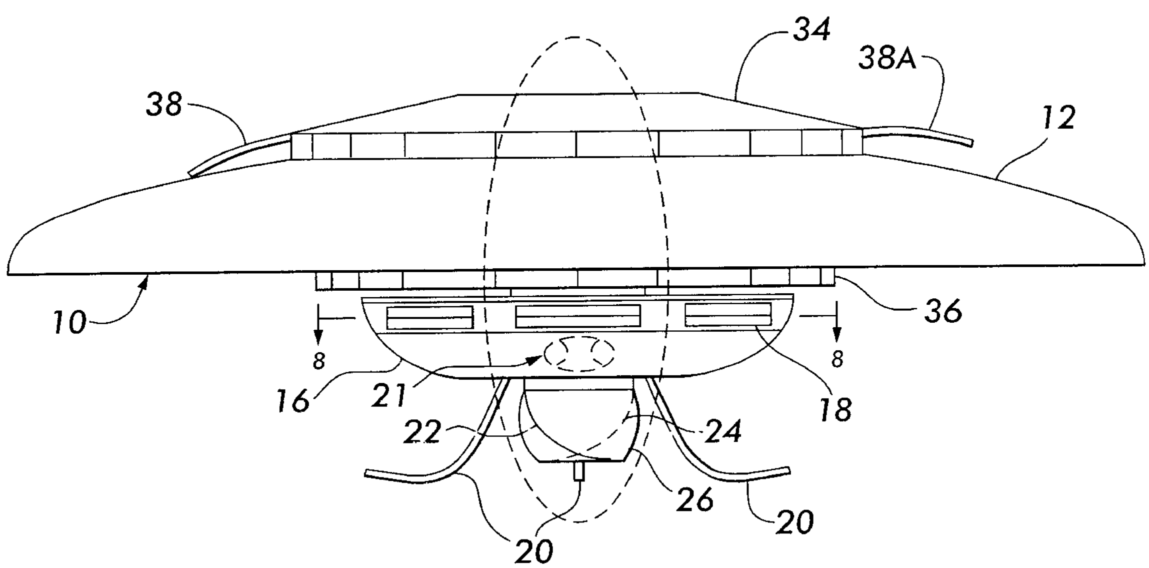


FIG. 1

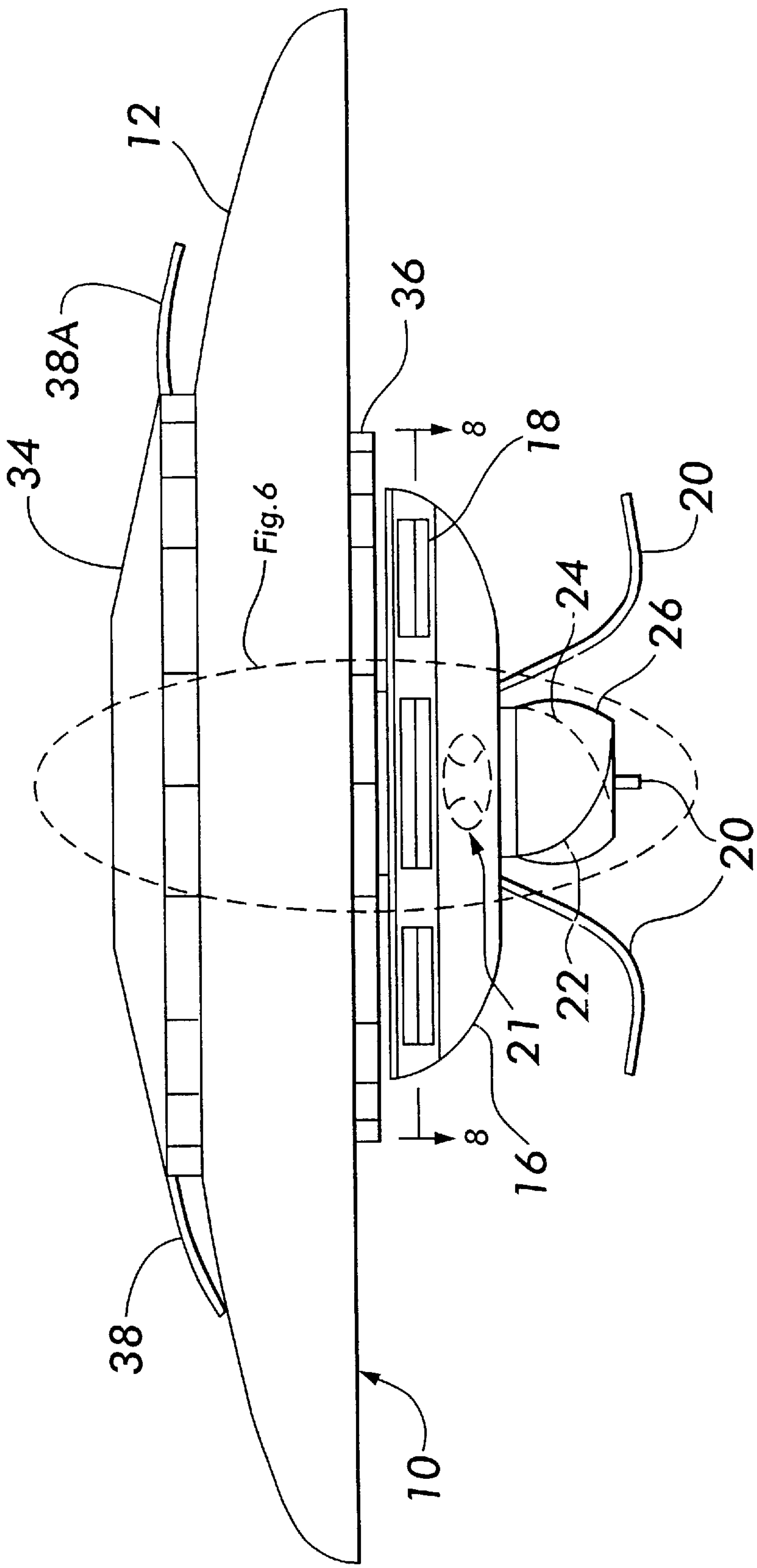
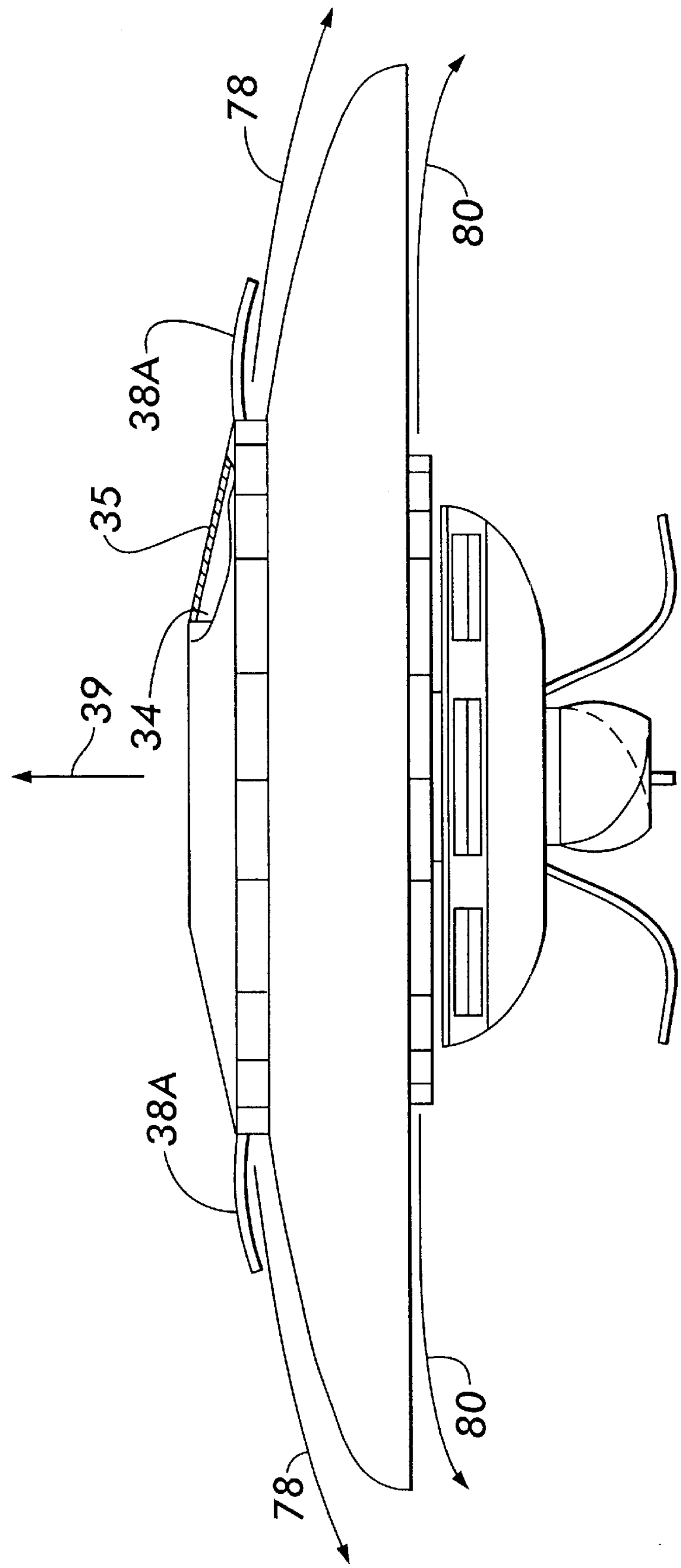


FIG.2



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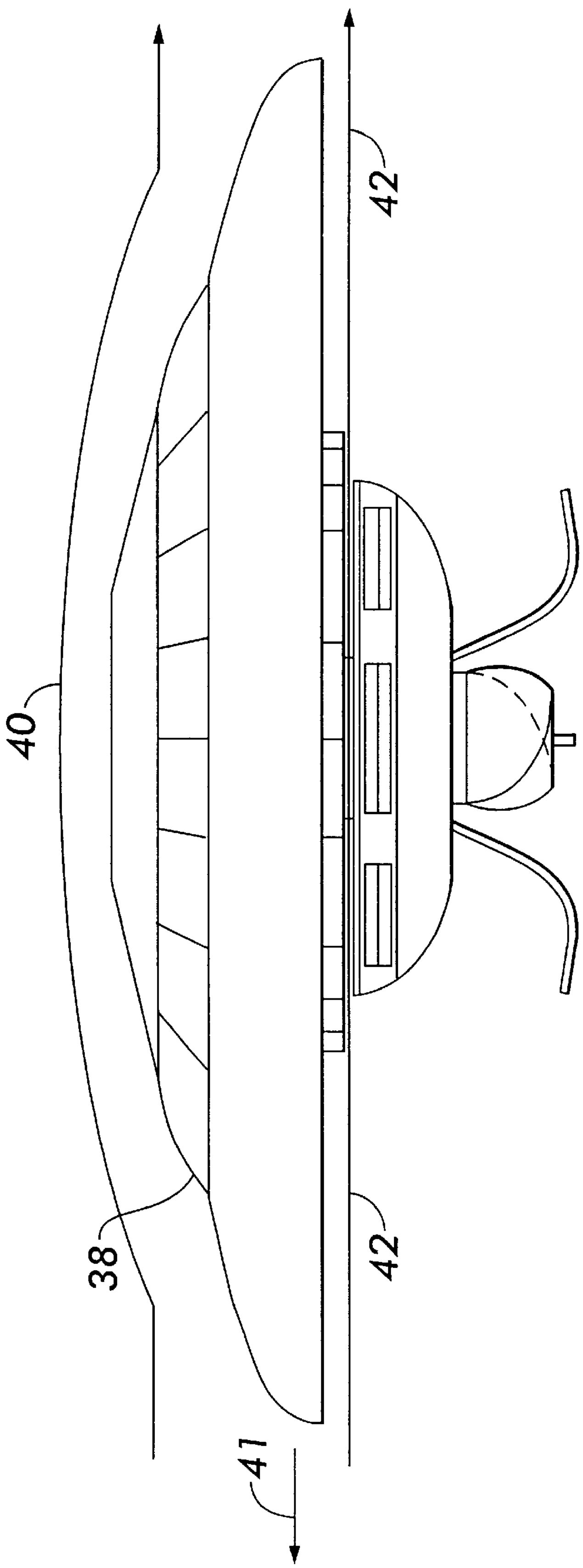


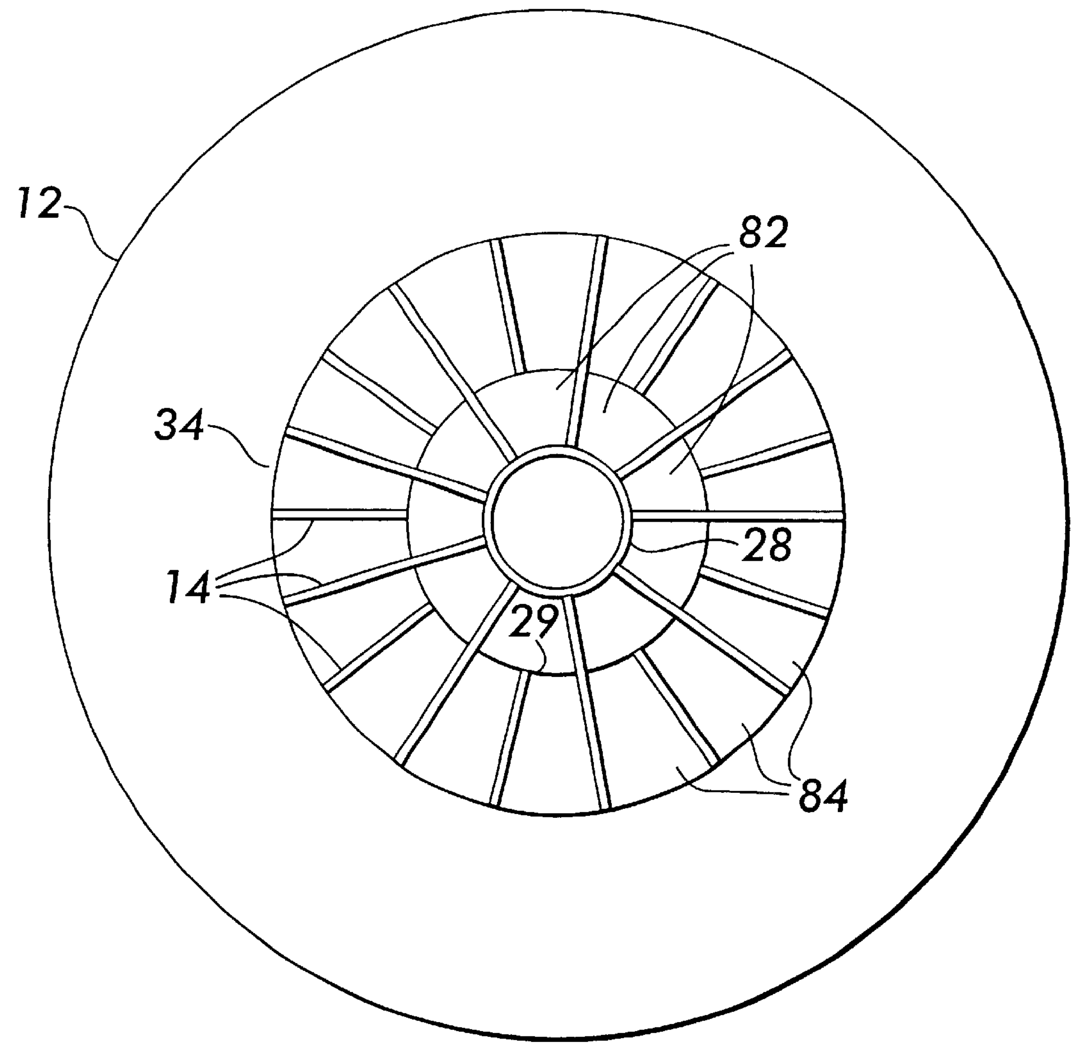


FIG.4

FIG.5

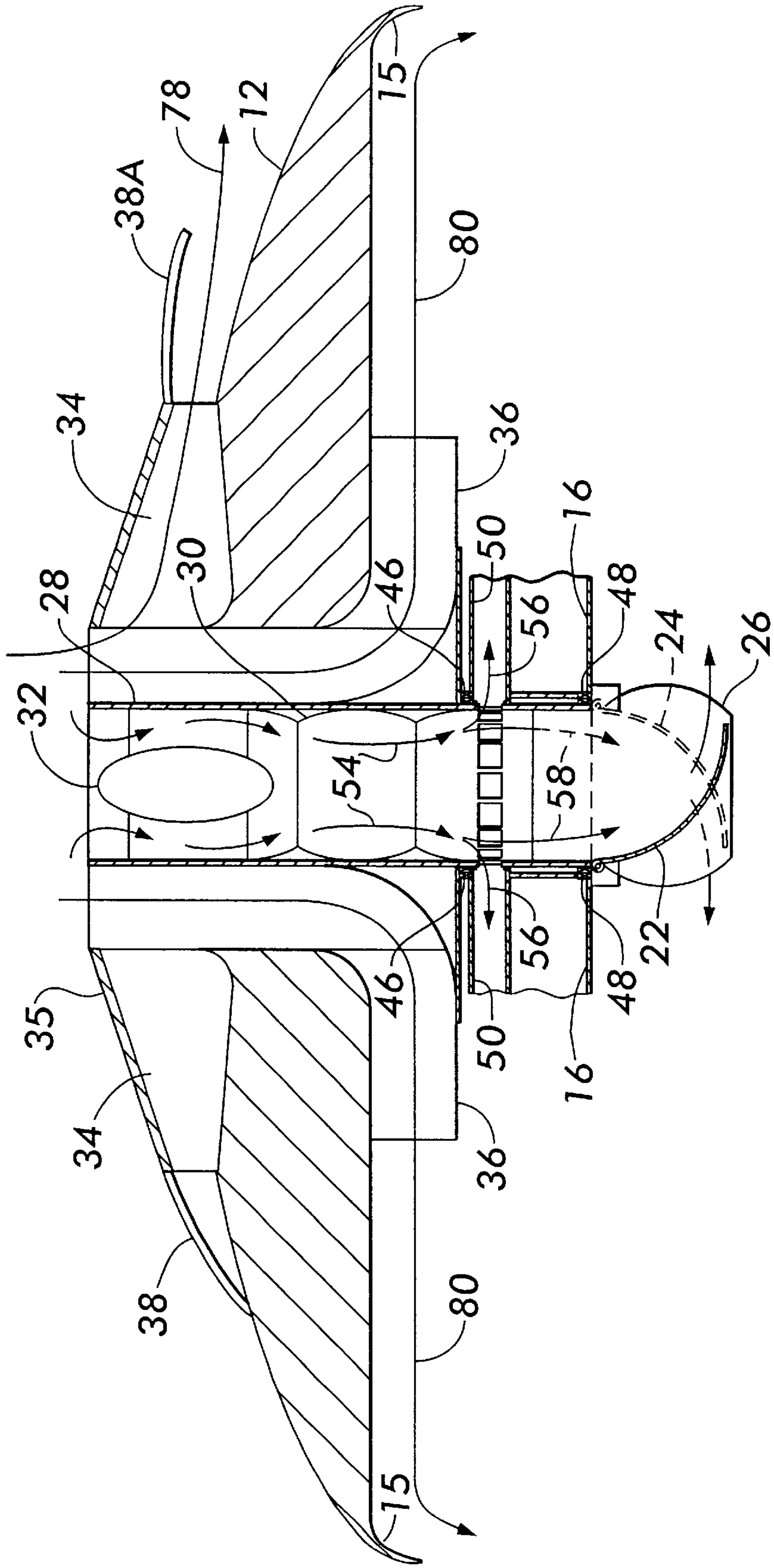
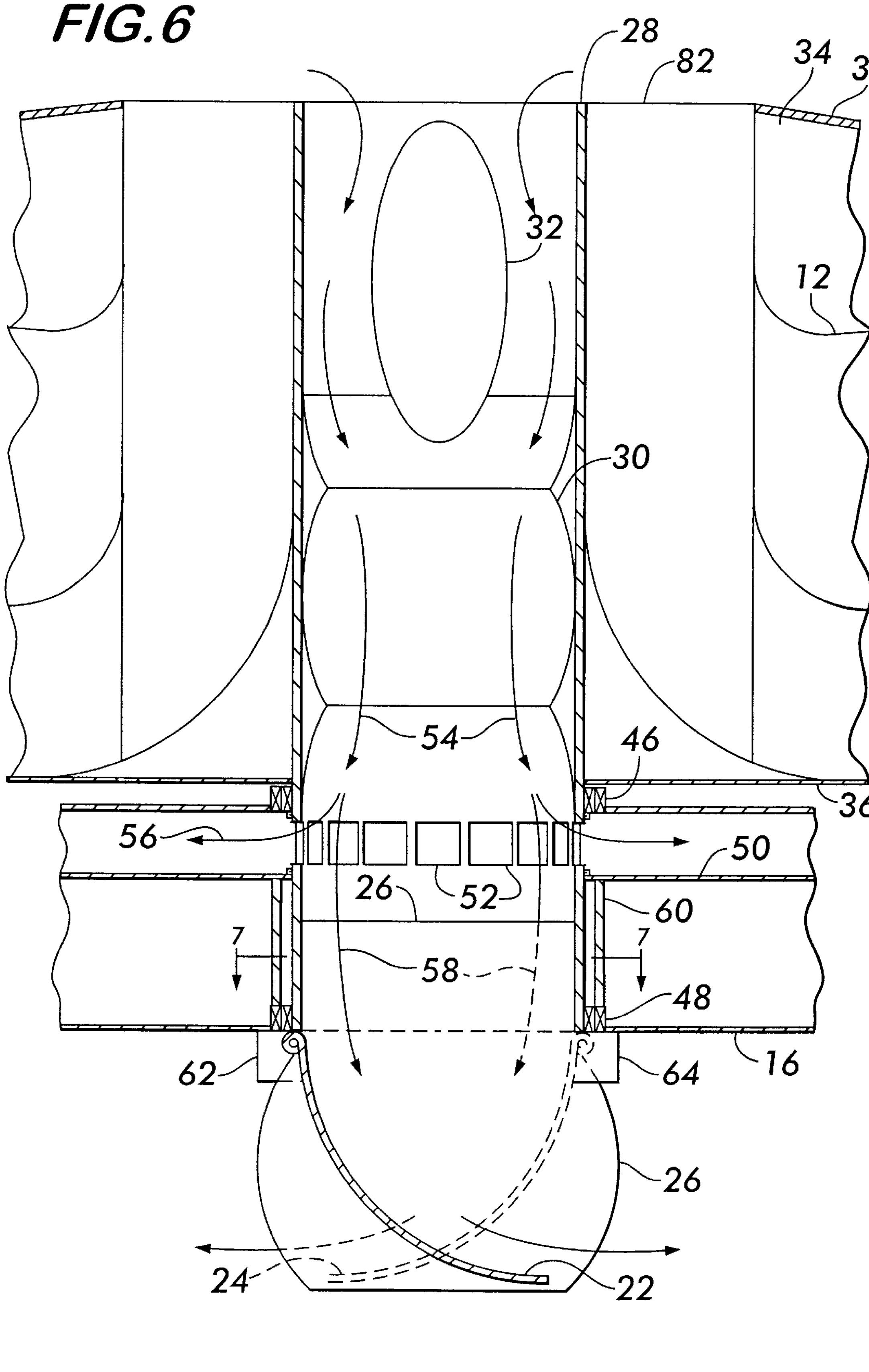


FIG. 6



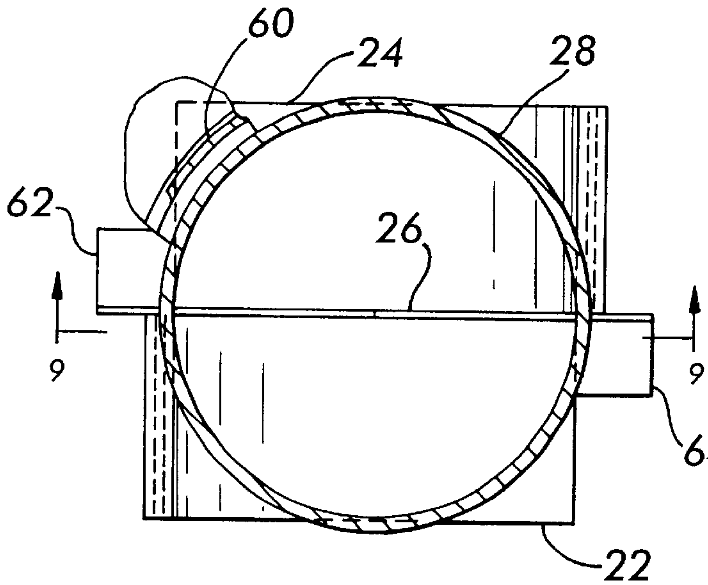


FIG. 7

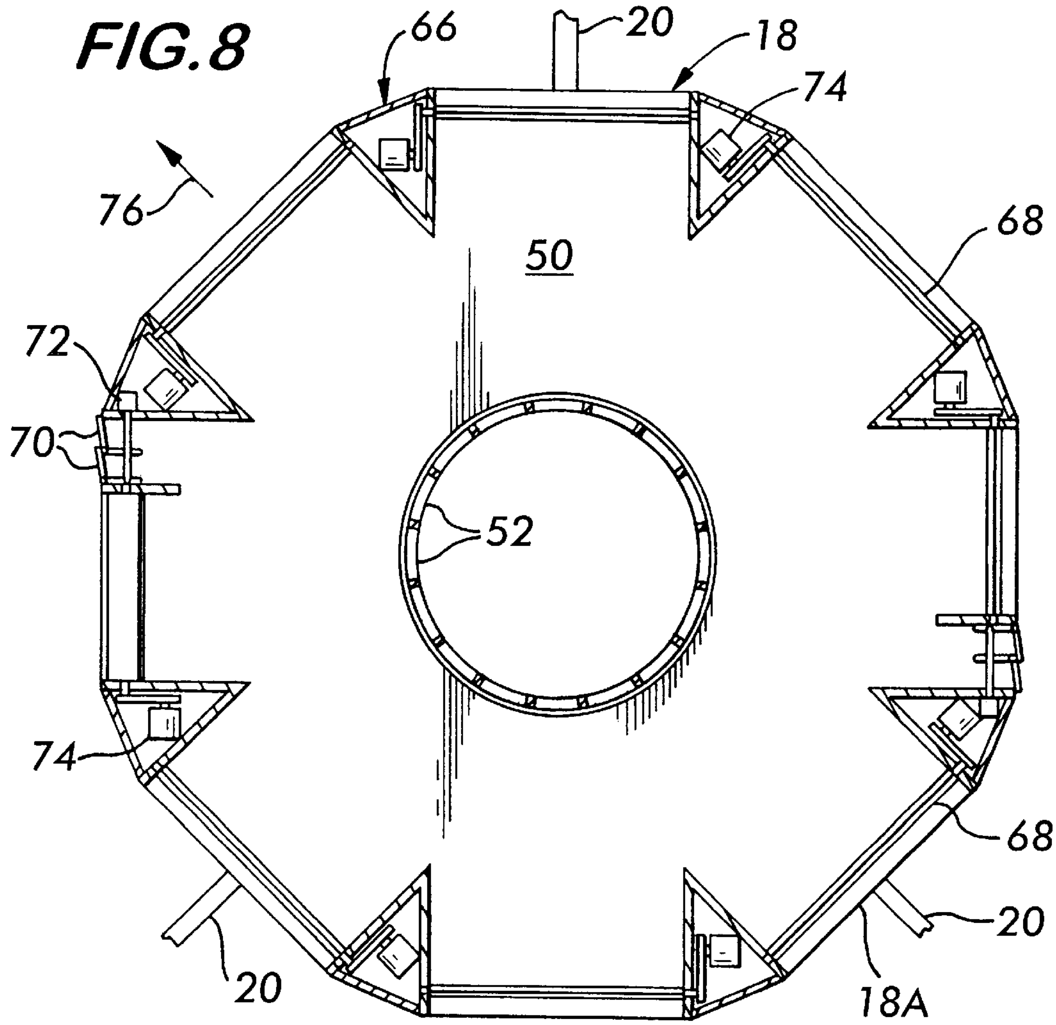


FIG. 8

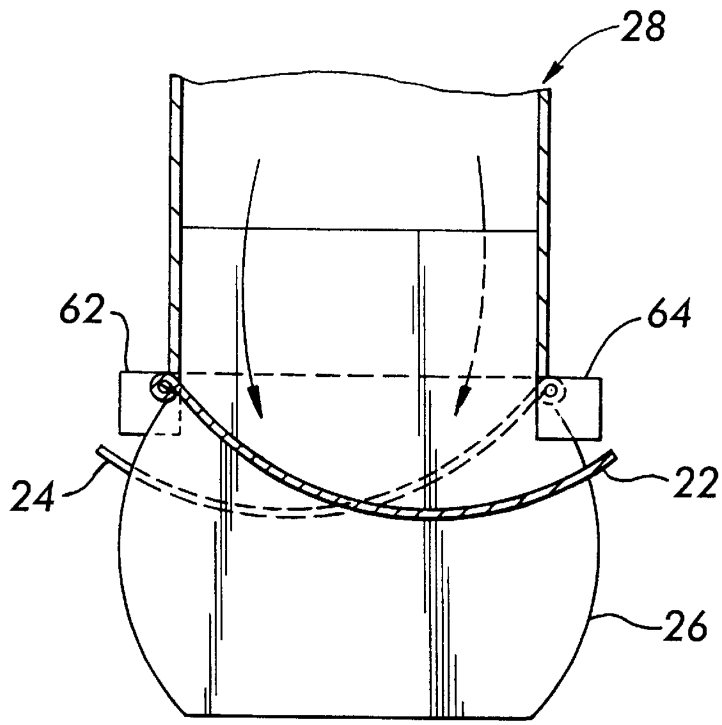
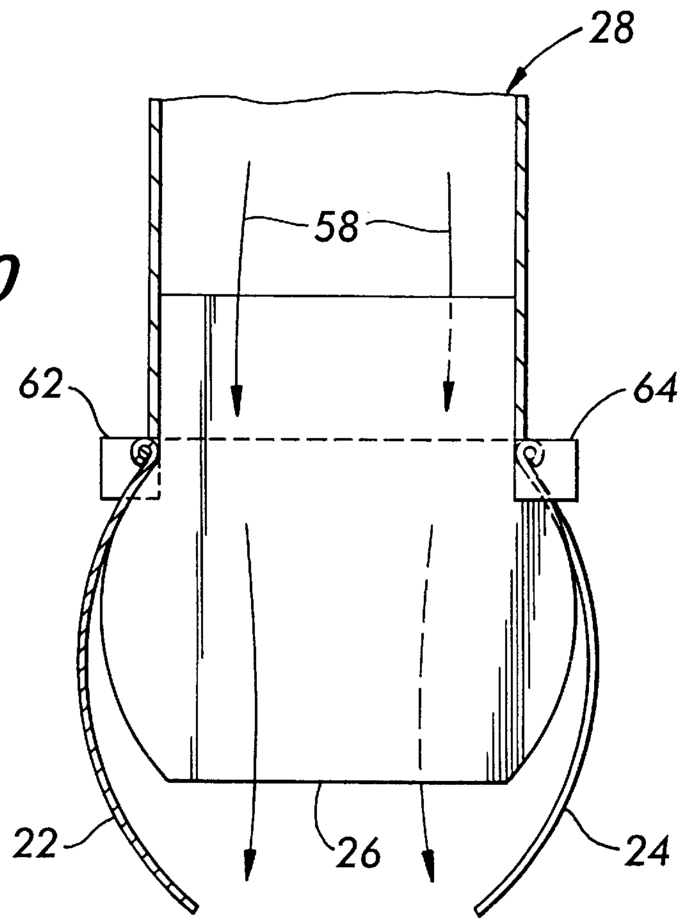


FIG. 9

FIG. 10



BLOWN AIR LIFT GENERATING ROTATING AIRFOIL AIRCRAFT

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part application of application Ser. No. 08/788,535, filed Jan. 24, 1997 by the inventor herein, entitled Evacuated Rotating Envelope Aircraft, now U.S. Pat. No. 6,016,991. The benefit of the earlier filing date of this application for so much as is common is claimed in this application. The teachings of the aforesaid application are incorporated herein by reference the same as if set forth at length.

FIELD OF INVENTION

The present invention relates to a new and unobvious type of a circular or round rotating airfoil aircraft and methods associated with enabling aircraft flight. More particularly, the present invention is directed to a new and unobvious aircraft which utilizes in flight an actively blown circular or round airfoil to produce vertical lift.

BACKGROUND OF THE INVENTION

Man has been able to cause powered aircraft to fly through the atmosphere since the early part of the Twentieth Century. Much work has been done and continues to be done in developing improved and more versatile aircraft.

The most commonly used type of aircraft today requires enormous landing strips for take off and landing. However, over the years, much work has been done in attempting to develop suitable, practical and improved vertical take off and landing (VTOL) aircraft. These have included helicopters as well as dirigibles, balloons and blimps.

Lighter-than-air- aircraft such as dirigibles and the like which utilize helium or other lighter-than-air gases have the disadvantage of not only the need to supply the lighter-than-air gas itself, the need to increase and decrease the volume of the gas for ascent and descent, the substantial structure, including its weight, for containing the lighter-than-air gas and the very large structure sizes required to house gases which are only somewhat lighter than air.

Helicopters are a much heavier-than-air aircraft requiring rotating propeller blade structures. Some attempt has also been made for providing vertical take off either by the means of propellers or rockets, sometimes mounted on wings which may be directed vertically for take off and horizontally for lateral flight.

However, none of these prior art devices nor any combination of them teaches or suggests a new class of aircraft as discussed and claimed herein.

SUMMARY OF THE INVENTION

The present invention creates a new category of aircraft or air transport vehicle. The present invention further includes new methods of achieving vertical take off and landing and flight in an economical, efficient and effective manner.

The present invention provides numerous advantages. An advantage of the present invention is that it provides an aircraft with vertical take off and landing (VTOL) capabilities thereby eliminating the need for enormous take off and landing runways. The VTOL capabilities of the present invention significantly reduce infrastructure requirements at ground-based air terminal facilities with consequent and substantial reductions in the environmental and economic impacts of such terminals, regardless of whether there are a small number of large terminal facilities or a large number of small terminal facilities.

Another advantage of the present invention is that its VTOL capabilities substantially improve the safety attributes of the aircraft as contrasted with most conventional aircraft since emergency landings may be safely conducted at vastly more locations.

Another advantage of the present invention is reduction in likelihood of sudden precipitous descent typically encountered by aircraft such as helicopters on the occurrence of a mechanical failure.

Another advantage of the present invention is that it provides an aircraft with a rotating airfoil that provides significant inertial stability to the total aircraft to resist outside disturbances and, therefore, provide a smooth flight.

Another advantage of the present invention is that it is able to provide such an aircraft constructed and operated as a light-weight vehicle by utilizing centrifugal force to provide structural rigidity to the rotating airfoil. This structural rigidity resulting from centrifugal force provides resistance to the external forces associated with airfoil lift and provides resistance to the external forces associated with aerodynamic pressure on the airfoil that occur when the aircraft is traveling in a lateral direction.

Another advantage of the present invention is the ability to provide control in flight utilizing both the lift of a blown rotating airfoil as well as the conventional lift provided by a conventional airfoil moving laterally depending upon the conditions of flight.

Another advantage of the present invention is that it provides an aircraft that is capable of both high speed, long distance, intercontinental operations as well as being a highly maneuverable VTOL aircraft thereby enabling a given volume of airspace to be safely occupied by a substantially larger number of aircraft.

Another advantage of the present invention is that it provides more efficient airspace utilization both at terminal locations as well as in areas between such terminal or airport locations thereby helping to reduce the growing problem of airspace congestion.

Another advantage of the present invention is that it provides an aircraft that is significantly more economical to manufacture and to operate and one that utilizes infrastructure and environmental resources much more efficiently.

Another advantage of the present invention is that it provides an aircraft that is significantly more fuel efficient thereby reducing the cost of air transport as well as reducing consequent chemical and noise pollution of the atmosphere.

Another advantage of the present invention is that aircraft based on the present invention may also incorporate the unique features, benefits and advantages provided by the invention entitled Evacuated Rotating Envelope Aircraft, of U.S. Pat. No. 6,016,991, particularly for larger aircraft.

Another advantage of the present invention is that it provides an aircraft that incorporates a rotating airfoil that provides the primary source of lift during lateral flight. The fact that this airfoil rotates provides an opportunity for cooling of the leading edge of the airfoil as portions of it rotate into and out of the area of maximum aerodynamic heating.

Briefly and basically, in accordance with the present invention, an aircraft is disclosed wherein vertical lift is provided by means of a blown rotating airfoil. In other words, in accordance with the present invention, air is caused to flow over a rotating airfoil producing reduced pressure above the airfoil and airflow is directed downwardly under the rotating airfoil, both producing an upward force or lift on the aircraft. The invention also contemplates employing the centrifugal force or inertial force of rotation of the rotating airfoil to augment the structural rigidity of the aircraft and to thereby improve its cost effectiveness. The terms centrifugal force and inertial force of rotation are used herein throughout interchangeably.

Further, in accordance with the present invention, the means for rotating the envelope is attached to the rotating airfoil and rotates with the airfoil. The means for rotating the envelope may be an engine (et, turbojet, turbofan or even turboprop), which provides sufficient force to rotate the airfoil against the force of air friction acting upon the external surfaces of the airfoil and to operate the centrifugal air fan(s) rotating with the airfoil.

Further, in accordance with the present invention, means such as exhaust baffles or deflectors are provided for dividing the output air exhaust of the central engine(s) into multiple flow streams with a purpose of creating a rotating torque force on the central engine(s) and the attached airfoil.

Further, in accordance with the present invention, the means for rotating is selected to provide rotation necessary to provide a sufficient centrifugal force on the material of the rotating airfoil whereby the need for and weight of mechanical support structures to withstand lifting forces and the forces produced by aerodynamic pressures on the airfoil may be reduced and/or minimized.

Further, the means for rotation of the envelope causes the envelope to rotate about an axis normal to the direction of lateral motion of the aircraft during flight thereby exposing the leading edges and surfaces of the airfoil to aerodynamic heating caused by contact with atmosphere during only a portion of each rotation of the airfoil. Rotation of the airfoil allows the heat to be dissipated as the heated portion of the airfoil rotates away from the leading edge position during each revolution.

Further, in accordance with the present invention, lift for the aircraft is also provided by lateral airfoil lift (Bernoulli effect principle) as produced by the wings on a conventional, commercial air plane, in contemporary use due to the lateral movement of the aircraft through the atmosphere.

Further, in accordance with the present invention, a payload compartment may be provided, mounted to said rotating airfoil by bearings whereby the rotating airfoil may be rotated without rotation of the payload compartment.

Further, in accordance with the present invention, the non-rotating payload compartment may be provided with lateral jets for enhancing the lateral motion of the aircraft during flight.

Further, other variations will be apparent to those skilled in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of illustrating the invention, there are shown in the drawings forms which are presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIG. **1** is an elevation view of the present invention illustrating major externally visible components.

FIG. **2** is an elevation view, partially broken away, of the present invention indicating air flow directions over and under the rotating airfoil without lateral motion of the aircraft.

FIG. **3** is an elevation view of the present invention indicating air flow directions over and under the airfoil during lateral motion.

FIG. **4** is a top view of the blown rotating airfoil with its top cover and exhaust covers removed.

FIG. **5** is a cross-sectional elevation view taken along a vertical plane through the center of the blown rotating airfoil and core tube area.

FIG. **6** is a cross-sectional broken away view taken along the dotted section line labeled FIG. **6** in FIG. **1**.

FIG. **7** is a cross-sectional view, partially broken away, taken along line **7**—**7** of FIG. **6**.

FIG. **8** is a cross-sectional view taken along line **8**—**8** of FIG. **1**.

FIG. **9** is a cross-sectional view taken along line **9**—**9** of FIG. **7** with the exhaust deflectors **22** and **24** shown in a substantially retracted position.

FIG. **10** is a cross-sectional view of the structure shown in FIG. **9** with exhaust deflectors **22** and **24** shown in the open position.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings in detail wherein like numerals indicate like elements, there is shown in FIG. **1** an aircraft **10** in accordance with the present invention. Aircraft **10** includes a circular or round airfoil **12** which is adapted to be rotated and, in a presently preferred embodiment, have air drawn from the ambient atmosphere blown across the upper surface of the airfoil by means of an upper centrifugal fan **34**. Lower centrifugal fan **36** forces air outwardly and downwardly under the airfoil. The airflow across the upper and lower surfaces of the airfoil may be generated by a single fan or blower, but preferably, these may be by two separate fans. Further, it is understood that any type of appropriate fan or other air moving device may be utilized to generate this airflow, but preferably a centrifugal fan would be utilized. Preferably, both upper centrifugal fan **34** and lower centrifugal fan **36** are attached to the airfoil **12** and rotate with it. The lower centrifugal fan **36** is optional, however it is included in the preferred embodiment shown in FIG. **1** and described herein. The air flow emanating from the upper fan **34** and traveling over the upper surface of the airfoil **12** is depicted by flow arrow **78** in FIG. **2**. Similarly, the air flow emanating from the lower fan **36** and traveling under the lower surface of the airfoil **12** is indicated by flow arrow **80** in FIG. **2**. These two air flow streams **78** and **80** act upon the airfoil **12** to create a lower-than-ambient air pressure over the top of the exposed airfoil and a higher-than-ambient air pressure under the bottom of the airfoil **12** thereby causing the airfoil to have net pressures on it in the upward direction. Additionally, the rotation of the airfoil **12** and the attached fans **34** and **36** causes the materials that these components are made of to encounter centrifugal force and this centrifugal force enhances or increases the structural rigidity of these components enabling them to be made of lighter weight materials than would otherwise be the case.

FIG. **1** indicates upper fan exhaust cover **38** in the closed position and upper fan exhaust cover **38A** in the open position. The exhaust covers are all actuated to be in the open position in those particular flight regimes when fan-driven air flow is required over the upper surface of the airfoil **12** to generate lift for the aircraft. Conversely, the upper fan exhaust covers **38** are all actuated to be in the closed position when the upper surface of the airfoil is being used to generate lift by moving laterally with respect to the ambient atmospheric environment.

Still most particularly referring to FIG. **1**, there is shown a non-rotating payload compartment **16**. Payload compartment **16** may carry people, weapons, goods or any other type of item needed to be transported by air. Although not shown, payload compartment **16** may be provided with windows or viewing ports. Preferably, payload compartment **16** may be equipped with an electronic external viewing system which may be more aerodynamically effective, efficient and economical. Also shown in FIG. **1** is a plurality of lateral motion jet ports **18**. These may be integrally formed as a part of the payload compartment or may be a separate structure above or below the payload compartment. As illustrated in the presently preferred embodiment, the lateral motion jet ports are formed integrally with the payload compartment.

In addition to the lateral motion jet ports **18**, payload compartment **16** may be equipped with one or more engines to provide additional lateral thrust thereby enhancing lateral velocity. One such engine is shown in dotted outline at **21**. This may be a jet engine or any other type of suitable engine. Additional such engines may be located around the payload compartment, preferably one being on each side or in each quadrant, but more or less may be utilized as desired. Further, these engines are optional.

Also shown in FIG. **1** is a plurality of light-weight landing gear **20**. Preferably, three such landing gear would be utilized, although any other suitable number may be utilized such as **4**, **5**, **6** or any other suitable number.

Also shown in FIG. **1** are moveable exhaust deflectors **22** and **24** along with an exhaust divider plate **26**. Exhaust deflector **24** is shown in dotted line because it is behind exhaust divider plate **26**.

Referring to FIG. **2**, the air flows passing outward over the top and bottom surfaces of the rotating airfoil that result from the actions of the upper and lower fans **34** and **36**, respectively, are depicted by flow arrows **78** and **80**, respectively, as described previously. Also shown in FIG. **2**, two of the plurality of upper fan exhaust covers **38**A are in the open position enabling the air outflow from the upper fan to blow or force air flow across the top surface of the airfoil and generate a lifting force in the direction of arrow **39** on this surface.

FIG. **3** indicates the air streams flowing over and under the airfoil **12** while it is moving at full speed in the lateral direction shown by arrow **41**. Flow arrow **40** indicates relative air flow over the top of the airfoil and flow arrow **42** indicates airflow under the bottom of the airfoil. These air flows are designed to produce lift in the airfoil of the present invention while it is in lateral motion relative to the ambient atmospheric environment in much the same way that a wing on a conventional commercial fixed-wing air plane produces lift.

Referring now to FIG. **4** where a top view of the blown air lift generating rotating airfoil is shown with the top cover **35** and the exhaust covers **38** of the upper fan **34** removed for clarity of illustration. The airfoil **12** and the upper fan **34** are shown as previously discussed. The fan blades **14** of the upper fan, a centrifugal type fan, are shown with half of them in this particular illustration being connected to the central core tube **28**. Between the central core tube **28** and the next larger concentric tube **29** are a plurality of air passage ways **82** that conduct outside air from above the aircraft into both the center area of upper fan **34**, and, via vertical air channels **82** into the central area of lower fan **36**. Lower fan **36**, also a centrifugal type fan, is organized in a very similar fashion. The dimensions of each fan, the shape and quantity of blades in each fan, and the quantities and dimensions of air passage ways are all subject to specific design for specific aircraft size and functional requirements and may vary from the general design indicated here in these areas of detail. The contents of the central core tube **28**, shown for example in FIGS. **5** and **6**, are not shown in FIG. **4** for clarity of illustration.

Referring now more particularly to FIG. **5**, this cross-sectional elevation view of the airfoil **12** and upper and lower fans **34** and **36** provides an understanding of how air is directed over the upper surface of the airfoil **12** by the upper fan **34** when the upper fan exhaust covers **38**A are open. This air flow **78** over the upper surface of the airfoil **12** generates a low pressure and a lifting force on the upper surface of the airfoil **12**. Similarly intake air for the lower fan **36** passes vertically down through air passages **82** in the center of the airfoil **12** where it is accelerated outward by the lower fan **36**. The exhaust air from the lower fan **36** passes outward horizontally until it meets the depending lip **15** at the periphery of the airfoil **12** where this airflow is then directed downward. The turning downward of the air stream moving outward over the lower surface of the airfoil **12** creates a lifting force in the lower surface of the airfoil **12**.

Referring now more particularly to FIG. **6**, taken in conjunction with FIGS. **1**, **5**, and **7**–**10**, there is shown a cross-sectional view through the center of the aircraft **10** showing the central core tube **28**, engine(s) **30** and other structure. Engine(s) **30** preferably may be a jet engine, a turbojet or turbofan engine, although any suitable engine such as a propeller engine may be feasible. Central core tube **28** has mounted therein a fuel tank **32** as the central core tube **28** is a convenient and stable location for such mounting. However, it is understood that other suitable locations may be utilized for the fuel tank, including an annular design located within the airfoil **12** or other suitable locations. Engine **30** is mounted to and rotates with the central core tube **28**, airfoil **12** and upper and lower fans **34** and **36**, that is they corotate. Continuing to refer to FIG. **6**, while simultaneously also referencing FIGS. **7** through **10**, as well as FIG. **1**, non-rotating payload compartment **16** is shown to be mounted on upper bearings **46** and lower bearings **48**. Payload compartment **16** may be provided with a wall **60** separating payload compartment **16** from central core tube **28**. The upper portion of payload compartment **16** may be provided with an air plenum **50** integrally formed as a part of non-rotating payload compartment **16**, or this plenum may be an independent non-rotating structure. However, in a presently preferred embodiment, air plenum **50** would integrally form a part of non-rotating payload compartment **16**.

Central core tube **28** is provided with a plurality of openings **52** which enable exhaust gases from engine **30**, as shown by arrows **54**, to exit into air plenum **50**, as shown by arrow **56**, as well as to continue directly downward through central core tube **28** as shown by arrows **58**.

The downwardly directed exhaust gases as shown by arrows **58** are divided by an exhaust divider plate **26**. Exhaust divider plate **26** divides the exhaust into two equal streams such that each stream may be deflected in a different direction from the other by means of moveable exhaust deflectors **22** and **24**. When movable exhaust deflectors **22** and **24** are positioned as shown in FIGS. **1** and **6**, central core tube **28** along with the airfoil **12**, as well as the attached upper and lower fans **34** and **36**, engine(s) **30** and fuel tank **32**, are caused to rotate. The exhaust gases deflected in this manner may cause high speed rotation. Further, the amount of the deflection and the degree of rotation may be controlled both by the exhaust gas flow rate and by the angle of exhaust deflectors **22** and **24**. Further, the opening of the exhaust deflectors in a manner similar to that shown in FIG. **10** allows the exhaust gases shown by arrows **58** to provide a substantial amount of vertical lift by the jet action of the exhaust gases' downward thrust, especially when the deflectors are open. The position of exhaust deflectors **22** and **24** may be controlled by suitable control means **62** and **64**, which may be any suitable type of control means including gears driven by an electric motor, pneumatic, hydraulic or any other suitable controllable drive means.

Exhaust deflectors **22** and **24** are shown in another position in FIG. **9** wherein, although rotation of the center core tube **28** is provided, the exhaust output is substantially obstructed to maximize the pressure and/or flow rate of these gases into the plenum **50** where these gases may then be used to provide lateral acceleration of the aircraft.

Referring now more particularly to FIG. **8** taken in conjunction with FIGS. **6** and **1**, the exhaust or air plenum **50** is shown with the openings **52** in central core tube **28** feeding exhaust into plenum **50**. The outer circumference **66** of air plenum **50** is provided with a plurality of lateral motion jet ports **18**, each of which is controllably opened or closed by a plurality of vanes **68**. As may best be seen in FIG. **1** in a presently preferred embodiment, two vanes would be utilized in each opening, however, it is understood that more or less vanes may be utilized depending upon the preference of the designer, and it is explicitly stated that a single vane could be utilized or it is contemplated that ten or more vanes could be utilized to controllably open and close each lateral motion jet port **18**.

In addition to the horizontally arranged controllable vanes **68**, a plurality of the lateral motion jet ports may be provided with controllable vanes **70** positioned in a vertical attitude to controllably direct the flow of exhaust gases in a direction counter to the direction of rotation of airfoil **12** thereby providing a counter-rotation or stabilization force to maintain plenum **50** as well as payload compartment **16** non-rotating. Vanes **70** compensate for the fact that bearings **46** and **48** are not perfectly frictionless. Vertical vanes **70** may be controllably operated by a suitable motor drive **72** and vanes **68** may be driven by a suitable controllable motor drive **74**. Both controllable motor drives **72** and **74** may be any suitable type of motor drive including electromechanical, electrical gear-driven, pneumatic, hydraulic or any other suitable drive to selectively control the position of the vanes.

The lateral motion jet ports provide a jet action to drive aircraft **10** in a particular direction. For example, if it were desired that aircraft **10** begin to move in the direction of arrow **76**, the vanes **68** of lateral motion jet port **18A** would be opened, preferably with all of the remaining vanes closed to prevent unwanted forces in other directions and to prevent aerodynamic drag. Of course, depending upon the amount of force needed to resist the rotation and overcome the friction of bearings **46** and **48**, vertical vanes **70**, are opened just sufficiently to overcome the friction of these bearings and to maintain the payload compartment, as well as plenum **50**, in a stable non-rotating condition.

The present invention illustrated in FIGS. **1** through **10** includes three means of lift or vertically upward directed acceleration.

First lift is generated by the air flows provided by the outputs of the upper and lower fans **34** and **36** as these air flows act on the upper and lower surfaces of the rotating airfoil **12** as may best be seen in FIG. **2** by the direction of the air flow arrows **78** and **80**. Air flow **78** moves outward from the upper fan **34** over the upper surface of the airfoil **12** and creates a lower-than-atmospheric air pressure over the top surface of the airfoil **12** as a result of air flow **78**. Air flow **80** moves outward from the lower fan **36** under the lower surface of the airfoil **12** until it meets the outer, downward extending lip **15** of the airfoil **12** where this air flow **80** is turned downward. Turning the mass of this air flow **80** downward creates a higher-than-atmospheric pressure under the lower surface of the airfoil. These two pressures acting on the upper and lower surfaces of the airfoil **12** create a lifting force in the airfoil.

A second means of lift is available when the aircraft **10** is moving laterally through the atmosphere. When the aircraft is moving laterally, the air flow path over the upper surface of airfoil **12** is longer than the air flow path over the lower surface of the airfoil resulting in higher velocity air movement and lower pressure over the upper surface as compared with the lower surface of the airfoil. This pressure difference provides an additional source of aerodynamic lift, sometimes referred to as air foil lift or lift in accordance with the Bernoulli effect principle.

Thirdly, the exhaust from the engines as described previously, in particular with FIG. **10**, provides an upward force due to the reaction of the downwardly directed exhaust gases.

The three sources of lift described above are not all necessarily used at the same time and in some cases all three are not available. For example, during start up operations and before the fans and airfoil have reached full rotational speed, full airfoil rotational lift is not available. Similarly, lateral airfoil lift is not available if the airfoil **12** is not in lateral motion with regard to the ambient atmospheric environment, such as during a perfectly vertical take off in still air.

Requirements for lift are also variable. For example, payloads and fuel loads are variable. Additionally, gravitational effects are reduced at higher altitudes thereby reducing lift requirements. Combinations of rotational airfoil lift and lateral air foil lift may be used for take offs that are not strictly vertical, but are accomplished in a relatively small area as compared to a conventional fixed wing aircraft. The present invention described with respect to FIGS. **1** through **10** may incorporate a comprehensive lift management control system that integrates and controls all lift sources and lift requirements at every instant of time.

Aircraft descent is primarily accomplished by reducing the lift of the aircraft and this is largely accomplished by reducing the rate of rotation of the airfoil and by reducing the rate of lateral motion with respect to the ambient atmosphere.

The fact that multiple, complementary sources of lift are incorporated in the present invention means that no one of them must be sized to accommodate all lift requirements. This may provide a significant improvement in efficiency and economy as compared to alternate aircraft lift approaches. Additionally, since the present invention incorporates multiple, complementary sources of lift, this built in redundancy factor adds to the safety margin of the vehicle. It is further noted that unique advantages in efficiency and economy are produced by the fact that one power source may serve all primary power needs of the aircraft, although some of these may be provided by other power sources, such as additional engines for redundancy. The four power requirements include:

1. Power to rotate the airfoil and its fans;
2. Power to be used as an extra source of vertical thrust for special situations (such as "popping" the aircraft off the ground during a take off operation);
3. Power for lateral motion jet ports to provide lateral acceleration and braking; and
4. Power to operate the payload compartment counter rotation jet ports.

The present invention of FIGS. **1** through **10**, if optimized for very high speed lateral motion, also offers significant benefits in the area of aerodynamic heating. A major component of the vehicle that impinges on the atmosphere is the airfoil **12** and this component rotates. Therefore, heat absorbed by each portion of the airfoil **12** while it is in the leading edge position is dissipated during the time that that portion is not in the leading edge position.

The present invention also provides substantial platform stability resulting from the gyroscopic action of the rotating envelope.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specifications as indicating the scope of the invention.

I claim:

1. An aircraft, comprising:

a circular shaped airfoil having an upper surface;

means for rotating said airfoil, wherein said means for rotating said airfoil includes an engine for causing gaseous fluid flow directed towards controllable deflectors, said controllable deflectors being adjustably adapted to cause selective amounts of rotation and lift; and

means for causing airflow across said upper surface of said airfoil to produce lift of said airfoil.

2. An aircraft in accordance with claim **1** wherein said airfoil is provided with a lower surface and including second means for causing airflow outwardly and downwardly from said lower surface to produce lift of said airfoil.

3. An aircraft in accordance with claim **2** wherein said second means includes a downwardly projecting lip on the periphery of said lower surface.

4. An aircraft in accordance with claim **1** wherein said means for causing airflow across said upper surface of said airfoil is attached to and adapted to rotate with said airfoil.

5. An aircraft in accordance with claim **2** wherein said second means for causing airflow outwardly and downwardly from said lower surface is attached to and adapted to rotate with said airfoil.

6. An aircraft in accordance with claim **1** including a plurality of lateral motion jet ports which are controllably openable and closable to selectively control at least a portion of the gaseous flow from said engine to provide a controllable lateral force to control lateral motion.

7. An aircraft in accordance with claim **1** wherein said circular shaped airfoil is caused to rotate during lateral flight to provide cooling of the leading edge of said airfoil in the direction of flight.

8. An aircraft, comprising:

a circular shaped airfoil having an upper surface and a lower surface;

means for rotating said airfoil, wherein said means for rotating said airfoil includes an engine for causing gaseous fluid flow directed towards controllable deflectors, said controllable deflectors being adjustably adapted to cause selective amounts of rotation and lift; and

means attached to and adapted to rotate with said airfoil for causing airflow across said upper surface of said airfoil and across and downwardly from said lower surface of said airfoil to produce lift of said airfoil.

9. An aircraft in accordance with claim **8** which includes a downwardly projecting lip on the periphery of said lower surface.

10. An aircraft in accordance with claim **8** including a plurality of lateral motion jet ports which are controllably openable and closable to selectively control at least a portion of the gaseous flow from said engine to provide a controllable lateral force to control lateral motion.

11. An aircraft in accordance with claim **8** wherein said circular shaped airfoil is caused to rotate during lateral flight to provide cooling of the leading edge of said airfoil in the direction of flight.

12. An aircraft, comprising:

a circular shaped airfoil having a convex upper surface;

means for rotating said airfoil;

a centrifugal fan centrally and integrally mounted to said circular shaped airfoil and extending above said upper surface of said circular shaped airfoil whereby said centrifugal fan rotates with said circular shaped airfoil;

said means for rotating said airfoil being integral with and rotating with said airfoil such that the rotating centrifugal fan extending above and integral to said convex upper surface causes airflow across said convex upper surface of said airfoil to produce lift of said airfoil.

13. An aircraft in accordance with claim **12**, including:

a second circular shaped airfoil provided with a substantially flat lower surface with a downward turned lip at its periphery;

a second centrifugal fan extending below and integral with said second circular airfoil wherein said second centrifugal fan rotates with said second circular shaped airfoil; and

wherein said second centrifugal fan integral with an extending below said lower surface of said second circular airfoil causes airflow across said lower surface and said downward turned lip of said second circular airfoil to produce lift of said airfoil.

14. An aircraft in accordance with claim **12**, including:

exhaust covers for said centrifugal fan, said exhaust covers being controllably openable and closable such that said exhaust covers may be open to increase lift and may be closed to enhance airflow over said circular shaped airfoil during lateral flight.

15. An aircraft in accordance with claim **12** wherein said means for rotating said airfoil includes an engine for causing gaseous flow directed towards controllable deflectors, said controllable deflectors being adjustably adapted to cause selected amounts of rotation and lift.

16. An aircraft in accordance with claim **15**, including:

a plurality of lateral motion jet ports which are controllably openable and closeable to selectively control at least a portion of the gaseous flow from said engine to provide a controllably lateral force to control lateral motion.

17. An aircraft in accordance with claim **12** wherein said circular shaped airfoil is caused to rotate during lateral flight to provide cooling of the leading edge of said airfoil in the direction of flight.

* * * * *

United States Patent [19]

Bose

[11] **Patent Number: 5,046,685**

[45] **Date of Patent: Sep. 10, 1991**

[54] **FIXED CIRCULAR WING AIRCRAFT**

[76] Inventor: **Phillip R. Bose,** 2088 Ahneita Dr., Pleasant Hill, Calif. 94523

[21] Appl. No.: **376,716**

[22] Filed: **Jul. 7, 1989**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 117,194, Nov. 3, 1987, abandoned.

[51] **Int. Cl.**[5] **B64C 29/00**

[52] **U.S. Cl.** .... **244/23 C**; 244/12.2; 244/2

[58] **Field of Search** .... 244/2, 12.2, 23 C, 73 R

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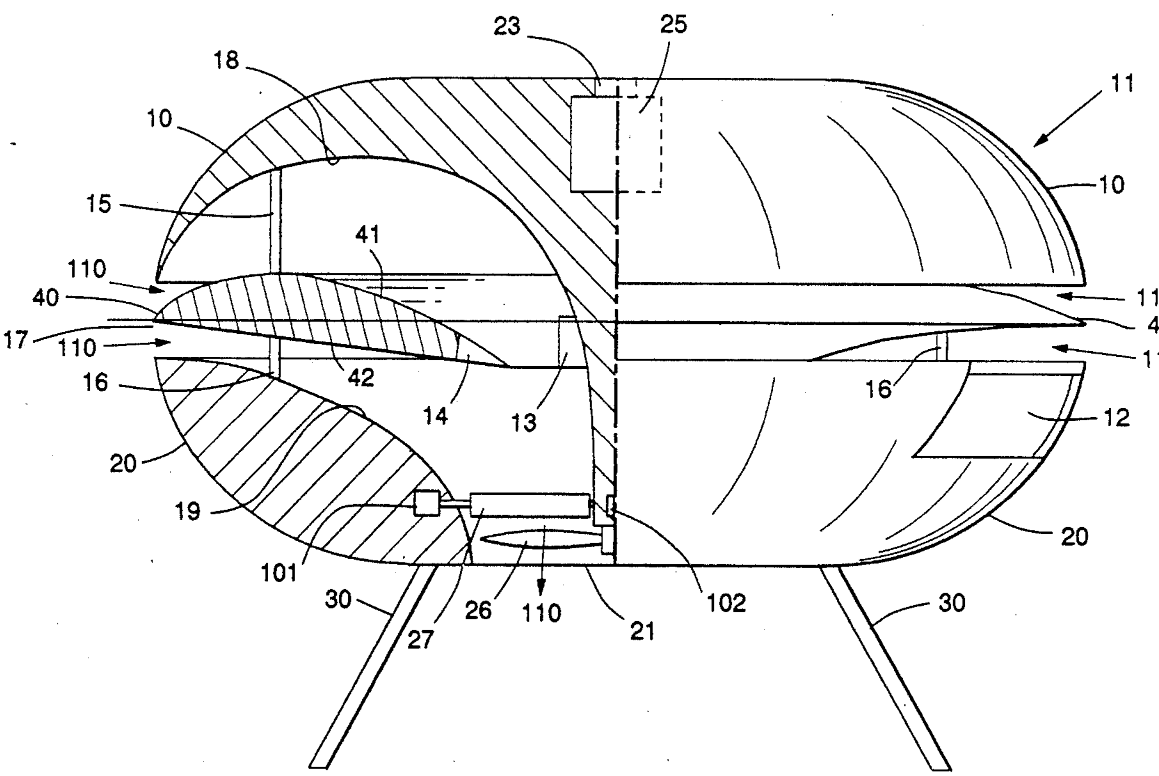
Primary Examiner—Joseph F. Peters, Jr.
Assistant Examiner—Anne E. Bidwell
Attorney, Agent, or Firm—Burns, Doane, Swecker & Mathis

[57] **ABSTRACT**

A heavier-than-air craft having a cylindrical external configuration comprising a single annular airfoil forming a circumferential lift wing. This fixed circular wing is surrounded by a circular fuselage of substantially the same diameter, closely spaced axially above and below the outer periphery of the annular airfoil, to allow radial air flow over and under substantially the full circumference of the airfoil. The radial air flow is induced through an axial opening in the center of one surface of the circular fuselage by an engine driven propeller, fan or jet effect.

19 Claims, 5 Drawing Sheets



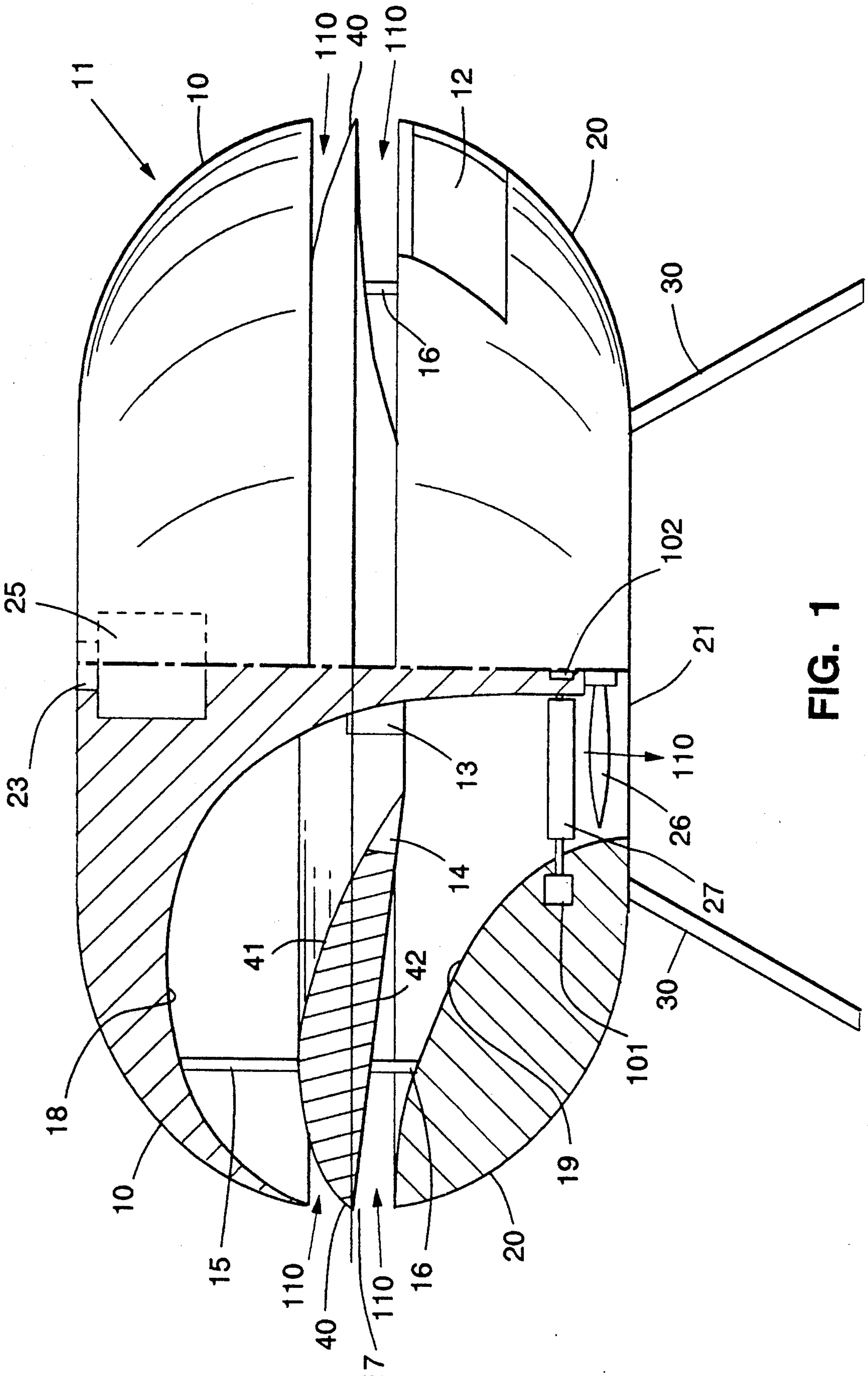


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FIG. 1

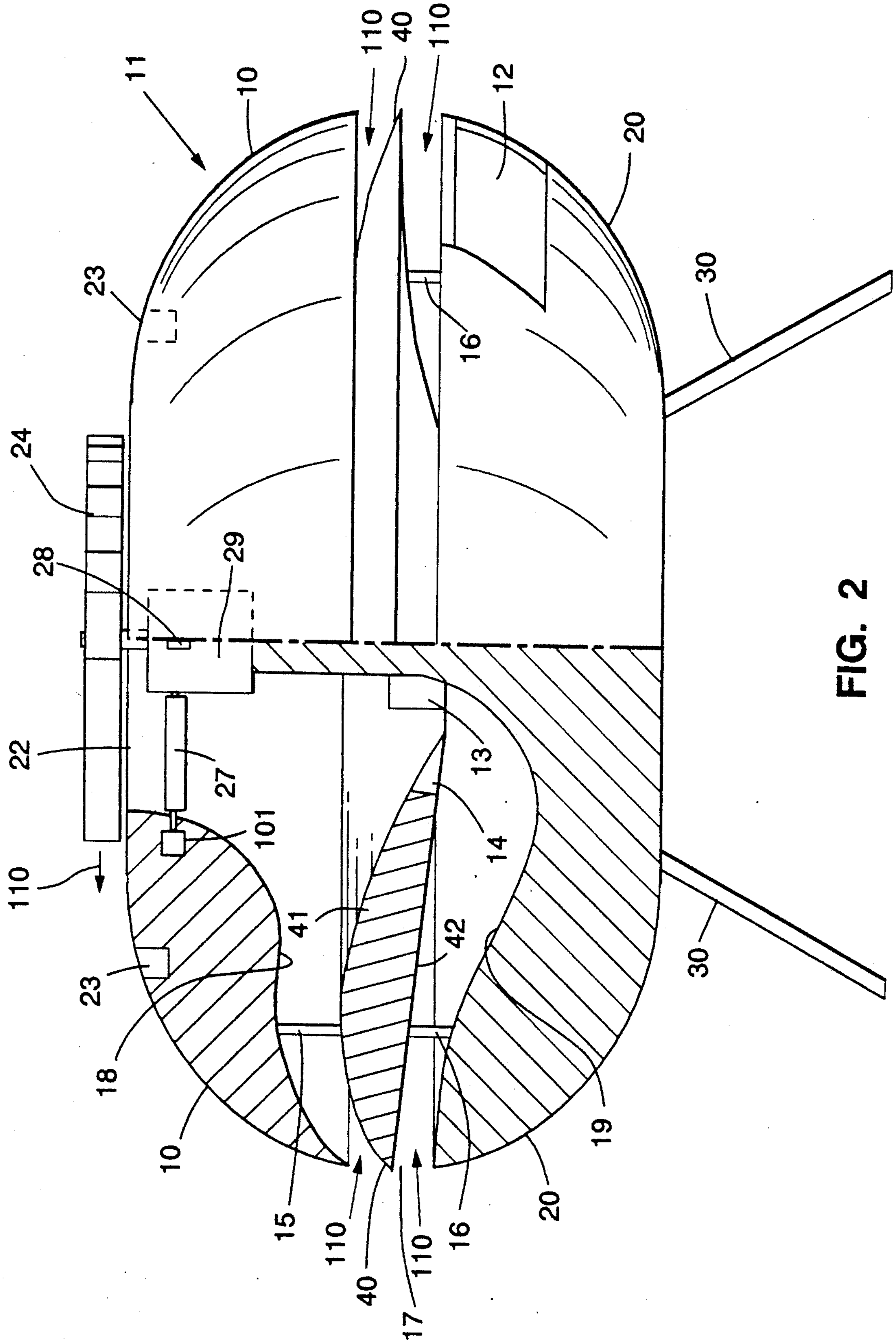
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FIG. 2

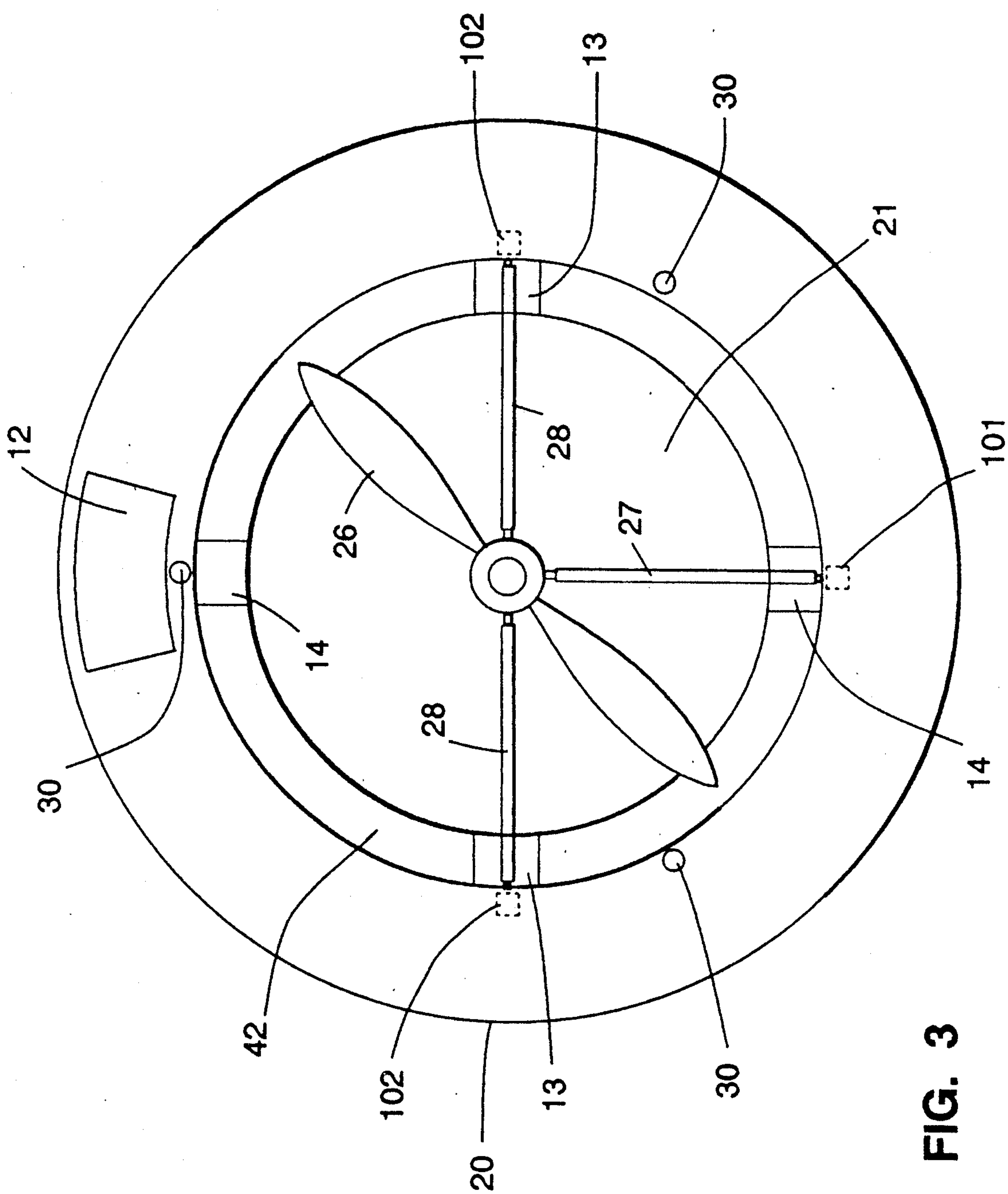

FIG. 3

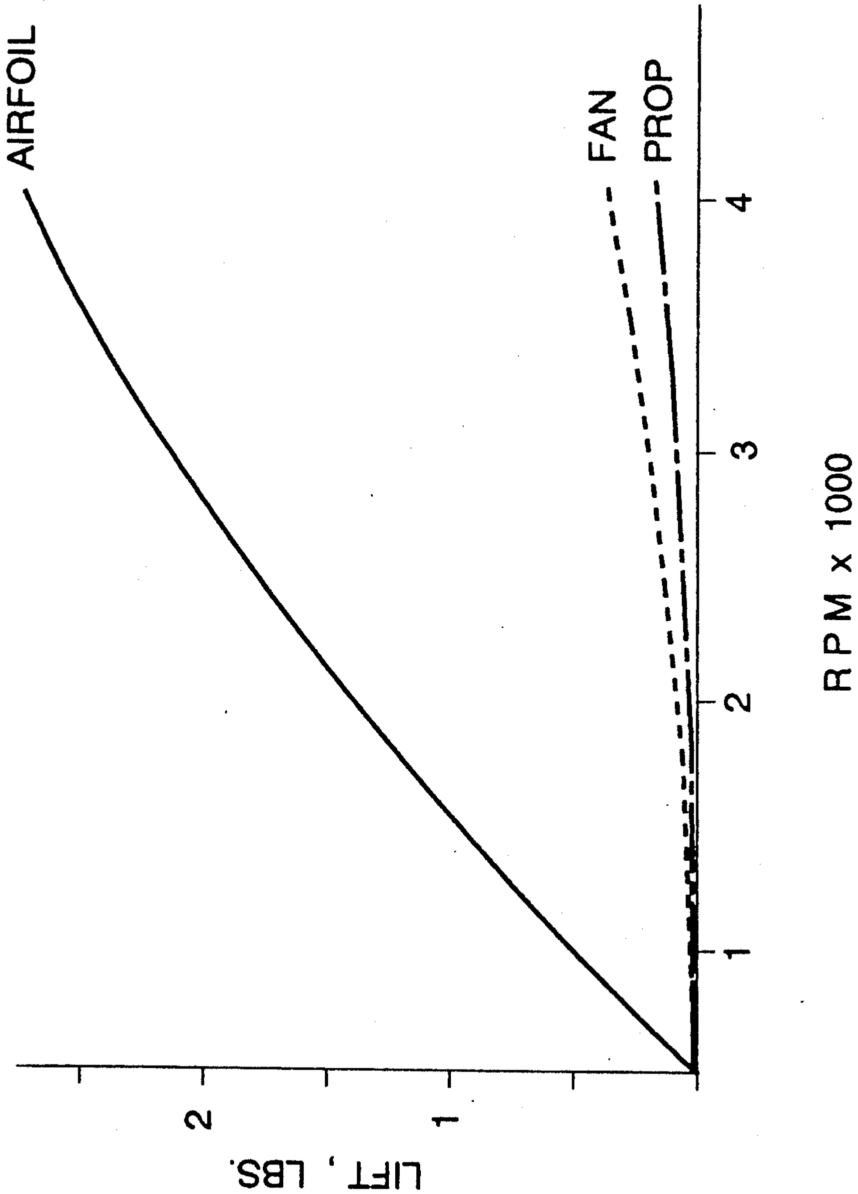

FIG. 4

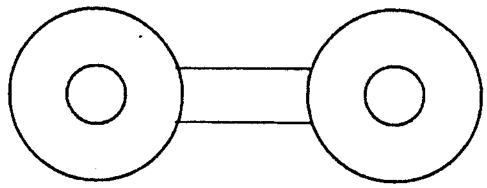

FIG. 5A

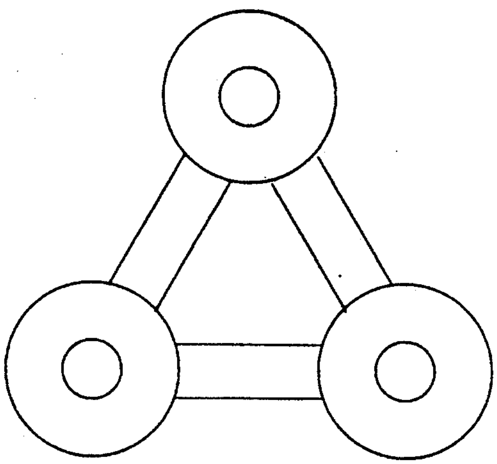

FIG. 5B

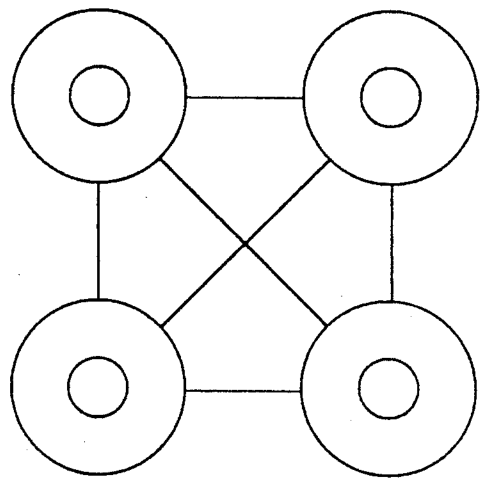

FIG. 5C

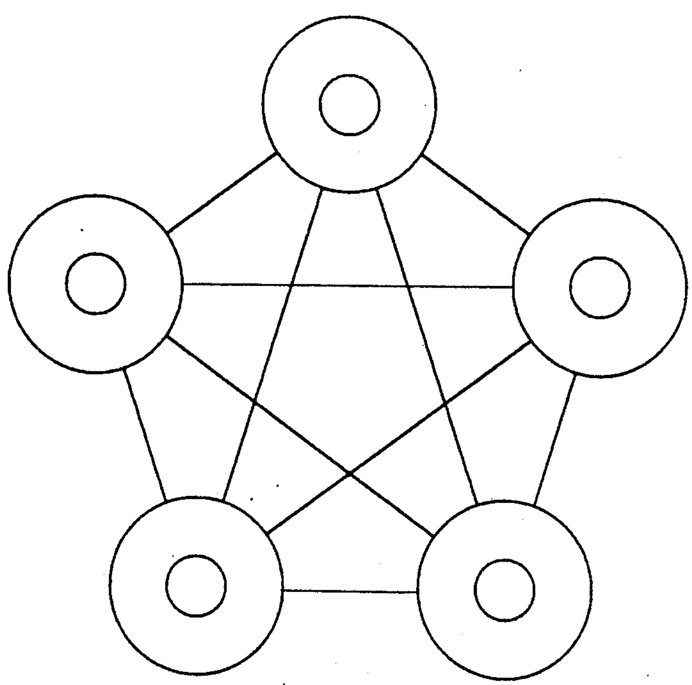

FIG. 5D

FIXED CIRCULAR WING AIRCRAFT

BACKGROUND OF THE INVENTION

This application is a continuation-in-part of my application Ser. No. 07/117,194 filed Nov. 3, 1987.

FIELD OF THE INVENTION

The present invention relates to vertical take-off and landing heavier-than-air aircraft. More particularly, it relates to helicopter type aircraft in which the lifting airfoil is stationary relative to the load and control-carrying fuselage. An annular wing member is stationary within an enclosing fuselage of substantially the same diameter and having a peripheral opening around the perimeter of the fuselage for air flow over and under the wing. The center portion of one of the fuselage covering surfaces is open so that a propeller, fan, or jet creates radial air flow either inwardly or outwardly over the annular wing to generate lift. Control surfaces, serving the purposes of conventional flaps, brakes, ailerons, elevators or rudders, cooperate between the internal fuselage and wing surfaces to control flight of the aircraft.

DESCRIPTION OF THE PRIOR ART

It has been the practice in circular wing aircraft to obtain lift by the resultant action of controlled downward jets of air created by rotation of the airfoil member to induce sufficient air flow to lift the aircraft or induce flow over airfoil contours, as assisted by fins, slots, valves and gates to create such lift. Such aircraft have used exhaust gases from gas turbines, compressors or propellers to induce air flow either inwardly or outwardly relative to the airfoil. Direct lift from lifting propellers has also been used. Such aircraft are maneuvered laterally and vertically by the uses of slots, vanes, controllable gates, baffles and fins.

Examples of conventional circular aircraft include the following:

U.S. Pat. No. 4,312,483—Bostram describes a rotating disc as a wing member primarily for flight stability. The peripheral, concentrated mass of the rotating disc provides no lift except in horizontal flight.

U.S. Pat. No. 4,044,972—Anker-Holth describes a circular winged aircraft with two concentric fixed airfoil wings separated by supporting walls. Ducted air flows over the top surface of a bottom airfoil for partial lift while the main lift is produced by lifting propellers. The ducted air is also used to maneuver the aircraft.

U.S. Pat. No. 3,572,613—Porter describes a hollow rotating circular wing with an upper central opening for air induction through spaced vanes to force air movement over an annular airfoil wing surface. A valving mechanism covers the vane ports for control.

U.S. Pat. No. 3,181,811—Maksim describes a helicopter type aircraft which obtains aerodynamic lift from helicopter type rotary blades increased by inducing air flow through concentric, stacked annular airfoils of decreasing diameter and a plurality of baffles to vary lift by the airfoils. These variable lift airfoils have adjustable pitch features. Also, slots are provided in the large diameter airfoil for additional control.

U.S. Pat. No. 3,041,009—Wharton describes an aircraft using a ring airfoil with a central opening and contra rotating fans located above the airfoil to discharge air down over the airfoil to provide lift. A canopy structure below the airfoil contains flaps which

open on engine failure to allow upwardly moving air to flow over the airfoil for descent control. Two adjustable control vanes function to eliminate aircraft rotation due to engine torque.

U.S. Pat. No. 2,468,786—Sharpe describes an aerodynamic impelling device which uses expanding gases from a gas turbine directed over stacked concentric circular airfoils of decreasing diameter to develop lift. No provision is made to control craft rotation caused by turbine engine torque or to meet the need for heat resistant airfoils.

In spite of a long history of circular aircraft with complicated mechanisms for control, none has taken advantage of operating the airfoil section in a regime of maximum lift-to-drag ratio along with the additional effect of the so-called, Coanda "wall effect." Such effect is induced by use of controlled space for fluid movement over and under the airfoil, to obtain high lifting forces for a given air flow over an enclosed stationary annular wing. Thus, the required vertical lifting force for flight is developed with substantially less power than that required to drive a conventional rotating airfoil or propeller. In this way, flow of relatively low volumes of air radially over the full circumference of an annular wing generates lift without need for forward flight of the airfoil.

SUMMARY OF THE INVENTION

In accordance with my invention, I have discovered that greater lift from a circular airfoil can be obtained by using a circular fuselage having approximately the same diameter as the fixed annular wing and having both a central opening and a circumferential opening in the enclosing fuselage to permit air flow both over and under the airfoil. A most particular advantage of fully enclosing the annular wing is in the ability to control flight characteristics of the aircraft without loss of lift at low speeds and under adverse external wind conditions acting on the lift surfaces of the aircraft. This discovery has been tested using different diameter models which demonstrate enhanced flight control. A configuration of this type greatly simplifies the aircraft structure and eliminates complicated valving mechanisms or dependence upon continuous integrity of a rotatable wing, as well as a rotary and counter-rotary support of the fuselage and power plant from the wing.

It is a particular object of the present invention to provide circular aircraft having a fixed circular wing and an enclosing fuselage with a circumferential opening and a central opening in at least one surface for radial air flow over the wing. Such aircraft is capable of hovering, horizontal flight, and lateral movement, as well as vertical take-off and landing, without complicated control mechanisms or dependence on rotary elements for continuous flight. A power source provides the energy to drive an air stream at a sufficient flow rate to make the aircraft operational and is located preferably at the center axis of the aircraft for balance. The few aircraft controls needed are similar to conventional wing design but they are internal of the airframe, and may form an integral part of the circular wing; however, if desired, some control elements may extend into the induced air stream from either the upper or lower portions of the fuselage.

The overall diameter of the aircraft depends on its usage, from a small diameter radio-controlled (R/C) recreational toy to drones, stationary platforms, aerial hoists, freight and passenger carrying craft. Dependent upon weight to strength limitations of the materials of construction, there are no theoretical limits to the craft's dimensions and lifting capacity.

Further objects and advantages of the present invention will become apparent from the following detailed description, with reference to the accompanying drawings which form an integral part of the specification.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical elevation view, partially in cross-section of an aircraft in accordance with the present invention, using bottom exhaust for the induced air flow.

FIG. 2 is a vertical elevation view, partially in cross-section of an aircraft in accordance with this present invention, using top exhaust for air flow.

FIG. 3 is a bottom plan view of the aircraft shown in FIG. 1 Aircraft.

FIG. 4 is a graphic representation of the relative contribution to lift (in pounds) from an airfoil of the present invention using a propeller, as compared to a propeller or a fan alone (in RPM).

FIGS. 5A to 5D schematically illustrate arrangements of multiple circular aircraft of the present invention joined together to form composite, multiple lift aircraft and respectively show as in FIG. 5A, dual, as in FIG. 5B, triangular, as in FIG. 5C, square or rectangular and as in FIG. 5D, pentagonal, arrangements of such aircraft.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows an aircraft in its simplest form in accordance with this invention. Top and bottom sections 10 and 20, respectively, comprise circular fuselage 11 and are axially spaced apart to form a peripheral opening 17 around the full circumference of fuselage 11. Circular fuselage 11 has substantially the same outer diameter as an annular, generally circular airfoil 40. A central axial opening 21 in lower section 20, around the fuselage's vertical axis, as in FIG. 1 or axial opening 23 in upper section 10, as in FIG. 2, permits air flow 110 to be induced radially along the chord of both upper surface 41 and lower surface 42 of airfoil 40 and from around substantially its full circumferential area. Such flow creates the required lift for flight of the aircraft at relatively low air velocities. These high lift forces, generated by relative low volume and low velocity air flow over airfoil 40, are believed to be due to the Coanda effect as noted above. However, whether or not such effect is generated, experimental results indicate that the generated lift is substantially greater than would be expected for the air flow quantity generated by the total output of the power plant generating such flow. Accordingly, it is the configuration of wing 40 as herein disclosed which generates such lifting power, without regard to how it is in fact created. For support on the ground aircraft 11 may include a landing gear 30 shown schematically as a tripod, in its extended, landing position.

High-lift, low velocity annular airfoil 40 which provides lift in this aircraft configuration, is suitably a modified NASA 4412 airfoil section built in a generally circular, annular shape. It contains ailerons 13 and stabilizers 14 which pivot relative to the trailing edge of airfoil 40, but at right angles to each other. These control surfaces are substantially identical so that their respective functions depend upon the direction of flight of circular airfoil 40 and aircraft fuselage 11. Ailerons 13 are pivotable about axes parallel to the line of flight to assist the aircraft to bank left or right. They may be connected such that as one moves up into the air flow, the other moves down to bank the aircraft, as in turning. Stabilizers 14 are likewise connected to pivot about axes perpendicular to the line of flight of the aircraft so that it can be maneuvered up or down in flight. Both can be operated to trim the aircraft while hovering, and as required in flight. Additional control surfaces may be added on larger type aircraft and may be pivotable either as a portion of the wing member or from the upper or lower fuselage sections to effect radial air flow over selected portions of the airfoil or wing.

Circular fuselage 11 comprising top and bottom sections 10 and 20, respectively, enclose generally circular airfoil 40. As shown, both top section 10 and bottom section 20 of circular fuselage 11 have substantially the same outer diameter as circular airfoil 40 and are axially spaced apart by spacers 15 and 16 to form peripheral opening 17 around the full circumference of fuselage 11. The axial width of opening 17 adjacent the outer circumference of airfoil 40 is preferably not greater than the total axial area for effective radial airflow between upper surface 41 and lower surfaces 42 of airfoil 40 and the respective inner surfaces 18 and 19 of top and bottom sections 10 and 20 of fuselage 11. Desirably, inner surface 18 is concavely curved relative to upper surface 41 so that air flow 110 generally expands in volume from intake opening 17, as it radially flows inwardly over a distance related to the curvature of upper surface 41. Similarly, inner surface 19 of bottom section 20 may be convexly curved to form an axially expanding space relative to the form of lower surface 42 of airfoil 40. Thus the generally expanding air flow area from peripheral opening 17 to central axial opening 21 is proportioned to the profile of curvature of airfoil 40. While not shown, if opening 17 is flared outwardly for air intake, the minimum axial area for such flow is at the leading edge of airfoil 40.

Upper and lower spacers 15 and 16, respectively, separate airfoil 40 from upper and lower fuselage sections, 10 and 20, and form required central peripheral opening 17. They also hold airfoil 40 in its necessary relationship to inner surfaces 18 and 19 within fuselage 11. Bolts (not shown) extend through fuselage 10, spacer 15, airfoil 40, spacer 16 and fuselage 20, to hold these parts firmly in the correct positions relative to each other. By locating spacers 15 and 16 circumferentially apart at intervals, lift generated by stationary airfoil 40 is transferred to fuselage 11. Definite relationships between the length of the spacers 15 and 16 and the curvature of airfoil surfaces 18 and 19 induce the desired Coanda effect by such radial air flow over selected portions, or the full, 360° circumferential surfaces of airfoil, or wing member, 40. During certain maneuvers, this ratio may be changed in flight to enhance control by adjusting such spacing or airfoil curvature mechanically, pneumatically or hydraulically. In normal flight, (takeoff, forward, reverse, hovering and landing) radial air movement 110 over airfoil surface 40 is maintained by propeller 26, driven by engine 25. As in conventional fixed wing, or rotary wing aircraft, the propeller may have fixed or variable pitch blades. Lateral movement of the aircraft may also be obtained by mounting movable vanes 27 and 28 to pivot at right angles to each other. Vane 27 is pivotable about an axis generally parallel to the line of flight and also may act as a rudder. Both vanes 27 and 28 are operable to control rotation of the aircraft against engine torque.

The forward and backward movement of the aircraft is by movable vane 28 mounted to pivot about an axis generally transverse to the line of flight. Additional vanes, similar to the slots of a Levolor blind, may be added, but for simplicity only a few are shown. Movable vane 27 is controlled as by actuator 101 in response to pilot command. Vane 28 has a similar actuator 102 that can be operated in unison with vane 27 as needed, or it can be operated separately. Although vanes 27 and 28 are separate from airfoil 40 they operate to alter air flow 110 through the fuselage in the same manner as those pivotally mounted o the wing.

In FIG. 1, air flow 110 is drawn radially inwardly through the perimeter opening between fuselage sections 10 and 20. Air is exhausted downwardly through central opening 21 in lower fuselage 20 after travelling over both the upper and lower surfaces of airfoil 40, as modified by control vanes 13, 14, 27 and 28. A pilot's compartment 12 is shown schematically as being located in lower fuselage 20.

FIG. 2 is similar to FIG. 1, except that air flow 110 is directed out of the top of central opening 22 in upper fuselage section 10 of the aircraft. A multi-blade radial fan 24 is driven by engine 29 in this configuration to produce air movement 110 with the attendant Coanda "wall effect" over the surfaces 41 and 42 of wing 40. Such Coanda force is effective at certain air velocities and is induced by the tendency of air flow 110 to travel close to the airfoil surfaces even though the curvature of surfaces 41 and 42 are several degrees away from the main axis of air flow across such surfaces. Thus in the arrangements shown, the generally radial air flow 110 over wing 40 even at low velocities creates the desired difference in air pressure between the upper and lower surfaces 41 and 42 to create lift of airfoil 40 and fuselage 11.

FIG. 3 is a bottom plan view of FIG. 1 and shows a suitable layout of control vanes 27, 28 as well as control surfaces 13 and 14 in more detail. Although only the pilot's area is shown, as at 12, other access openings and areas may be provided for fuel tanks, freight, passengers and general utilities in either or both fuselage sections 10 and 20.

FIG. 4 is a graphic representation of the lift that is produced by airfoil 40 as compared to the lift of propeller 26 or fan 24, alone. It will be seen that air flow created by application of power generated by an engine driven fan or propeller, or by a jet engine lift is developed over the full circumference of any given diameter of an annular wing aircraft, constructed in accordance with the present invention. Such lift substantially exceeds the lift power or thrust of a propeller or fan alone over the same range of propeller or fan speeds.

While not illustrated, it will be understood that lift and propulsion of aircraft of the same fuselage configuration may be generated by inverting the leading and trailing edges of annular wing member 40. That is, the leading edge may be at the central opening of the fuselage and the trailing edge adjacent circumferential opening 17 between the upper and lower sections of the fuselage. However, in general, lift of an airfoil is generated by approximately 30% of the chord (width) of the wing. For this reason, maximum lift is obtained with radial air flow from the perimeter to the open center of the air foil due to the greater length of such chord at the outer diameter of the annular wing.

In ultralight aircraft having a single engine, it is known to use parachute means deployable by pilot action for controlled descent. In the embodiment of FIG. 1, parachute means 23 provides such a capability. In larger aircraft, multiple engines may be selectively used to drive propeller 26 or fan 24 either singly or redundantly for low velocity descent.

As indicated in FIGS. 5A to 5D two or more fuselages 10 having fixed annular airfoils may be joined together to form a composite, multiple lift aircraft for increased lift capacity of the assembly. As required, such configuration may be a pair of dually joined fuselages 10, as in FIG. 5A, triangularly joined fuselages as in FIG. 5B; four fuselages joined as a square or rectangle as in FIG. 5C, or multiple fuselages may be joined in a poly-pointed configuration, such as the five fuselages, arranged in a star shape, as shown in FIG. 5D.

Various modifications and changes in the apparatus of the present invention will become apparent to those skilled in the art from the above-described embodiments. While the preferred embodiments have been described, it is intended to claim all such modifications falling within the true scope of the invention as defined by the following claims.

I claim:

1. A heavier-than-air aircraft having a generally circular external configuration comprising

a single annular airfoil forming a stationary circumferential lift member for said aircraft;

a circular fuselage having an upper section and a lower section of substantially the same diameter overlying and underlying the outer periphery of said annular airfoil,

said annular airfoil being affixed to each of said upper and lower sections of said circular fuselage at circumferentially spaced-apart locations to form axial openings in said fuselage above and below said annular airfoil and around the periphery thereof,

said axial openings above and below the periphery of said airfoil being not greater than the axial spacing along the radial chords of the upper and lower surfaces, respectively, of said annular airfoil from said overlying and underlying surfaces of said upper section and said lower section, respectively, of said fuselage for radial air flow through said fuselage over and under the full circumference of said annular airfoil;

said circular fuselage having a central opening formed in at least one surface thereof to permit air to flow through said fuselage between said central opening and the peripheral axial opening and radially over the upper and lower surfaces of said annular airfoil;

air drive means supported in a central portion of said fuselage member for generating an axial flow of air through the open inner circular area of said annular airfoil and said central opening in said fuselage to generate radial air flow over the circumference of the lift surfaces of said annular airfoil, and control surface

means pivotable relative to portions of the radial surface of said annular airfoil to modify radial air flow through said axial openings between said upper and lower sections of said fuselage and over said airfoil for directing the flight path of said aircraft.

2. A circular aircraft in accordance with claim 1 wherein said control surface means are within the diameter of said circular fuselage and pivotally connected to said annular airfoil to produce lateral, vertical, horizontal or hovering flight without external appendages to said circular fuselage of said aircraft and said control surface means are operable independently or collectively to control or enhance lift of said airfoil and additional control surface means within said axial opening operable to coordinate banking, load changes, wind gusts and maneuvering of said aircraft.

3. A circular aircraft in accordance with claim 1 wherein at least one of the surfaces of said stationary annular airfoil is variable in curvature to change air flow thereover to vary the lift to drag profile thereof.

4. A circular aircraft in accordance with claim 1 wherein said central opening in said circular fuselage is in said upper section thereof whereby air for flow over said annular airfoil is expelled from or drawn into said circular aircraft axially to the upper surface of said fuselage.

5. A circular aircraft in accordance with claim 1 wherein said central opening in said circular fuselage is in said lower section thereof whereby air for flow over said annular airfoil is expelled from or drawn into said circular aircraft axially to the lower surface of said fuselage.

6. A circular aircraft in accordance with claim 1 wherein said annular airfoil for producing lift and propulsion of said aircraft includes control means for selectively generating lift by radial air flow passing thereover either inwardly or outwardly with air exhaust being expelled either along the vertical axis of said fuselage or around said peripheral openings in said perimeter of said fuselage, said control means including moveable control surfaces cooperating with said annular airfoil to perform the functions of slats, flaps, air brakes, spoilers, ailerons, or air flow directors to control or enhance lift of said annular airfoil comparable to a conventional aircraft wing.

7. An aircraft wherein at least two fuselages in accordance with claim 1 are joined together to form a composite, multiple lift aircraft.

8. A composite, multiple lift, aircraft in accordance with claim 7 wherein a multiplicity of said annular airfoil aircraft in accordance with claim 1 are selectively joined to form a triangular, square or poly pointed configured composite aircraft of increased lifting capability.

9. A circular aircraft for vertical, horizontal or hovering flight, comprising

single an annular wing member affixed at circumferentially spaced apart locations to a circular fuselage member of substantially the same diameter as said wing member, said circular fuselage being axially spaced from both the upper and lower surfaces of said annular wing member to form a circumferentially open area above and below the outer periphery of said wing member,

said circumferential open area extending radially and circumferentially inwardly at an axial distance above and below said annular wing member not less than the respective axial distances above and below the outer periphery of said wing member,

a central open area in at least one surface of said fuselage member generally concentric with, and having a similar diameter to, the central open area of said annular wing member,

air propulsion means supported coaxially within said fuselage member, said propulsion means comprising power means for generating air flow, selected from the group consisting of propeller means, fan means and reactor gas means, adequate to create radial air flow through said circumferential open area and over said fixed annular wing member sufficient to lift said aircraft,

flight control means having surface areas movable relative to portions of said annular wing member to modify selected portions of said radial air flow through said cylindrical open area and over said wing member,

fuselage piloting means for controlling operation of said propulsion means and said flight control means,

said fuselage member including load carrying means for support of said flight control means and fuel for said propulsion means, and

said propulsion means producing adequate air flow simultaneously over said annular wing member and said control means to permit lateral, vertical, horizontal or hovering flight capabilities as well as normal or reverse propulsion of said aircraft by operation of said piloting means.

10. A circular aircraft in accordance with claim 9 wherein said surface areas of said flight control means are pivotally connected to said annular wing member to produce lateral, vertical, horizontal or hovering flight without external appendages to said circular fuselage of said aircraft and said flight control means are operable independently or collectively to control or enhance lift, and additional flight control means operable to coordinate banking, load changes, wind gusts and maneuvering of said aircraft.

11. A circular aircraft in accordance with claim 9 wherein at least one of the surfaces of said fixed annular wing member is variable in curvature to change air flow thereover to vary the lift to drag profile thereof.

12. A circular aircraft in accordance with claim 9 wherein said central open area in said circular fuselage is in the upper surface thereof whereby air for flow over said annular wing member is expelled from or drawn into said circular aircraft axially to the upper surface of said fuselage.

13. A circular aircraft in accordance with claim 9 wherein said central opening in said circular fuselage is in the lower surface thereof whereby air for flow over said annular wing member is expelled from or drawn into said circular aircraft axially to the lower surface of said fuselage.

14. A circular aircraft in accordance with claim 9 wherein said annular wing member and said air propulsion means for producing lift and propulsion of said aircraft include control means for selectively generating lift by radial air flow passing thereover either inwardly or outwardly with air exhaust being expelled either along the vertical axis of said fuselage or at said circumferential open area of said fuselage, and said flight control means includes moveable control surfaces cooperating with said annular wing member to perform the functions of slats, flaps, air brakes, spoilers, ailerons, or air flow directors to control or enhance lift of said annular wing member comparable to a conventional aircraft wing.

15. An aircraft wherein at least two fuselages in accordance with claim 9 are joined together to form a composite, multiple lift aircraft.

16. A composite multiple lift aircraft in accordance with claim **15** wherein a multiplicity of the fuselage said annular airfoil aircraft in accordance with claim **1** are selectively joined to form a triangular, square or poly pointed configured composite aircraft of increased lifting capability.

17. A helicopter-like aircraft comprising a circular fuselage including a generally circular overlying portion and a generally circular underlying portion, said portions being of substantially the same diameter and coaxially spaced apart from each other to form a cylindrical open volume within said fuselage,

the opposing surfaces of said portions extending outwardly from the axes thereof toward the peripheries of said portions and forming a circumferential opening in said fuselage around the periphery of said cylindrical volume, having an axial width not greater than the axial width of said cylindrical volume over its radial span,

one of said portions having a coaxial central opening therethrough for radial flow of air through said cylindrical volume, between said circumferential opening said central opening,

a single annular airfoil having a peripheral diameter not greater than the diameter of said portions and axially spaced therebetween so as form radial airflow passageways over and under said airfoil to generate lift for said aircraft,

the central portion of said annular airfoil having a diameter substantially the same as the diameter of said central opening in said one portion of said fuselage,

said circumferential axial opening and said central opening thereby substantially limiting airflow through said cylindrical volume to radial flow over said annular airfoil,

airflow generating means supported by said fuselage for pumping air generally coaxially through said central opening in said fuselage and said central portion of said airfoil to induce radial air flow over and under substantially the full circumference of said annular airfoil,

flight control surfaces within said cylindrical volume pivotable relative to portions of the radial surface of said annular airfoil for directing the flight of said aircraft, and

piloting means within the area of said circular fuselage for controlling said flight control surfaces and said airflow generating means.

18. An aircraft in accordance with claim **17** wherein the axial spacings of the overlying and underlying portions of said circular fuselage from said single annular airfoil increase toward the concentric axes of said fuselage and said airfoil.

19. An aircraft in accordance with claim **17** wherein the axial spacing thereof of said single airfoil from said overlying and underlying portions of said fuselage progressively decreases radially from the concentric axes toward the peripheries.

* * * * *

United States Patent [19]

Langley et al.

[11] **Patent Number: 5,054,713**

[45] **Date of Patent: Oct. 8, 1991**

[54] **CIRCULAR AIRPLANE**

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[21] Appl. No.: **332,489**

[22] Filed: **Apr. 3, 1989**

[51] **Int. Cl.**[5] **B64C 29/04**; B64C 29/02; B64C 29/00

[52] **U.S. Cl.** .... **244/12.2**; 244/23 C; 244/73 B; 244/73 C

[58] **Field of Search** .... 244/12.2, 23 C, 73 B, 244/73 C, 207

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Primary Examiner—Margaret A. Focarino
Assistant Examiner—James M. Kannofsky

[57] **ABSTRACT**

The invention is a circular airplane with an oblately spheroidal body which derives lift from a wall or ribbon jet exhausting over its upper surface. The jet is produced by a mixed flow fan driven by an internal combustion or gas turbine engine within the body. A fixed guide van assembly removes the swirl from the outlet flow of the mixed flow fan. The jet exiting from the fixed guide vane assembly follows the curved surface of the body, exhausting downward, and produces lift. The magnitude of lift produced in each quadrant of the airplane may be reduced for thrust vectoring by flow control gates which partially block the flow of air from the fixed guide vane assembly. Rotation control vanes introduce a controlled swirl into the flow of air from the fixed guide vane assembly to effect rotation of the airplane. Actuators for flow control gates and rotation control vanes, and a flight control system, are provided.

19 Claims, 4 Drawing Sheets

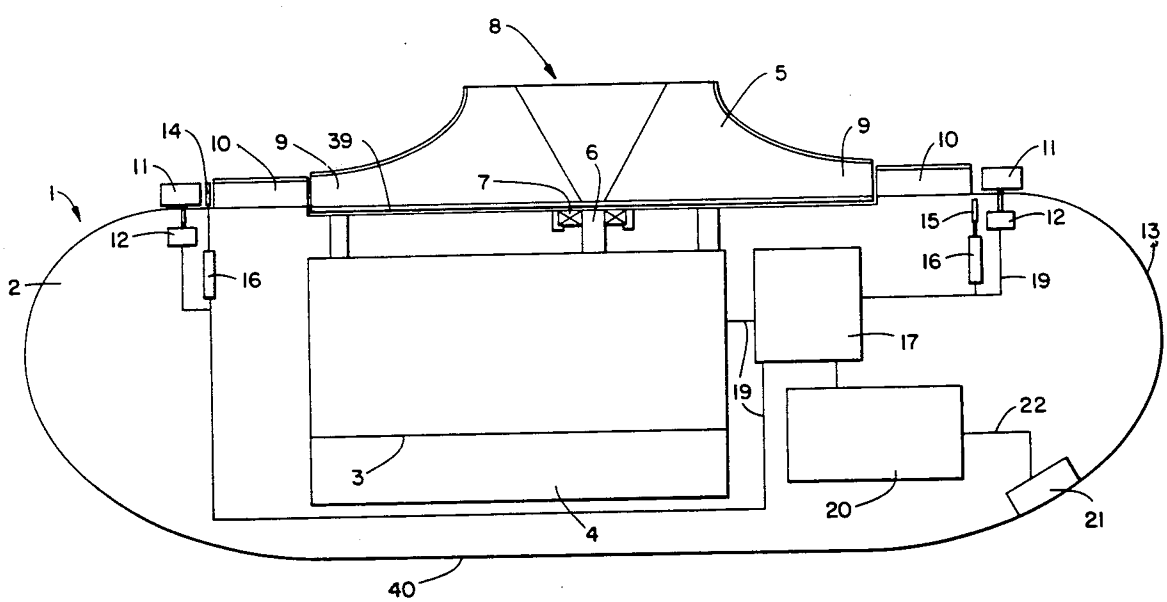


FIG. 1

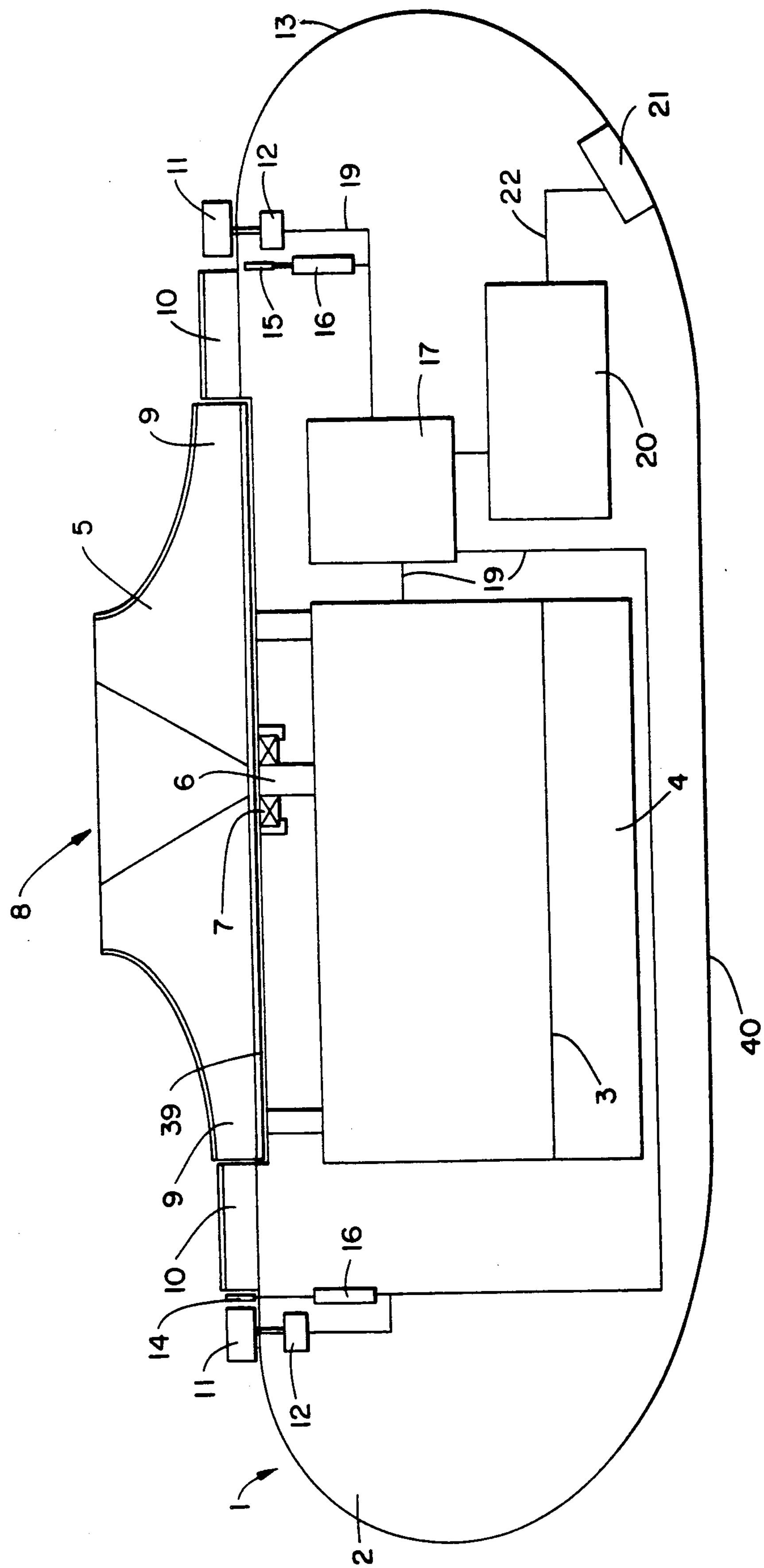


FIG. 2

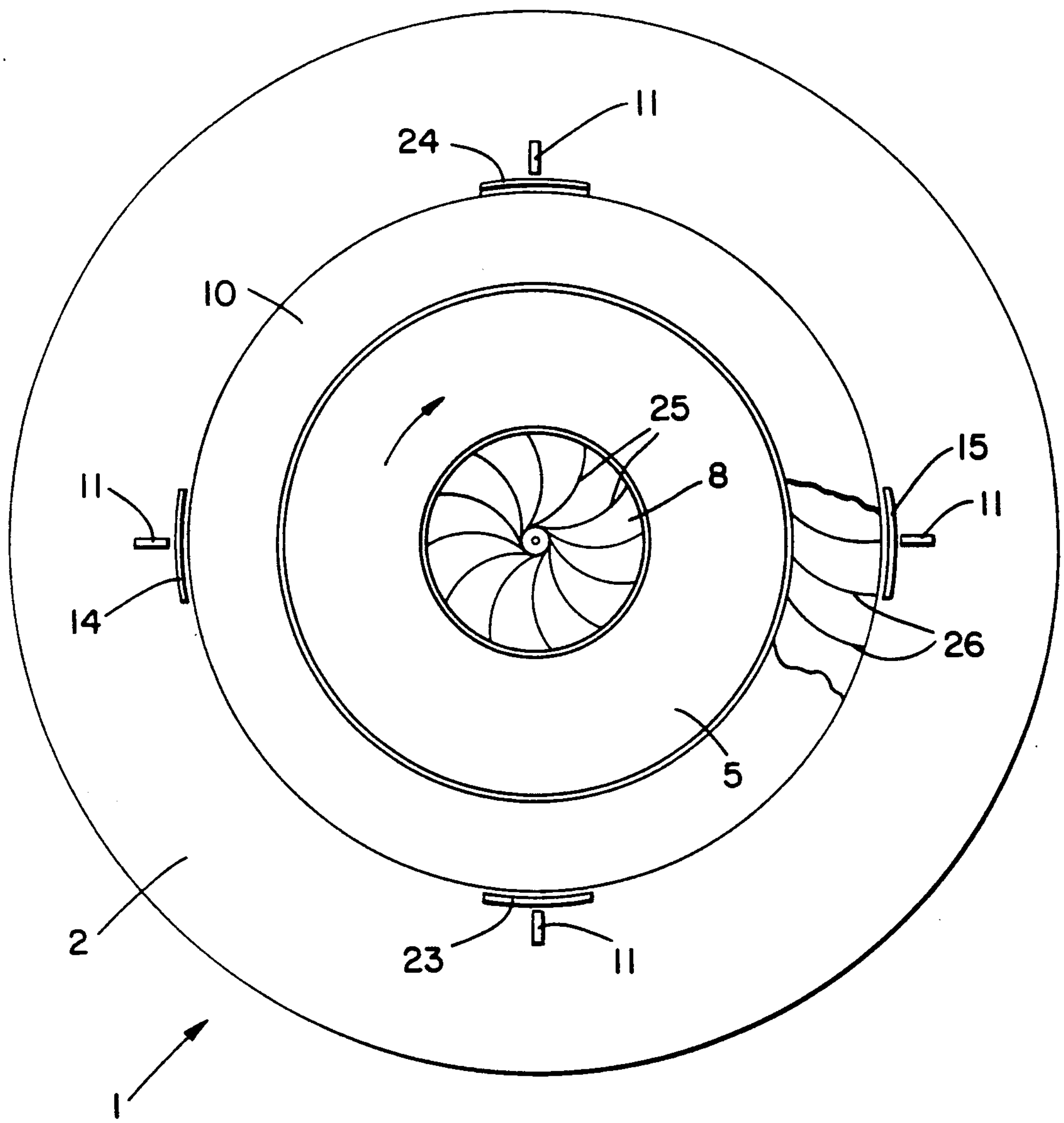


FIG. 3

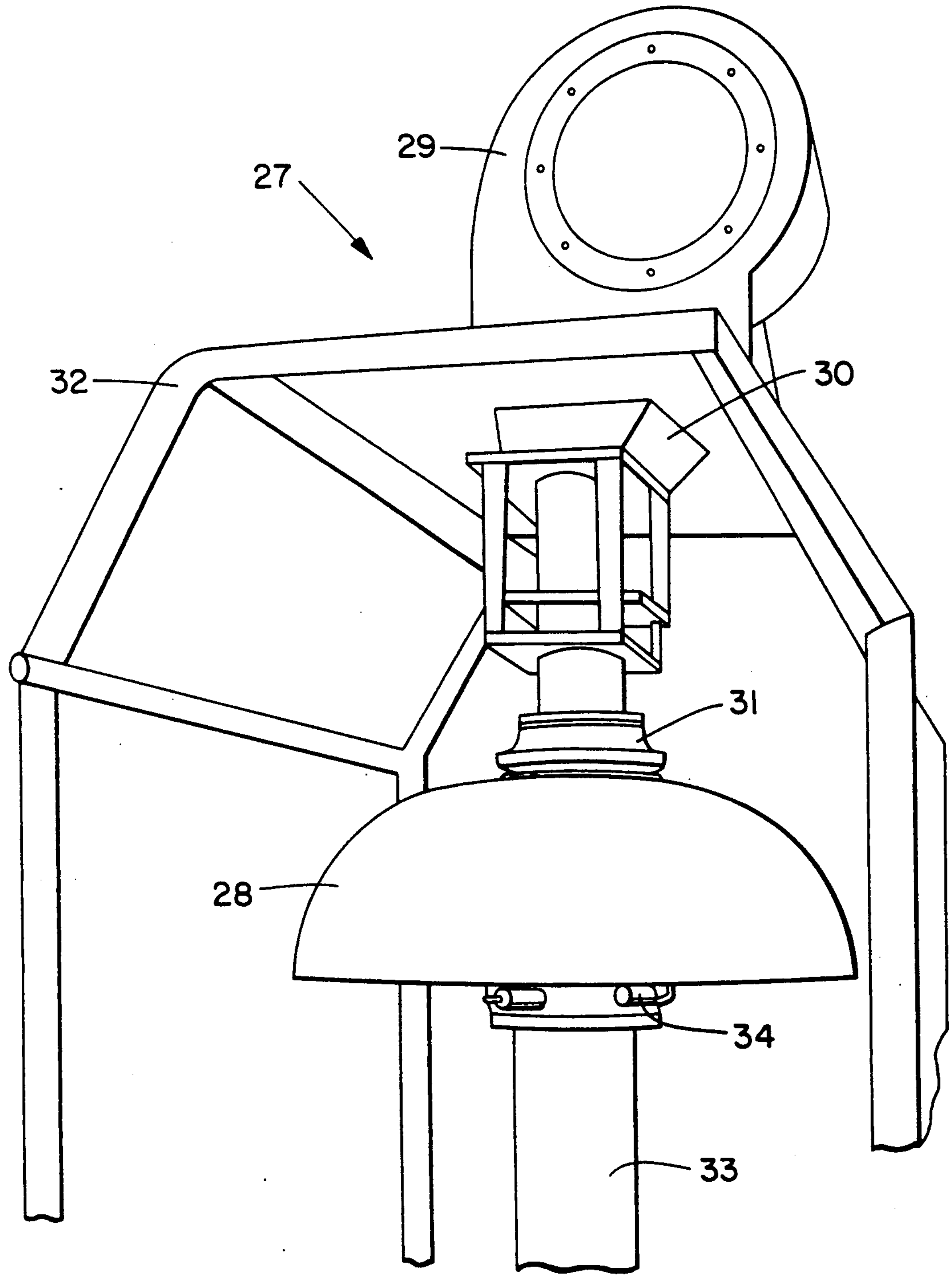
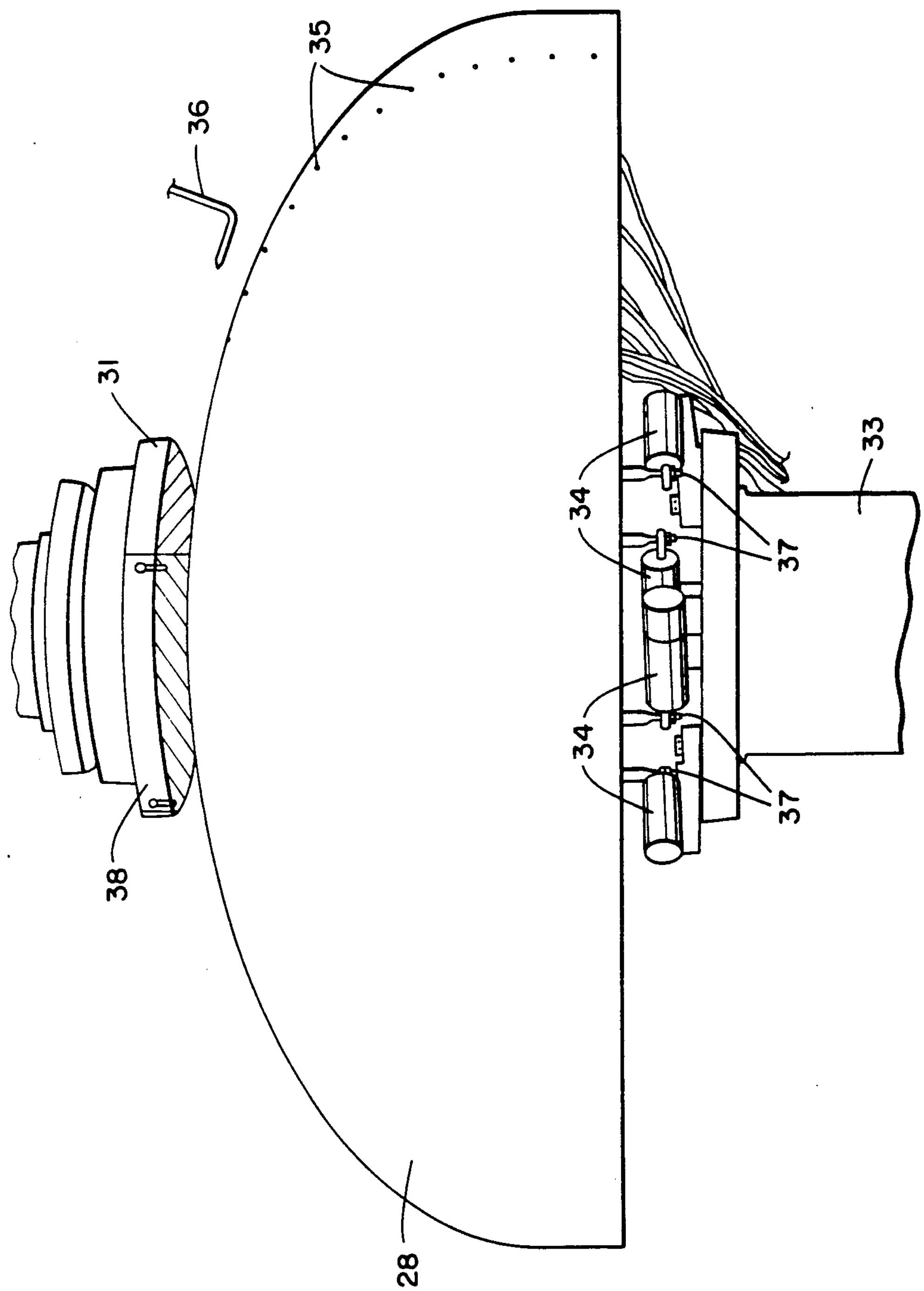


FIG. 4



CIRCULAR AIRPLANE

BACKGROUND OF THE INVENTION

A number of U.S. patents have been issued for circular aircraft configurations, embodying a variety of approaches to the generation of lift and control of attitude. Some of these patents teach levitation of a body by the direct thrust of single or multiple jets: more recent patents (e.g. U.S. Pat. Nos. 2,978,206, 2,996,266, 3,041,009, 3,276,723, 3,405,889, 3,592,413, 3,612,445, 3,697,020, and 3,785,592) utilize the flow of jets over the surface of wing-like structures. A review of these patents reveals that none of them contains predictions of load capacity, dimensions, power requirements, or the lift which would be generated by the configurations proposed. A review of the technical literature indicates that there have been no actual experiments with such craft, either tethered or in free flight.

During recent developments of VTOL and STOL aircraft, a great deal of analytical and experimental work has been performed on the behavior of jets exhausting parallel to lifting surfaces. For example, in a five-year study done by Rockwell ("A Study of Wall Jets and Tangentially Blown Wings", N. D. Malmuth, W. D. Murphy and J. D. Cole, Rockwell International Science Center—Report of ONR Contract N-0014-76-C-0350) the analysis of a jet exhausting over the upper surface of a wing was advanced to the point where subsonic and supersonic flows over a lifting surface could be modelled in detail, but no experimental verification was carried out. In their conclusions, the writers projected that more accurate results awaited further development of parabolic marching techniques.

At the David Taylor Naval Ship R&D Center, the controlled deflection of a large jet by a thin annular jet was investigated experimentally, ("Investigation of Parameters Influencing the Deflection of a Thick Wall Jet by a Thin Wall Jet Coflowing over a Rounded Corner", Gregory G. Huson, David Taylor Naval Ship R&D Center—Report DTNSRDC/ASED-83/10) with the indication that this is an effective means of vectoring thrust of a jet exhausting over the surface of a lifting body. Among the conclusions reached were that the effectiveness of this technique for thrust vectoring would be sensitive to the radius of curvature of the lifting surface, and to the relative upstream location of the main and control jets.

Further advances in the theory of turbulent wall jets were made in a study funded by ONR, conducted by Grumman Aircraft Corporation ("Theoretical Aerodynamics of Jets in Ground Effect Phase V—Asymptotic Theory of Turbulent Wall Jets", R. E. Melnik and A. Rubel, Grumman Aerospace Corporation—Final Report, Contract N00014-81-C-0549). The authors recommended experimental verification, but concluded that flows adjacent to a curved surface were difficult, if not impossible, to model. Papers in two recent AGARD Conferences have dealt with the subject of lift production by the combination of jets and adjacent surfaces, with particular application to VTOL and STOL aircraft. A session of the November 1981 conference was devoted to the topic "Jet Interactions with Neighboring Surfaces". In this session investigators from the University of Virginia ("An Experimental Investigation of an Upper Surface Blowing Configuration", G. D. Catalano, J. B. Morton and R. R. Humphris—AGARD November 1981) reported on laser velocimetry experiments performed with jets adjacent to a flat plate and to a flap upper surface. They were unable to project whether the jet would attach to the surface of the flap under static conditions.

The May 1984 AGARD Conference dealt with enhancement of lift by various means. One of the pertinent papers ("Modelling Circulation Control by Blowing", M. M. Soliman, R. V. Smith and I. C. Cheeseman, AGARD May 1984) was a study by Westland Helicopters of the lift and drag reduction effects of circulation control by blowing, on flows around circular bodies. The authors projected that the theory they developed would also predict the effects on lift of circulation control by blowing, for airfoils of any shape.

Applicants have been unable to find any references which deal with analytical prediction of lift for a circular aircraft, and no reports of experimental measurements on such craft. We decided to study the lifting characteristics of such a craft experimentally, and have developed a novel configuration which has a useful payload, can be controlled with stability and has operational utility. The report of our experiments is contained in "Circular Airplane Investigation", Final Report on Contract F33657-87-C-2164, Vatell Corporation, Apr. 18, 1988.

The principal difference between a helicopter and a circular airplane is in mechanical complexity. The rotor or rotors of a helicopter turn at a speed which is slow compared to that of the engine, and a gearbox is required to multiply the torque and reduce the speed of the engine. To control flight the pitch of the helicopter blades must be varied in two modes; all at once, to establish overall lift, and cyclically, to produce a lift vector and compensate for the effects on lift of horizontal motion through the air. The rotating main rotor blades produce a large torque in the horizontal plane on the helicopter, and in a single rotor craft this must be opposed by a separately controlled tail rotor. Multiple rotor helicopters balance the torque of one main rotor against that of the other to achieve cancellation and control vehicle rotation. The reference "New Aerodynamic Design of the Fenestron for Improved Performance", A. Vuillet and F. Morelli, AGARD Conference Proceedings No. 423, October, 1986 contains the statement: "The number of helicopters crashed due to failed or impacted tail rotors is about 0.15 per 10,000 hours of flight in the accident log book, as compared to a registered overall number of accident of 0.71 per 10,000 hrs of flight"

In "Summary of Drive-Train Component Technology in Helicopters", Gilbert J. Weden and John J. Coy, AGARD Conference Proceedings No. 369, January 1985, problems with the power transmission systems of helicopters are summarized: "Achievement of long-lived, reliable power transfer systems can be difficult to achieve and today's helicopters are one of the most severe applications of this technology. Helicopters (sometimes referred to as flying fatigue machines) present the ultimate test of materials and designs for reliability. The many failure mechanisms for bearing and gears must be weighed against anticipated loads which are not know with certainty. In addition to known classical modes of failure, such as pitting, scoring, and bending fatigue, there are unanticipated events that can ground helicopters. Things like sudden leaks producing low oil levels, undetected contamination of lubricant, and poor maintenance practices can severely lower the reliability of the mechanical components of the transmission."

By contrast, a circular airplane of the type we propose can be designed to operate with direct coupling (no gears) between its engine and fan, and has no rotor and no pitch controls. Any torque produced by the air flow which produces lift may be minimized by redirecting it with airfoils or vanes, so there is no need for a tail rotor or second main rotor. Flight control surfaces can be simple gates or dampers which modify the velocity distribution external to the craft. Rotation of the craft can be controlled by simple vanes which divert the main flow horizontally. Lift is controlled by engine speed, or for more rapid response may also be controlled by throttling the main lifting jet flow.

Applicants' circular airplane should be able to achieve a level of reliability which is close to that of its engine alone, because the components added for flight control are not highly stressed, and may even be designed for aerodynamic redundancy. In contrast, the flight control elements of the helicopter are among its most highly stressed, and have consequently high failure rates. An internal combustion engine power plant for a circular airplane would have the advantage that it operates at speeds which will allow direct coupling to the fan, although turboshaft or turbofan engines may ultimately prove to be practical, especially for larger craft.

A helicopter has its center of lift well above the center of gravity of the craft, and this produces a large righting moment which must be overcome by the cyclic pitch controls for any change in attitude. In applicants' circular airplane, the center of lift will be near the center of gravity, and the righting moment which must be overcome by vectoring of lift will be quite small.

The moment of inertia of the helicopter main rotor is quite large, and gyroscopic effects have a pronounced effect on maneuvering. In contrast, the moment of inertia of applicants' circular airplane will be much smaller, and only the rotating parts of the engine produce gyroscopic effects.

Because the helicopter blade moves a large volume of air at low pressure, it is efficient in generating lift. The circular airplane will be less efficient, because it moves a smaller volume of air at a higher velocity and pressure. The payload of a circular airplane will be less than that of a helicopter with the same fuel rate.

In general a helicopter is much more observable than a circular airplane will be, because of its greater size and the large rotating blade assembly. The circular airplane should have a small infrared signature because its heated exhaust can be mixed with a much larger volume of air. The vehicle body may be constructed of reinforced plastics which have a low radar reflectivity. The noise of a circular airplane will be limited to that of its engine and the fan it drives, and vibration can be minimal, depending on how well these components are balanced. Noise reaching the ground should be extremely low, in fact this vehicle may be almost as quiet as a glider because the body will shield engine noise from the ground and the jet velocity around the body of the vehicle will be relatively low. All high speed, turbulent mixing will occur above the vehicle.

In "Minimisation of Helicopter Vibration Through Active Control of Structural Response", S. P. King, A. E. Staple, AGARD Conference Proceedings No. 423, October, 1986 the problem with vibration in helicopters is succinctly described, "The control of vibration has been and remains, a problem for all rotary winged vehicles. Considerable efforts have been expended over many years in attempts to reduce vibration to acceptable levels. On the helicopter there are many sources of vibration, but the most important component is generated by the main rotor and occurs at a frequency (bR) equal to the product of the number of blades (b) and the rotor speed (R). This blade passing frequency vibration is an inherent consequence of driving a rotor edgewise through the air, and can never be completely eliminated, although the magnitude of the rotor excitation can be controlled by careful rotor system design. The response of the air frame is also sensitive to the dynamic characteristics of the fuselage, and again careful design can minimize the response. As understanding of the nature of the problem has increased, and the ability to predict the dynamic response of both rotor and airframe has improved, it has become possible to design a helicopter for low vibration, or at the very least to avoid those problems which have led to very high vibration in the past. The trend for increased cruise speed, and mission endurance has, however, aggravated the problem, since the magnitude of the rotor vibratory loads increases with speed, and the effect of vibration on human fatigue is proportional to exposure time."

Little can be said about the relative speeds in horizontal flight of helicopters and circular airplanes. Helicopters have a fundamental limitation: the backwardly moving rotor blades produce less lift than those moving in the direction of travel. At some limiting speed the backwardly moving blades will stall, and the helicopter cannot approach this speed with safety.

While circular airplanes may not have advantages over helicopters in vertical takeoff and landing, they may be able to make the transition to horizontal flight more easily, and may be ultimately capable of higher speeds than helicopters. Horizontal flight characteristics of applicants' circular airplane are unknown, but its speed will probably be limited to less than the exit velocity of the main jet. With certain vehicle profiles a scheme for diverting all of the flow to one side of the vehicle may make it possible to achieve high speed horizontal flight, but this remains to be explored.

The helicopter applications for which applicants' circular airplane may be most attractive are those which require:

(1) reliability;
(2) maneuverability;
(3) small payload;
(4) low vibration; and
(5) low observability.

Among military applications the one which immediately stands out is the battlefield reconnaissance mission. Here the ability to operate from a small base is crucial, and the circular airplane has a real advantage. It will be able to take off and land in a space not much larger than its own area with greater safety than a helicopter, whose rotating blades are extremely hazardous to personnel.

Reconnaissance missions may be separated into manned and unmanned types. In the former, the payload consists of a pilot, sensors, computers and communications equipment. A typical payload might be 500 to 1000 pounds, and flight times of 1-3 hours are typical of tactical applications, mostly in slow speed, level flight. There is a strong trend towards the use of remotely piloted vehicles for reconnaissance. In these applications the payloads are smaller, but other requirements are the same. "Mini-helicopters", powered by internal combustion engines, have been developed for this use, but they have all the complexity, and most of the control problems, of larger helicopters and are extremely limited in payload and endurance.

In the commercial and industrial marketplace the prospects for circular airplane applications are similar. While a circular airplane may never be used for heavy lifting, there are surveillance and monitoring tasks now performed by helicopters which it could do better. Providing a truly maneuverable but steady platform for aerial photography, a remotely piloted circular airplane could be launched from the back of a pickup truck and directed to take photographs from a variety of angles. It could be used for observation of forest fires, natural and man-induced disasters, and routine traffic and crime surveillance. With a laser beam projected from a ground station, this type of craft could be directed to a fixed position over its objective, perform its mission, then be brought back to the launching site in a "beam riding" mode with the exposed film or recorded data.

These and other advantages are achieved in applicants' circular airplane configuration, which is herein disclosed and described in detail.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional, partly schematic view of the circular aircraft which shows its main propulsion means and control surfaces.

FIG. 2 is a partially cutaway top view of the circular aircraft which shows further details of the control surface arrangement.

FIG. 3 is a perspective view of the experimental apparatus which was used to measure lift and explore controllability of the circular aircraft.

FIG. 4 is a perspective view of the experimental model showing the static pressure taps which were used to measure pressure forces on the model, and the gate used in experiments to vector the thrust of the model.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 is a sectional view of applicant's invention, with some parts shown schematically. As shown in this figure, circular airplane 1 comprises an oblately spheroidal body 2 whose major diameter is in the horizontal plane. The top surface 39 and bottom surface 40 of the spheroid are shown in this view to be planar, but this is not critical to the proper functioning of the invention. The body 2 houses a prime mover 3, a supply of fuel 4, and a mixed flow fan 5. A mixed flow fan induces the air flow along lines parallel to its axis of rotation and discharges the air flow radially, accomplishing turning of the flow within the body of the fan. The mixed flow fan is connected to the prime mover by a shaft 6, supported by a bearing 7. The inlet end 8 of the fan faces upward. When the fan is rotated by the prime mover, air is drawn down into the fan by its axial blades and then discharged from the fan outlet 9 by centrifugal force. Whirling motion of the air discharged by the fan is corrected by fixed guide vane assembly 10.

The airplane is equipped with two or more rotation control vanes 11 which can be rotated about their vertical axes by actuators 12. These vanes are positioned in a coordinated manner so as to divert the flow of air from the fixed guide vane assembly 10 either clockwise or counter-clockwise around the airplane's vertical axis, thus influencing its rotation about that axis.

The air flow from the fixed guide vane assembly discharges horizontally, but then curves downward, following the smoothly curved outer contour 13 of the body 2. This generates lift by a combination of effects which will be described in detail later in this disclosure. The amount of lift is approximately proportional to the mass flow rate of air. The direction of lift relative to the vertical axis of the airplane is controlled by four gates, two of which (14, 15) are shown in this view. Each gate is controlled by an actuator 16, and may be moved by its actuator between a raised position, as shown for gate 14, and a lowered position, as shown for gate 15. In the fully raised position the gate partially blocks the flow of air from one side of the fixed guide vane assembly 10, reducing the lift on that side. Thus the net direction of lift is controlled by gate positions, allowing the airplane to be tilted in any direction during flight.

Operation of the rotation control vanes and the gates is under command of a flight control computer 17, which also controls the speed of the prime mover 3. Sensing and power signals for actuators 12 and 16 and the prime mover 3 are conducted by a wiring harness 19. A mission computer 20 determines the flight path of the airplane, responding to stored instructions and to signals from a sensing array 21, which is interconnected to the mission computer 20 by a wiring harness 22.

FIG. 2 is a partially sectional top view illustrating further details of the invention. Locations of the four rotation control vanes 11 and of the gates 14, 15, 23 and 24 are clearly shown. Fixed guide vane assembly 10 is shown partially in cutaway to illustrate the fixed guide vanes 26, which receive the swirling air flow from the mixed flow fan 5 and discharge it in a radial direction. This view also shows the blades 25 of the mixed flow fan 5, visible from its inlet end.

Referring to FIGS. 1 and 2, the operation of the invention will now be described in detail.

To achieve stable flight, a circular airplane must (a) develop lift which is controllable over a range of values which includes the gross weight of the airplane, (b) control tilt of the airplane about two horizontal axes, and (c) control airplane rotation about its vertical axis. To generate lift, it is necessary for the airplane to accelerate a mass flow of air downward and maintain a positive pressure difference from the bottom to the top surfaces of the airplane. The effective lift is a result of both these effects, but it may be confusing to state that the lift is a summation of the two. The lift may be fully characterized as a mass acceleration effect or as a pressure effect, or (less precisely) as a combination of the two. A "pressure component" of lift and an "acceleration component" of lift may be derived, but the division between them is arbitrary and their sum is always the same. Thus there are two precise ways to describe how the circular airplane develops its lift; as a pressure effect or as a mass acceleration effect. Each is a complete description of the lift principle of the invention.

The generation of lift by mass acceleration for the invention may be described as follows. A mass of still air above the aircraft is accelerated into the inlet 8 of the mixed flow fan 5 and then discharged radially and horizontally through fixed guide vane assembly 10. The mass flow exits as a thin high velocity horizontal ribbon jet with energetic mixing occurring at both top and bottom surfaces. The mixing process will entrain additional mass flow from the surrounding air into the jet and cause it to decelerate and increase in thickness. Absent the curved surface 13 of the airplane, the jet would continue horizontally and dissipate the energy imparted to it by the mixed flow fan uniformly in all directions. However, the surface **13** prevents entrainment of surrounding air by the lower surface of the jet, so a pressure differential is created across the jet and it turns downward, following the curvature of the surface. As the jet turns, it mixes even more energitically on its upper and outer surface, entraining still air and increasing the mass flow even further. Lift is generated by the net acceleration of the air mass through the mixed flow fan and the acceleration of the surrounding air mass which mixes with the jet. The amount of lift may be determined by measuring and integrating the velocity profile of the resulting vertical flow.

The generation of lift by pressure for the invention may be described as follows. The mixed flow fan **5** ingests air from above by creating a region of lowered pressure over the area of its inlet **8**. The air discharged from fixed guide vane assembly **10** entrains air from the surroundings by energetic mixing, and creates a net negative pressure across the entire top area of the airplane. Some of the air discharged from the airplane curves completely around the body **2**, creating a slight positive pressure underneath it. The lift of the circular airplane may be determined by measuring and integrating the pressure distribution over its entire surface.

Lift measurements or computations made by the two methods above should yield the same value.

The preferred embodiment of applicants' invention generates a greater amount of lift for a given horsepower than circular airplanes described in the reference because (a) the mixed flow fan **5** is more efficient in imparting momentum to the air and (b) the smooth contour of the surface **13** is optimum for turning the resulting flow downward and inducing energetic mixing of the ribbon jet with the surrounding air. Computer codes developed by applicants to predict lift for the aircraft, incorporating empirical values derived from actual experiments, indicate that the lift of this airplane will be in excess of 4 lbs. per horsepower. This is sufficient to allow use of a conventional internal combustion engine, although the payload and range for such a craft would be limited. With a gas turbine prime mover, more useful payloads and improved ranges would be achieved.

While development of lift is important for a flight capability in a circular airplane, the ability to vector the lift is equally important for airplane attitude and flight control. The preferred embodiment of applicants' invention achieves this by differential control of the mass flow of air around the body **2**. We have experimentally determined that a reduction of mass flow on one side of a circular aircraft will result in a reduction of the lift generated on that side. Thus it is possible to create a vectoring of thrust by partially blocking the jet on one side. This is the function of gates **14**, **15**, **23** and **24** and actuators **16**. When it is desired to tilt one side of the aircraft downward, the gate on that side is raised into the jet, and lift on that side will be reduced. Net lift for the whole airplane will not be significantly reduced, because the flow to other sides of the aircraft will increase slightly.

Applicants' preferred embodiment circular airplane controls rotation about its vertical axis by re-introducing swirl in the lifting jet flow. Rotation control vanes **11** divert part of the flow from a radial direction to exit at an angle from the radial line. The four rotation control vanes are actuated together, producing a net torque on the body of the airplane.

The prime mover **3** of applicants' preferred embodiment is an internal combustion engine, preferably a 2-cycle, lightweight engine producing 1 horsepower per pound of gross weight. Such an engine will operate reliably for long periods at 6,000 to 8,000 rpm, and will produce sufficient torque to drive a 24" diameter mixed flow fan with good efficiency. A small gas turbine engine would produce greater horsepower in the same weight, but applicants are not aware of any such engines in this small size. An oscillating rotary vane engine patented by Robert K. Cordray (U.S. Pat. No. 4,605,361) would produce even greater horsepower per pound, but the reliability of this engine is unknown.

The supplying of air and fuel and elimination of heat and exhaust products of the prime mover for the circular airplane are subject to ordinary engineering by those skilled in the art of aircraft design.

Applicants' preferred embodiment circular airplane is designed to perform as a remotely piloted, or unmanned autonomous vehicle. To that end, it is equipped with a mission control computer **20**, a flight control computer **17**, and a sensor or array of sensors **21**. The flight control computer **17** maintains stability of the airplane and determines which actuators will be operated to cause it to follow a commanded flight path. The function of the mission control computer **20** is to command the airplane through its intended path for performance of surveillance or other tasks. Signals from the sensor array **21** will be detected, analyzed and stored, either to determine the flight path or for later analysis by ground facilities. The airplane may be equipped with a communication link to facilitate remote piloting or modification of the mission or downloading of data from the sensors. The variety of missions and equipment configurations possible is beyond the scope of this disclosure.

CIRCULAR AIRPLANE LIFT EXPERIMENTS

The practicality of a circular airplane hinges on its having sufficient lift and on the existence of some means for control of the lift vector. Applicants performed an experimental study whose objective was to investigate the lift and control characteristics of a circular aircraft configuration. Air flows around such an aircraft, driven by an annular jet exhausting over the upper surface, were studied experimentally and analyzed by computer modelling. The experimental results were then used to determine the mixing length constants of the computer model, in order to develop an analytical/empirical method for calculating the flows, pressures and lift characteristics of a circular aircraft. Thrust vectoring methods were also explored.

FIG. **3** shows the experimental apparatus **27** used in this investigation. The aircraft model **28** is a 36 inch diameter, 12 inch high spun aluminum body, formed from a flat plate ¼ inch thick. The model has a flat top 12 inches in diameter, and jet attachment surfaces with a circular profile and an inside radius of 12 inches. Suspended above the model is an air supply, consisting of an electrically driven Aerovent type 450BI centrifugal blower **29** and a transition duct **30** which conducts the air from the rectangular outlet of the blower to a 12 inch diameter horizontal jet-forming nozzle **31** centered over the flat top of the model. The blower and transition pipe are suspended above the model by a rigid pipe framework **32** which is lagged to the concrete floor of the laboratory. The model is mounted immediately below the jet-forming nozzle on a pedestal **33**, also lagged to the floor. The model is supported on the pedestal by four Tedea 305E 5 Kg. capacity load cells **34**.

As illustrated in FIG. **4**, the model has **19** pressure taps **35**, installed in and flush with the upper surface. Ten of these taps are spaced along a streamline at 2 inch intervals; the first one located just under the lip of the nozzle **31** and the last at the extreme skirt of the model. The remaining nine taps (not shown) are on streamlines displaced 90°, 180° and 270° from the line of the first ten taps, and are at approximately 6 inch intervals along their respective streamlines. Pressures from these taps were all measured by an inclined water manometer (not shown).

A movable total pressure probe **36**, mounted on an ICL 2 inch travel micrometer-driven dovetail slide (not shown), is connected to another tube of the manometer. The slide is mounted on an adjustment plate and support rod (not shown), which allow it to be positioned anywhere in relation to the model surface.

Each of the load cells **34** supports a quadrant of the model on a vertical adjustment screw jack **37** which can be used to adjust (a) the height of the model above the pedestal **33**, (b) its angle relative to the jet-forming nozzle **31**, and (c) the proportion of the total weight supported by the individual load cell.

After assembly of the experimental apparatus, applicants calibrated the load cells in place using a measured weight suspended from the ball socket which normally supports the model. Constants were then calculated for use in compensating for the individual cell zero offset and gain. The nozzle height was adjusted and the final opening measured and recorded for each quadrant, using a dial caliper. The whole model was then raised to a point just short of touching the bottom of the nozzle, and leveled. A final adjustment approximately equalized the static force supported by each load cell to just under 4 Kg. The gap between the top of the model and the top surface of the nozzle lower lip was then measured and recorded.

At each nozzle height setting the initial data taken were the quiescent manometer readings and static force values. These were recorded and the blower was turned on. Manometer static pressure readings and the forces on the model were then recorded. At each of three or four positions along the model surface a total pressure profile was measured, using the movable probe **36**. In all cases measurements started at the model surface and continued as far away from the surface as necessary to record the full velocity profile.

In an attempt to cause the jet to separate from the model surface, the model was lowered in increments until there was a 0.75 inch gap between it and the bottom of the nozzle. At this point the jet was still attached. The lift force decreased from 3.41 Kg. to 3.05 Kg. with a nominal nozzle opening of 0.625".

Applicants investigated thrust vectoring by attaching a 9.5 inch long, 4 inch high clear plastic gate **38** to one quadrant of the nozzle. The gate was moved in increments from a fully open position to fully closed, and force measurements were taken with the load cells.

The experiment and analysis clearly indicate feasibility for an aircraft based on this principle. A lift to power ratio of between 5 and 7 lbs./hp. seems to be possible for a configuration like the one tested. The lift can be vectored by simple means and controlled in magnitude by adjusting the speed of the prime mover. Rotational control was not investigated.

VARIATIONS UPON THE PREFERRED EMBODIMENT

While the circular airplane of applicants' preferred embodiment is configured as a remotely piloted or unmanned autonomous vehicle, other configurations are possible, for the performance of other missions. For example, a scaled-up version of the circular airplane could carry a person for short distances at low altitudes. This would be a "personal" airplane, used for recreational or business purposes. In larger sizes the circular airplane might be used as a cargo or passenger carrier.

The prime mover described as part of the preferred embodiment is an internal combustion engine, for which many alternatives exist. A gas turbine could be used to drive the mixed flow fan, either directly or through a gearbox. The exhaust flow of the gas turbine could be directed downward from the body of the airplane or combined with the lifting jet flow to dilute it to lower temperatures. A rotary engine such as the Wankel might provide a higher power to weight ratio than the piston engine, with acceptable reliability. Alternatively, an electric motor could be used, particularly for tethered flight applications, with electric power transmitted to the airplane by wire, microwave, or other directed beams.

In FIG. **2** the gates **14**, **15**, **23** and **24** and rotation control vanes **11** are shown to be in the same quadrants of the airplane. This arrangement concentrates structural and electrical components in four areas, but may create interference between the controls. For example, the authority of a rotation control vane **11** is reduced when its corresponding gate is raised. To reduce this effect with a slight increase in vehicle weight, the rotation control vanes may be located midway between the gates.

To enable more agile maneuvering, such as might be required by a military forward artillery observer application, the gates **14**, **15**, **23** and **24** and rotation control vanes **11** may be increased in size. This will increase their authority and increase the rotary accelerations that are possible for the vehicle. There are also alternatives to gates as a means of modulating the lift forces in quadrants of the aircraft. For example the ribbon jet may be caused to separate from the curved surface (**13**, FIG. **1**) in a quadrant of the body by a flow of pressurized air through a slot at the same position as the gate slot (see Huson, op. cit.). Alternatively the curvature of the surface may be changed abruptly by raising a flap downstream of the fixed guide vane assembly. Any means which causes the flow over a quadrant of the airplane to be reduced, or which causes the flow to separate in a quadrant, can be used to vector the thrust.

The actuators **16** recited as part of the preferred embodiment circular airplane may be hydraulic cylinders, hydraulic vane motors, integrated electro-hydraulic or electromechanical actuation devices. If hydraulic, the vehicle must have a source of hydraulic power, otherwise the actuators may be energized directly by electric power.

While a mixed flow fan is believed to be best for its combination of light weight and efficiency, with higher speed prime movers such as gas turbines an axial flow fan and nozzle combination may prove to be more effective. The trade-off in this case is engine weight against propulsive efficiency: the lighter engine operates at higher speeds, possibly too high for a mixed flow fan, but the axial flow fan is less efficient. A gearbox, with its added weight, losses and limited life, may be the best way to match the gas turbine and the mixed flow fan.

Structural materials for applicants' circular airplane must have a high strength to weight ratio. Candidate materials are carbon fiber reinforced carbon composites, aluminum lithium alloys, and the more conventional fiberglass reinforced epoxy resins, honeycomb metals, balsa wood laminates and the like. For weight minimization the prime mover will be the structural nucleus of the airplane, with most components attached to it directly.

From the foregoing it is clear that applicants' invention may be practiced in many forms by those knowledgeable in the art of aircraft design without departing from the spirit and scope of this disclosure.

We claim:

1. An airplane having a nearly circular plan form, comprising:

- an oblately spheroidal hollow aerodynamic body with its smallest dimension vertical and its largest dimension horizontal, having an aperture at the center of its upper surface;
- an engine mounted within said aerodynamic body having a vertical output shaft extending upwards through said aperture;
- a mixed flow fan rotatably attached to the end of said output shaft having its axial induction opening facing upward and its bottom surface flush with the upper surface of said aerodynamic body;
- a guide vane assembly for removing the swirl from the discharge of said mixed flow fan, fixedly mounted to the upper surface of said aerodynamic body, surrounding and closely coupled to the discharge opening of said mixed flow fan, wherein said discharge flow exiting said guide vane assembly follows the external contour of said aerodynamic body and is directed essentially vertically downward, producing aerodynamic lift;
- means for adjustably reducing the flow of said mixed flow fan over a sector of its radial discharge opening;
- means for adjustably imparting a swirl to part of the discharge flow of said guide vane assembly; and
- means for controlling the speed of said engine.

2. The device of claim **1** in which said upper surface of said aerodynamic body is a horizontal plane and said discharge flow of said guide vane assembly exits horizontally.

3. The device of claim **1** in which said upper surface of said aerodynamic body is convexedly curved and said discharge flow of said guide vane assembly exits with a downward component of velocity.

4. The device of claim **1** in which said means for adjustably reducing the flow of said mixed flow fan is a gate adjustably raised across the discharge opening of said guide vane assembly.

5. The device of claim **1** in which said means for adjustably imparting a swirl to part of the discharge flow of said guide vane assembly is a vane adjustably rotated in said discharge flow.

6. The device of claim **1** further comprising flight control means connected to said means for adjustably reducing the flow of said mixed flow fan over a sector of its radial discharge opening, to said means for adjustably imparting a swirl to part of the discharge flow of said guide vane assembly and to said means for controlling the speed of said engine, for controlling the flight path of said airplane.

7. The device of claim **6** further comprising mission command means connected to said flight control means, for predetermining the flight path of said airplane.

8. The device of claim **7** further comprising sensor means connected to said mission command means for detecting signals and conditions from the environment of said airplane.

9. An unmanned autonomous vehicle having a nearly circular plan form, comprising:

- an oblately spheroidal hollow aerodynamic body with its smallest dimension vertical and its largest dimension horizontal, having an aperture at the center of its upper surface;
- an engine mounted within said aerodynamic body having a vertical output shaft extending upwards through said aperture;
- a mixed flow fan rotatably attached to the end of said output shaft having its axial induction opening facing upward and its bottom surface flush with the upper surface of said aerodynamic body;
- a guide vane assembly for removing the swirl from the discharge of said mixed flow fan, fixedly mounted to the upper surface of said aerodynamic body, surrounding and closely coupled to the discharge opening of said mixed flow fan, wherein said discharge flow exiting said guide vane assembly follows the external contour of said aerodynamic body and is directed essentially vertically downward, producing aerodynamic lift;
- means for adjustably reducing the flow of said mixed flow fan over a sector of its radial discharge opening;
- means for adjustably imparting a swirl to part of the discharge flow of said guide vane assembly;
- means for controlling the speed of said engine;
- flight control means connected to said means for adjustably reducing the flow of said mixed flow fan over a sector of its radial discharge opening, to said means for adjustably imparting a swirl to part of the discharge flow of said guide vane assembly and to said means for controlling the speed of said engine, for controlling the flight path of said vehicle;
- mission command means connected to said flight control means, for predetermining the flight path for said vehicle; and
- sensor means connected to said mission command means for detecting signals and conditions from the environment of said vehicle.

10. The device of claim **9** in which said upper surface of said aerodynamic body is a horizontal plane and said discharge flow of said guide vane assembly exits horizontally.

11. The device of claim **9** in which said upper surface of said aerodynamic body is convexedly curved and said discharge flow of said guide vane assembly exits with a downward component of velocity.

12. The device of claim **9** in which said means for adjustably reducing the flow of said mixed flow fan is a gate adjustably raised across the discharge opening of said guide vane assembly.

13. The device of claim **9** in which said means for adjustably imparting a swirl to part of the discharge flow of said guide vane assembly is a vane adjustably rotated in said discharge flow.

14. A vertical takeoff and landing vehicle having a nearly circular plan form, comprising:

an oblately spheroidal hollow aerodynamic body with its smallest dimension vertical and its largest dimension horizontal, having an aperture at the center of its upper surface;

an engine mounted within said aerodynamic body having a vertical output shaft extending upwards through said aperture;

a mixed flow fan rotatably attached to the end of said output shaft having its axial induction opening facing upward and its bottom surface flush with the upper surface of said aerodynamic body;

a guide vane assembly for removing the swirl from the discharge of said mixed flow fan, fixedly mounted to the upper surface of said aerodynamic body, surrounding and closely coupled to the discharge opening of said mixed flow fan, wherein said discharge flow exiting said guide vane assembly follows the external contour of said aerodynamic body and is directed essentially vertically downward, producing aerodynamic lift;

means for adjustably reducing the flow of said mixed flow fan over a sector of its radial discharge opening;

means for adjustably imparting a swirl to part of the discharge flow of said guide vane assembly; and

means for controlling the speed of said engine.

15. The device of claim **14** in which said upper surface of said aerodynamic body is a horizontal plane and said discharge flow of said guide vane assembly exits horizontally.

16. The device of claim **14** in which said upper surface of said aerodynamic body is convexedly curved and said discharge flow of said guide vane assembly exits with a downward component of velocity.

17. The device of claim **14** in which said means for adjustably reducing the flow of said mixed flow fan is a gate adjustably raised across the discharge opening of said guide vane assembly.

18. The device of claim **14** in which said means for adjustably imparting a swirl to part of the discharge flow of said guide vane assembly is a vane adjustably rotated in said discharge flow.

19. The device of claim **14** further comprising flight control means connected to said means for adjustably reducing the flow of said mixed flow fan over a sector of its radial discharge opening, to said means for adjustably imparting a swirl to part of the discharge flow of said guide vane assembly and to said means for controlling the speed of said engine, for controlling the flight path of said vehicle.

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US005102066A

United States Patent [19]

Daniel

[11] **Patent Number: 5,102,066**

[45] **Date of Patent: Apr. 7, 1992**

[54] **VERTICAL TAKE-OFF AND LANDING AIRCRAFT**

[76] Inventor: **William H. Daniel**, 121 Tulsa Dr., Rogers, Ark. 72756

[21] Appl. No.: **560,582**

[22] Filed: **Jul. 30, 1990**

[51] **Int. Cl.**^{5} **B64C 29/00**; B64C 39/06

[52] **U.S. Cl.** .... **244/12.2**; 244/23 C; 244/73 C

[58] **Field of Search** .... 244/12.2, 23 R, 23 C, 244/23 A, 73 C

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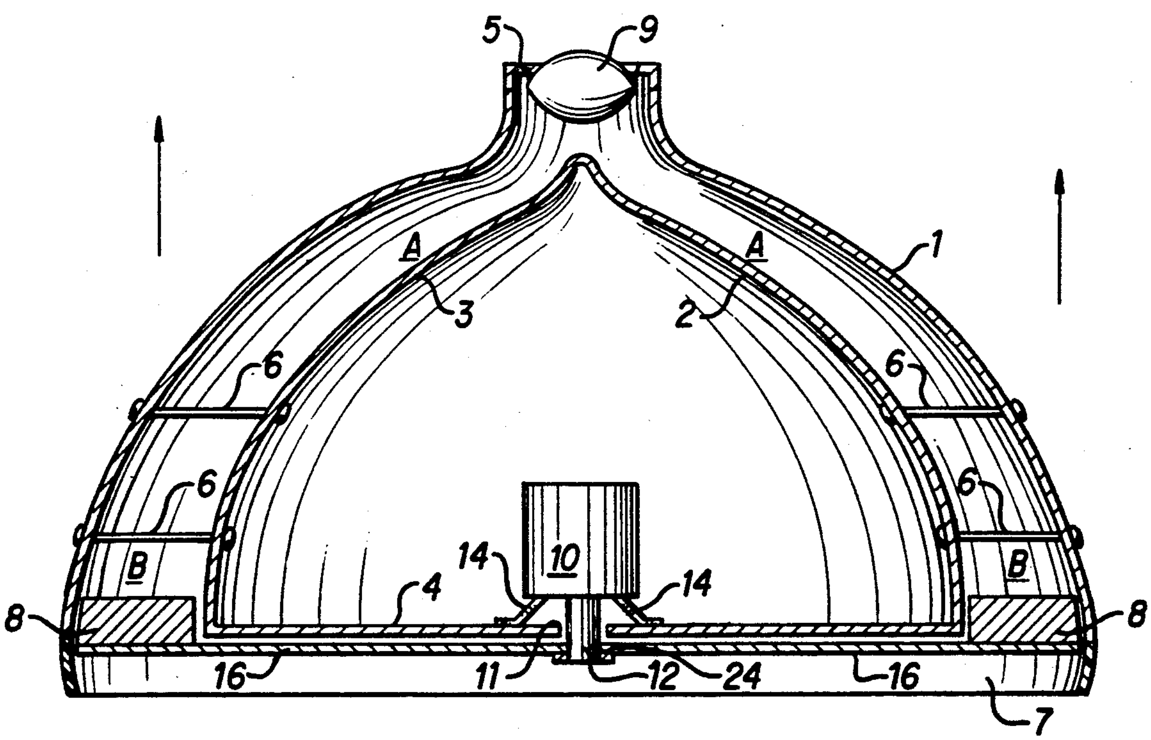
Primary Examiner—Galen Barefoot
Attorney, Agent, or Firm—Young & Thompson

[57] **ABSTRACT**

In a vertical take-off and landing craft, a pair of nested dome-shaped shells are spaced apart and rigidly interconnected by struts. The outer shell has a central opening formed in its top, and the shape of the shells is such that the space between the two shells progressively widens from the central top part of the shells to the peripheral bottom part of the shells. A circular series of arcuate airfoil units is disposed in the annular space between the bottoms of the shells, and is driven in rotation by an engine mounted on the inner shell. Upon rotation of the circular series of arcuate airfoil units, low pressure is generated above the airfoil units and high pressure below, such that air is drawn down through the central opening of the outer shell to produce a thrust which permits vertical displacement of the aircraft.

8 Claims, 3 Drawing Sheets



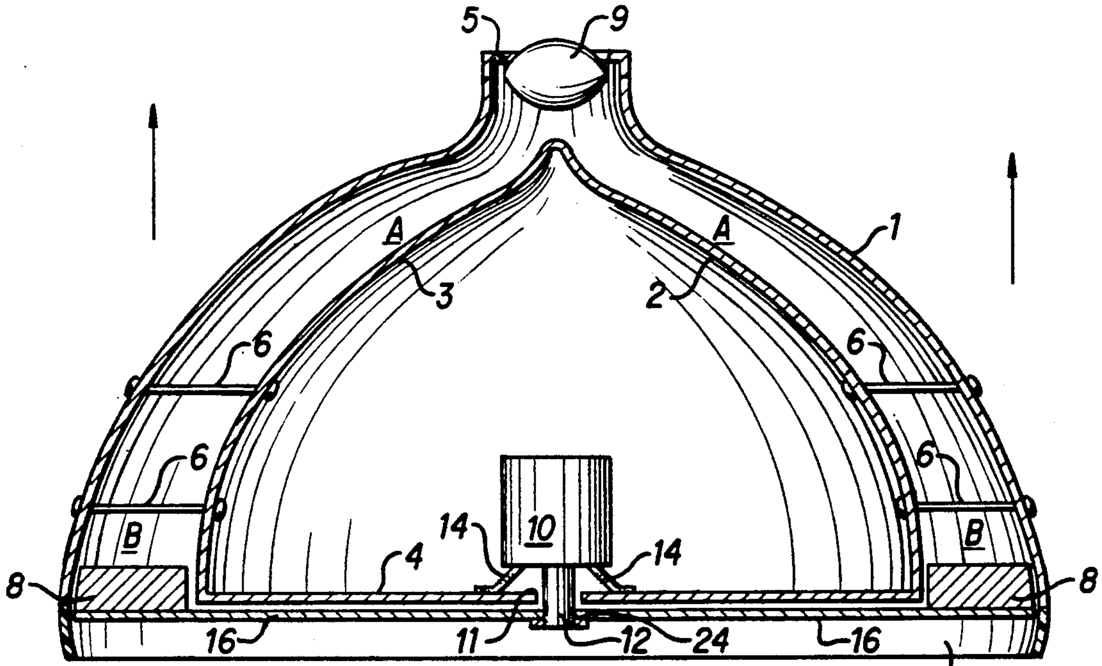

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FIG. 1

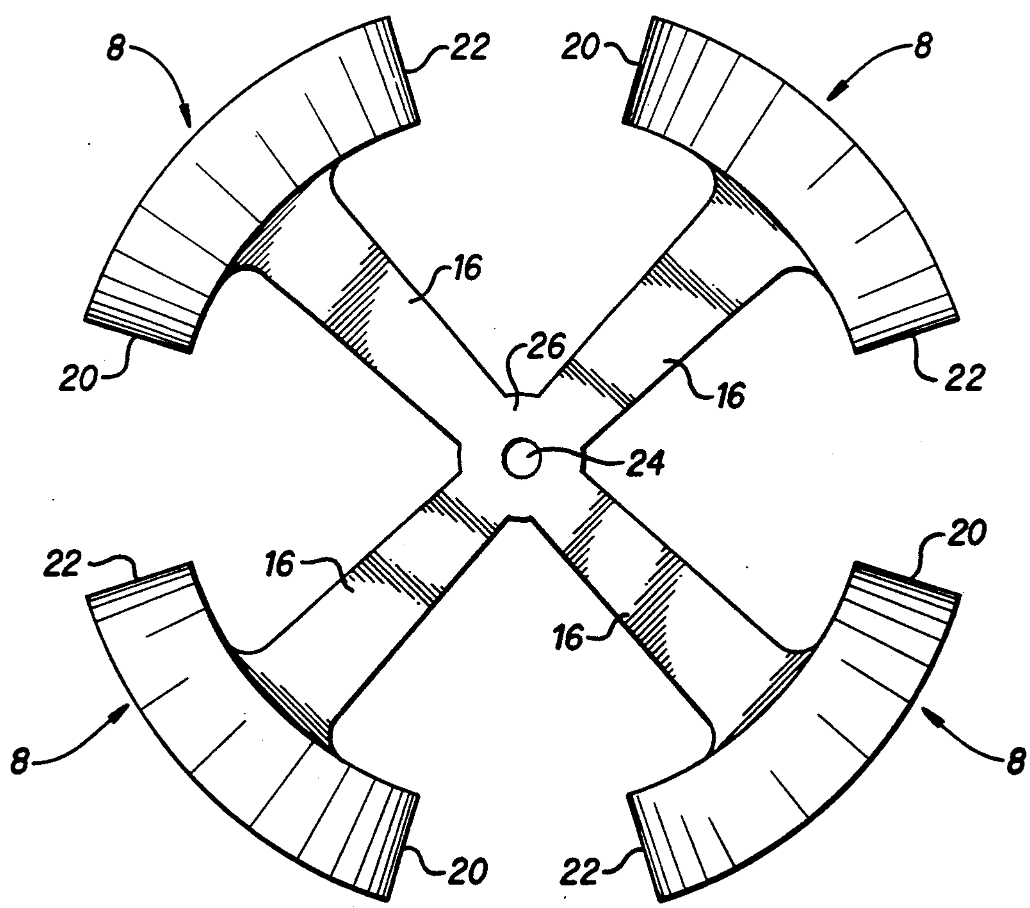
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FIG. 2

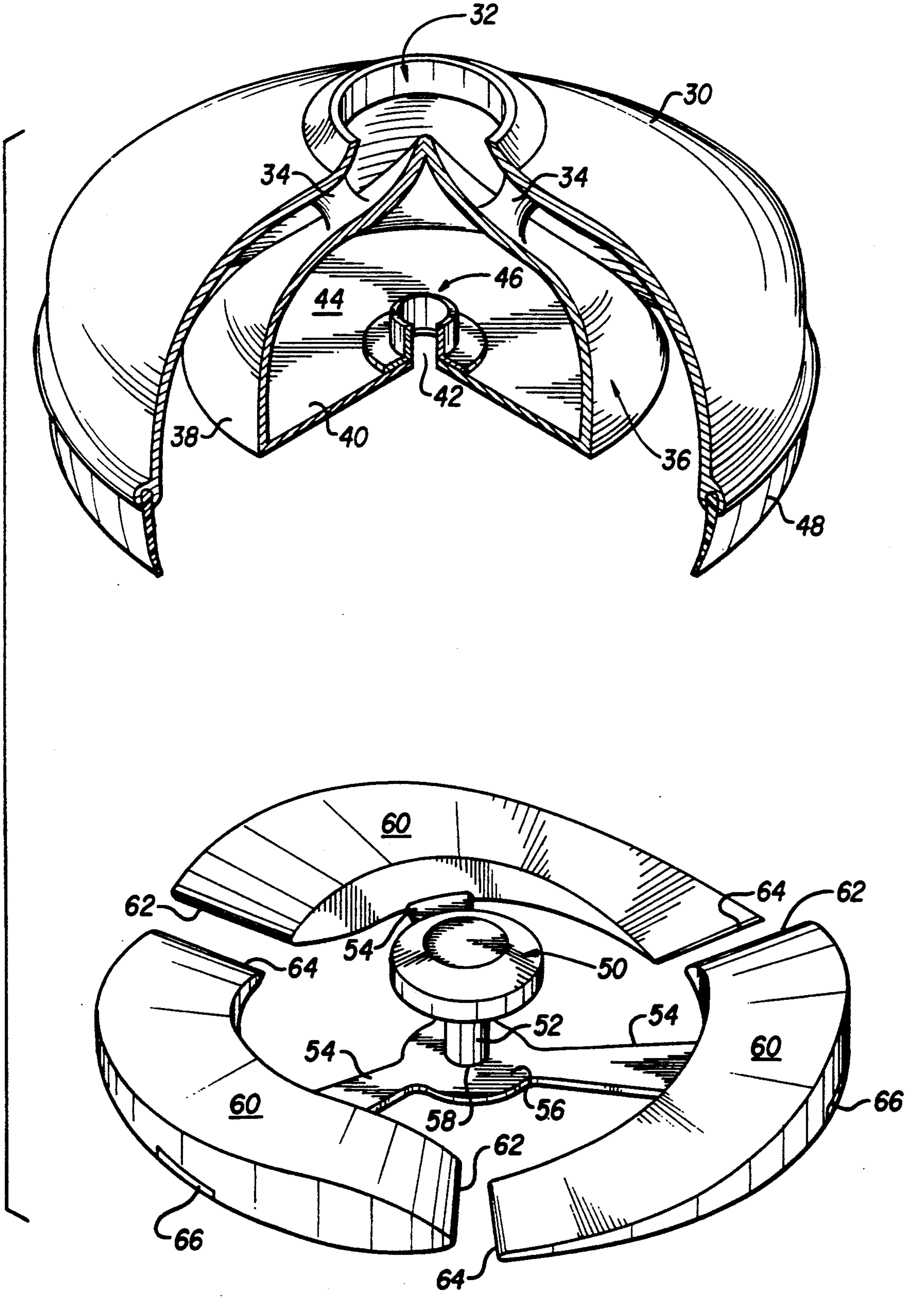
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FIG. 3

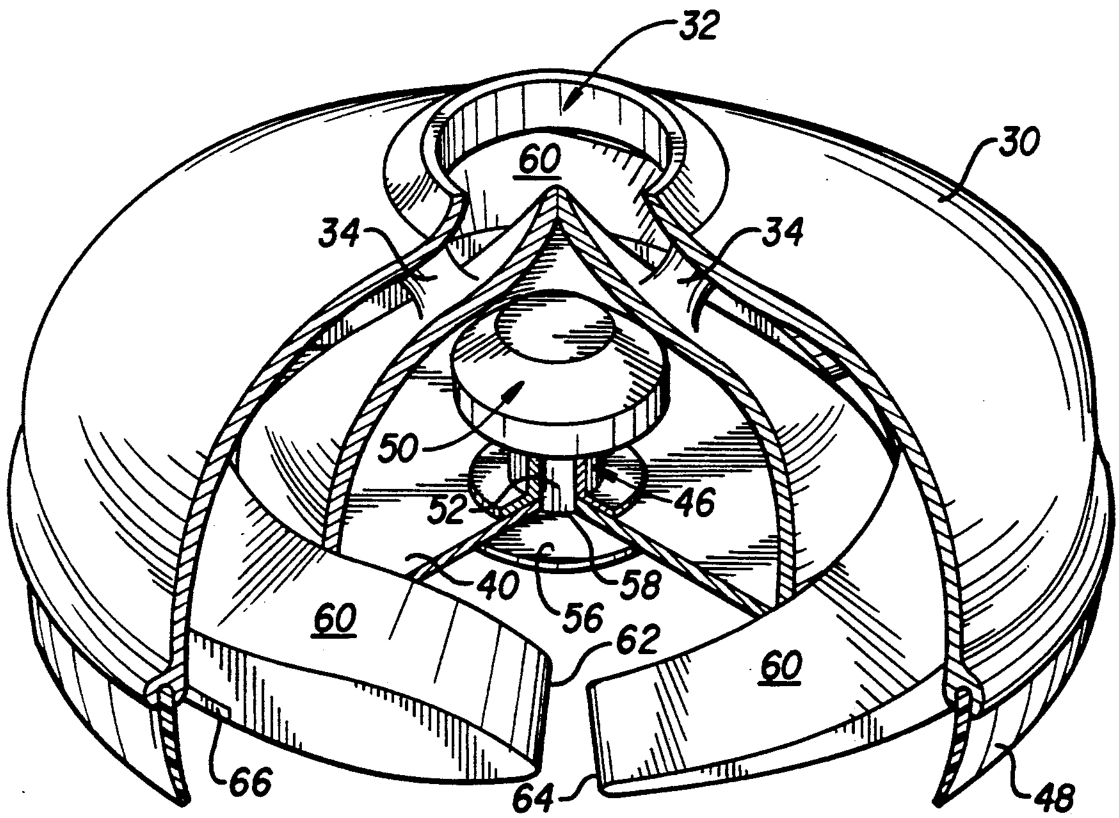

FIG. 4

VERTICAL TAKE-OFF AND LANDING AIRCRAFT

The present invention relates to aircraft design, and more particularly to the construction of an improved vertical take-off and landing craft (VTOL).

In copending application Ser. No. 07/521,565 of the same inventor, the discovery of important fluid dynamic principles has been embodied in a pump and oil-water separator, to improve the movement of a fluid through a body. In the present application, these principles are embodied somewhat differently, to improve the movement of a body through a fluid.

The present invention thus relates to a VTOL craft comprising a pair of nested dome-like shells, which are interconnected and maintained in spaced relation by struts. The outer shell has a central opening at its top, and the two shells together define an open annular space at their bottoms. These shells are so configured that the spacing between the two shells progressively increases from their tops to their bottoms.

Disposed in the annular space between the bottoms of the two shells is a circular series of arcuate airfoil elements, arranged with their leading edges all facing in the same direction about the circle. The airfoil elements are interconnected by a spoked member, which in turn is coupled to the output shaft of a motor housed on or within the inner shell. The motor drives the circular series of airfoil elements in rotation, within the annular space defined by the bottoms of the two shell elements.

As each of the airfoil elements is moved through the air between the two shells, there is created a reduced pressure region on its upper surface, and a higher pressure region on its lower surface, as is known in the art. Within the structure according to the invention, the low pressure regions on the upper surfaces of the airfoil elements serve to draw air through the central opening of the outer shell and down into the space between the two shells, from whence it is expelled under high pressure beneath the rotating series of airfoil elements, thereby to create a thrust which displaces the VTOL craft vertically.

The invention will be explained in greater detail with reference to the accompanying drawings, which show two preferred embodiments according to the invention, and in which:

FIG. 1 is an axial section through a VTOL craft according to a first embodiment of the invention;

FIG. 2 is a plan view of the propeller structure used in the embodiment of FIG. 1;

FIG. 3 is an exploded view, partially in section, of a VTOL craft according to a second embodiment of the invention; and

FIG. 4 is an assembled view, also partly in section, of the embodiment according to FIG. 3.

Referring now to the drawings, and more particularly to FIGS. 1 and 2, there is shown a first embodiment of the VTOL craft according to the invention. As seen in FIG. 1, the craft comprises a generally dome-shaped outer shell 1, which is provided with a central opening 5 at its top and is open at its bottom. An inner shell 2 is disposed concentrically within the outer shell and is rigidly secured thereto by means of struts 6. The struts 6 must be capable of maintaining the inner and outer shells 1 and 2 as a unitary assembly, but should not be so large or so numerous as significantly to impede the airflow within the space between the two shells.

The inner shell 2 is composed of a dome-shaped member 3 and a disc-shaped floor member 4, which closes the dome-shaped member 3 at its bottom. The dome 3 and disc 4 will typically be separate interassembled elements, for ease of manufacturing, but these members may also be formed integrally such that the inner shell 2 is of one-piece construction.

On the center of the disc-shaped floor 4 is mounted a prime mover 10, supported on the floor 4 by means of supporting legs 14. The prime mover 10 may be any form of motor or engine capable of powering its output shaft 12 at an output sufficient to fly the craft. In the case of a motor fueled by a combustible fuel, suitable exhaust piping, not shown, will lead from the motor to the exterior of the craft. Exhaust piping may also open into the space between the two shells, from whence the exhaust gas will be drawn into the downward flow of air by a venturi effect.

The output shaft 12 of prime mover 10 extends downwardly through a hole 11 formed in the floor member 4, and is rigidly secured in a further hole 24 formed centrally of a plate comprising the spoke members 16.

The plate comprising spoke members 16 underlies the floor plate 4, and is better seen in the plan view of FIG. 2. As shown in FIG. 2, each of the spoke members 16 has a radially inward end connected to or formed integrally with a central member 26 comprising the hole 24, and a radially outward end connected to a respective one of the airfoil elements 8.

The radial extent of the central member 26 and the spoke members 16 may vary reciprocally beyond what is shown in FIG. 2. That is, the central member 26 may be of greater diameter, and the spoke members 16 of lesser diameter; indeed, the central member 26 may extend radially all the way to adjacent the airfoil elements 8, such that the spoke members 16 only underlie the airfoil elements 8. At present, however, it is preferred to form the propeller unit as shown in FIG. 2, to reduce the weight of the assembly. The propeller unit as shown in FIG. 2 will also permit access, between a pair of adjacent spoke members 16, to a hatch provided in the floor plate 4.

Although the propeller unit of FIG. 2 is shown comprising four airfoil units 8, it will be appreciated that the number of airfoil units, and hence the number of spoke members 16, may be varied at will depending on the size and use requirements of the VTOL craft, from a minimum of two airfoil units, up to any desired maximum number of airfoil units.

The airfoil elements 8 may be as described in the earlier U.S. Pat. No. 3,261,297 to the present inventor, the entirety of which is hereby expressly incorporated by reference to the extent not inconsistent herewith. The airfoil elements 8 according to the embodiments of FIGS. 1 and 2 differ from those depicted in U.S. Pat. No. 3,261,297, in that the present airfoil elements are curved in their horizontal plane, whereas those of the earlier U.S. patent are curved in their vertical plane.

Each of the airfoil elements 8 comprises a leading edge 20 and a trailing edge 22, with the series of airfoil elements 8 arranged such that the leading edges all face in the same direction about the circle.

The propeller unit of FIG. 2 is received in the overall structure shown in FIG. 1, such that the circular series of airfoil elements 8 occupies the lowermost region of the annular space defined by the outer shell and inner shell 2.

The outer shell **1** and inner shell **2** are configured such that the space defined therebetween gradually increases from the top of the shells to the bottom. That is, the shells are closer together in the regions indicated A, and further apart in the regions indicated B, with the space between the shells progressively and continuously widening between the regions A and B. Moreover, as the shells **1** and **2** are symmetrical about an axis containing the output shaft **12** of prime mover **10**, the view of FIG. **1** would be produced by taking any axial section through this embodiment.

The craft of FIG. **1** further comprises a downwardly depending annular skirt **7** attached to the lower edge of the outer shell **1**. The skirt **7** may advantageously be formed of a rigid yet slightly resilient elastomer material, to promote a more gentle landing of the craft. The skirt **7** may also serve as an interconnecting member, to interconnect the depicted twin shell structure with a downwardly depending passenger or cargo compartment. In this case, the interconnecting skirt would appropriately be frusto-conical, extending radially inwardly down toward the attached passenger compartment, which passenger compartment would then have a width about the same as the diameter of the inner shell **2**. The inwardly sloping walls of the interconnecting skirt in this case would have openings to permit free passage of the air flow expelled by the propeller unit. Indeed, it would be possible to attach to the interconnecting skirt a downwardly depending chain of passenger and/or cargo compartments, connected to one another in the manner of a railroad car, and with the lowermost compartment having landing gear.

Disposed within the central opening **5** at the top of the outer shell **1**, is an adjustable damper **9** by which the amount of air drawn in through the opening **5** can be varied. That is, the damper **9** is controlled by the operator of the craft or by remote control, to cause the opening **5** to be more or less obstructed, and thus to increase or decrease the airflow through the opening **5**.

In operation, the VTOL craft according to the embodiments of FIGS. **1** and **2** is started by operating the prime mover **10**, which rotates the propeller unit of FIG. **2** by way of its output shaft **12** which is rigidly secured to the propeller unit. As the propeller unit spins within the annular space defined between the bottom of the outer shell **1** and inner shell **2**, a region of low pressure is created on the upper surfaces of the airfoil elements **8**, and a corresponding region of high pressure on the lower surfaces of the airfoil elements **8**. In response to the low pressure, air is drawn in through the central opening **5** formed in the outer shell **1**, from whence it flows downwardly from region A to region B.

According to a significant feature of the invention, the closest distance between the outer shell **1** and inner shell **2** progressively increases from the region A and B, such that the flow of air from region A to region B is progressively less constricted. In this manner, it has been found that the regions of low and high pressure above and below the propeller unit, respectively, can be maintained even though the craft is open to the atmosphere at its top and bottom.

The low and high pressure regions, along with the expulsion of air downwardly by the propeller unit, create a thrust which displaces the VTOL craft upwardly through the air, in the direction indicated by the arrows of FIG. **1**. The speed of ascent can be controlled by the speed at which the propeller unit is rotated, and also by the extent to which the damper **9** is opened. By suitably slowing down the propeller and/or restricting the opening **5** with the damper **9**, the descent of the craft can also be effectively controlled.

The structure shown in FIGS. **1** and **2** provides for controlled vertical displacement of the VTOL craft. It will be appreciated, however, that the VTOL craft shown can also be equipped with conventional directional controls to provide controlled lateral movement, as is within the knowledge of those skilled in the art.

FIGS. **3** and **4** show a second embodiment according to the invention, which operates in the same manner as the embodiment of FIGS. **1** and **2**.

Referring to FIG. **3**, outer shell **30** and inner shell **36** are rigidly interconnected by strut members **34**. Outer shell **30** has a central opening **32** at its top, and at its bottom is secured to the annular skirt member **48**. In this embodiment, no damper is provided in the central opening **32**, as the speed of ascent and descent can be adequately controlled solely by varying the speed at which the airfoils are rotated.

The inner shell **36** has a dome-shaped element **38** and a floor plate **40**, which together define an interior cabin **44** suitable for receiving cargo and/or passengers. The floor plate **40** has a central hole **42** for passage of the motor shaft, and also has in this embodiment an engine mount **46** for supporting the engine above the hole **42**.

FIG. **3** also shows the propeller drive assembly of this embodiment, comprising a central plate member **56** having three spokes **54** radiating therefrom, each spoke being connected to a respective airfoil unit **60**. The airfoil units **60** of the present embodiment are the same as the airfoil units **8** of the preceding embodiment, except that the airfoil units **60** are three in number, rather than four, and their arcuate extent has been correspondingly increased. Each of the airfoil units **60** comprises a leading edge **62** and a trailing edge **64**, with the series of airfoil units **60** being so arranged that the leading edges face the same direction in the circle. The central plate member **56** comprises a hole **58** in which is fixedly received the output shaft **52** of prime mover **50**. It will be noted in this embodiment that the prime mover **50** with its output shaft **52** will be joined to the plate member **56** only through the hole **42** of the inner shell **36**; that is, the motor and propeller unit according to this embodiment are not separable as an integrated unit from the twin shell structure.

FIG. **3** also illustrates the manner of connecting the spoke members **54** to the airfoil units **60**. Specifically, the connection of the spoke members to the air foils should not interfere with the aerodynamic characteristics of the upper and lower surfaces of the air foil units **60**. Accordingly, the ends **66** of spokes **54** which are connected to the airfoil units **60** are received in suitable cut-outs provided on the lower surface of the airfoil units. Connection between the spoke members **54** and airfoil units **60** may also be had by bolts passing from the spoke members **54**, or directly from a disc **56** of increased diameter, through the side of the airfoil units **60**.

FIG. **4** shows the embodiment of FIG. **3** in an assembled state, from which it can be seen that, as in the previous embodiment, the plate member **56** and spokes **54** underlie the floor plate **40** of the inner shell **36**, and the airfoil units **60** occupy the annular space between the bottom of the inner shell **36** and outer shell **30**. The manner of operation of the embodiment of FIGS. **3** and **4** is as described for the embodiment of FIGS. **1** and **2**.

Although the invention has been described in connection with various preferred embodiments thereof, it will be appreciated that the embodiments are given solely for purposes of illustration, and are not to be construed as limiting the invention as set forth in the true spirit and scope of the appended claims.

What is claimed is:

1. A vertical take-off and landing aircraft, comprising an outer dome-shaped shell having a central axis and an inner dome-shaped shell disposed concentrically within the outer shell, struts rigidly interconnecting the inner and outer shells and maintaining a predetermined spacing therebetween, said outer shell having an upper central opening and being open at its bottom, thereby to define an annular air space between the inner and outer shells, the inner and outer shells being so configured as to have a progressively widening space therebetween moving centrally of the shells toward their bases; a circular series of airfoil elements disposed within the annular air space adjacent the bottoms of the inner and outer shells, each of said airfoil elements extending along an arc of a circle centered at the central axis of the outer shell, said airfoil elements each having a width not exceeding the spacing between the bottoms of the outer and inner shells and said airfoil elements being disposed between the outer and inner shells; and a motor mounted on the inner shell and having an output shaft coupled by a plate member to the circular series of airfoil elements, thereby to rotate the circular series of airfoil elements in unison.

2. The aircraft according to claim 1, further comprising a damper disposed within the central opening of the outer shell, and adjustable to vary the size of said opening.

3. The aircraft according to claim 1, further comprising a downwardly depending annular skirt secured at the lower edge of the outer shell.

4. The aircraft according to claim 3, wherein said annular skirt is formed of an elastomer material.

5. The aircraft according to claim 1, wherein said circular series of airfoil elements comprises three airfoil elements.

6. The aircraft according to claim 1, wherein said circular series of airfoil elements comprises four airfoil elements.

7. The aircraft according to claim 1, wherein said inner shell defines an interior chamber receiving the motor.

8. The aircraft according to claim 7, wherein said inner shell comprises a motor mount supporting the motor and guiding its output shaft downwardly through the inner shell.

* * * * *

US005149012A

United States Patent [19]

Valverde

[11] Patent Number: 5,149,012

[45] Date of Patent: * Sep. 22, 1992

[54] TURBOCRAFT

[76] Inventor: Rene L. Valverde, 4405 Toledo St., Coral Gables, Fla. 33146

[*] Notice: The portion of the term of this patent subsequent to Aug. 13, 2008 has been disclaimed.

[21] Appl. No.: 757,326

[22] Filed: Sep. 10, 1991

[51] Int. Cl.[5] B64C 39/06

[52] U.S. Cl. .... 244/12.2; 244/23 C; 244/53 R; 244/60; 244/12.3

[58] Field of Search .... 244/12.2, 23 C, 12.3, 244/23 R, 52, 60, 62, 17.19, 12.1, 36, 53 R

[56] References Cited

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3,020,003 2/1962 Frost et al. .... 244/23 C

Primary Examiner—Galen Barefoot
Attorney, Agent, or Firm—Oltman and Flynn

[57] ABSTRACT

An aircraft having a substantially circular body having a profile in the direction of flight as a profile of an airplane wing, at least two concentric counter-rotating turbo-blade assemblies within said body for effecting a vertical lifting air stream through said assemblies. Power generating devices and devices for coupling the power generating devices to the turbo-blade assemblies for maintaining them in rotary motion. It also includes thrusting devices coupled to the power generating devices for applying horizontal thrust to the aircraft, retro-boosting devices including a plurality of combustion chambers located below the turbo-blade assemblies for boosting said vertical lifting airstream. Also included is a compressed air plenum disposed below said turbo-blade assemblies in fluid communication with the combustion chambers and to the intake portion of the power generating means for supplying oxygen for sustaining combustion in said combustion chambers and for sustaining power in said power generating means, including upper vanes disposed above said turbo-blade assemblies for ingesting air, and lower vanes disposed below said compressed air plenum for exhausting air, and respective upper and lower vane control means.

24 Claims, 13 Drawing Sheets

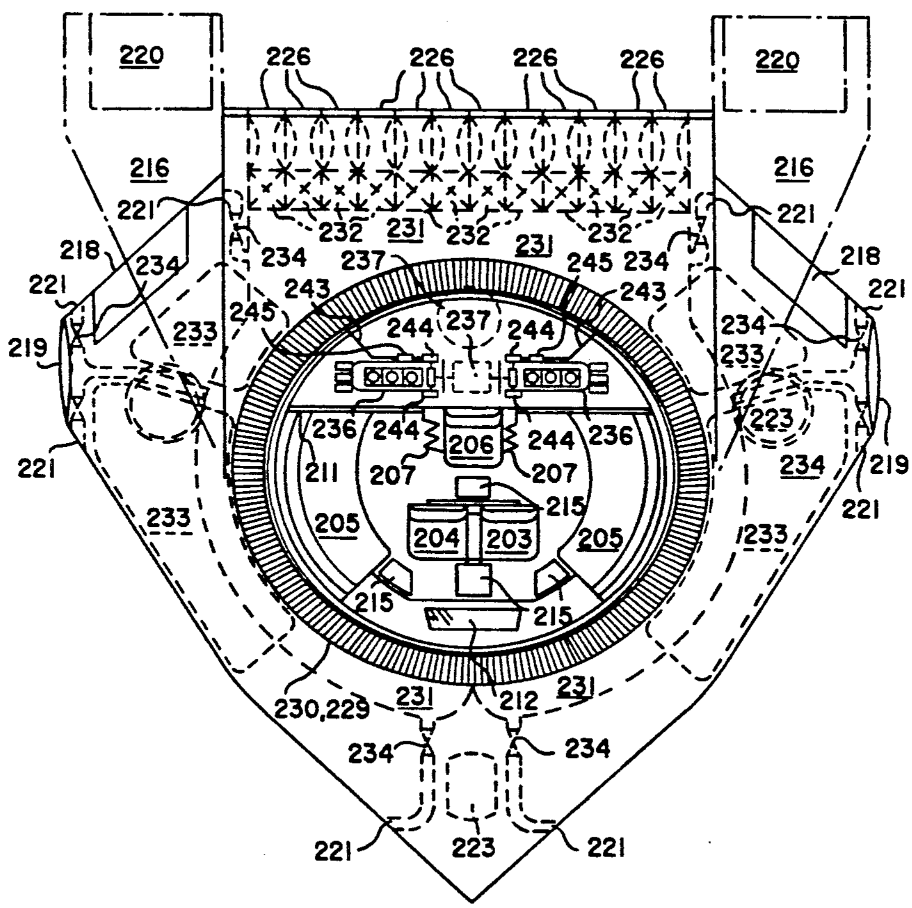


FIG. 1

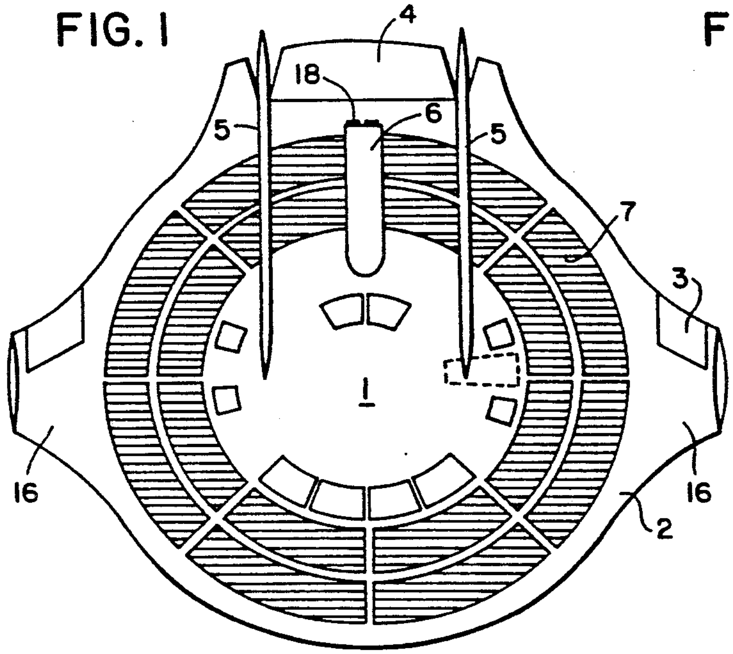


FIG. 2

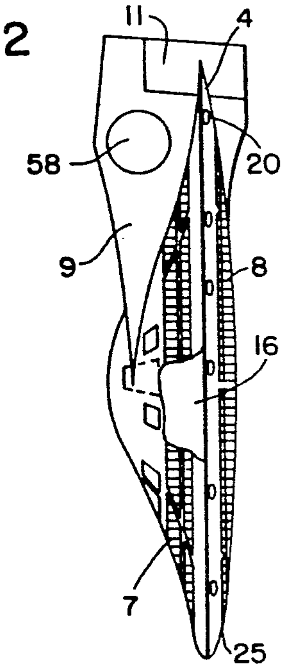


FIG. 3

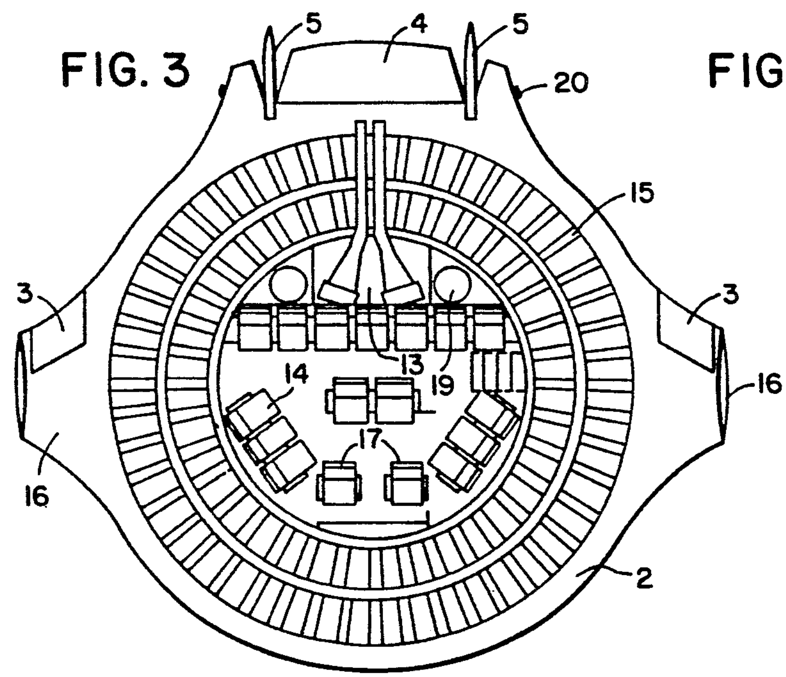


FIG. 4

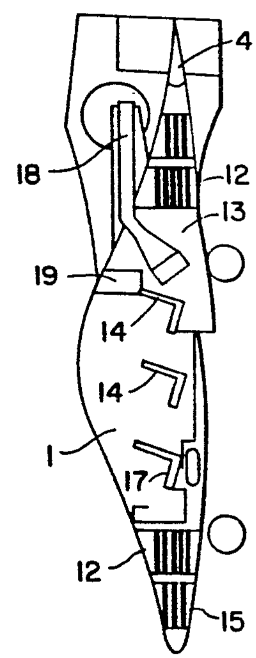


FIG. 5

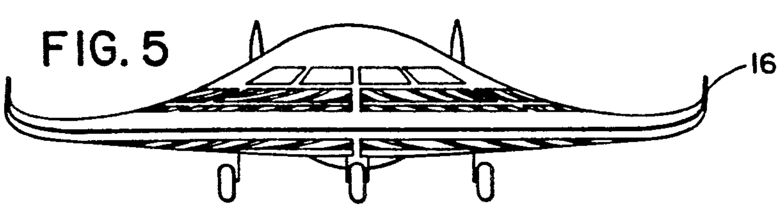
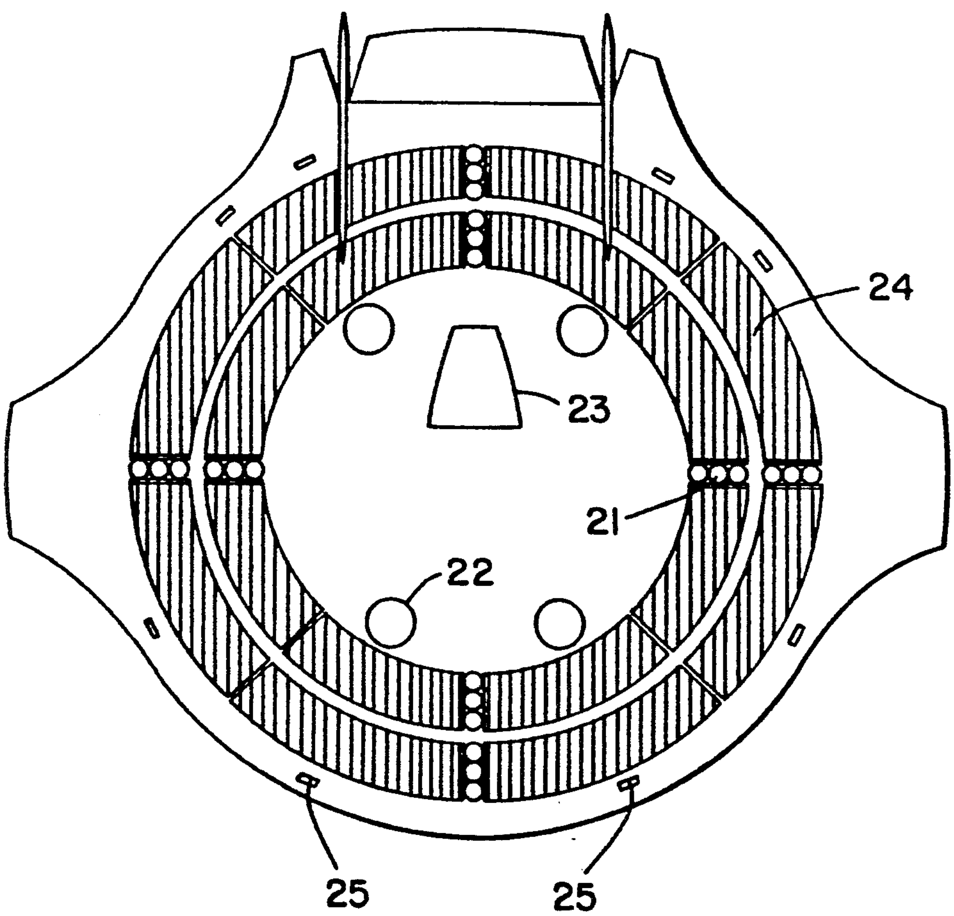


FIG. 6



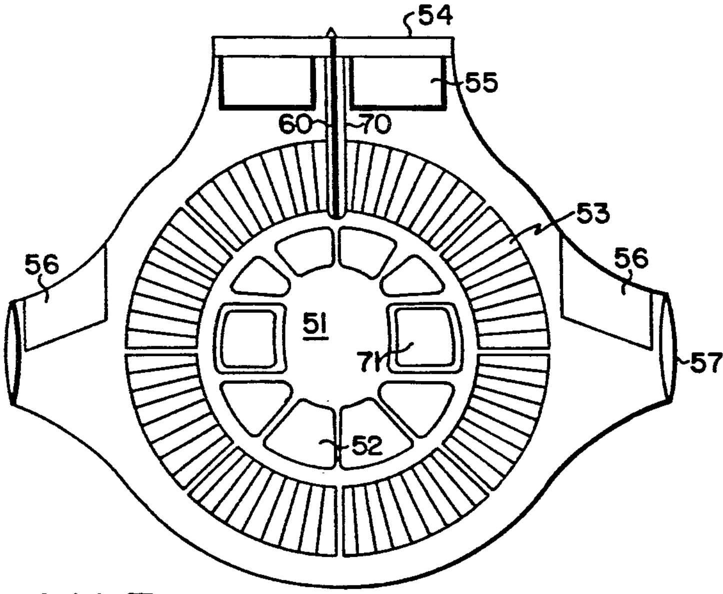


FIG.7

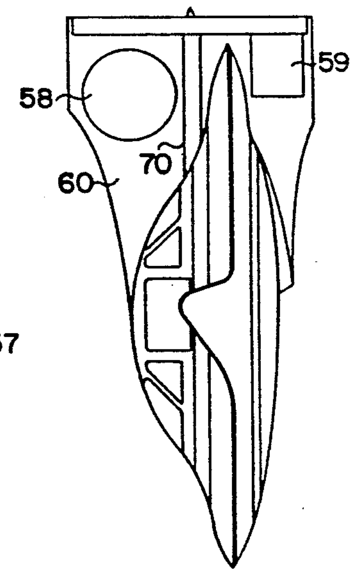


FIG.8

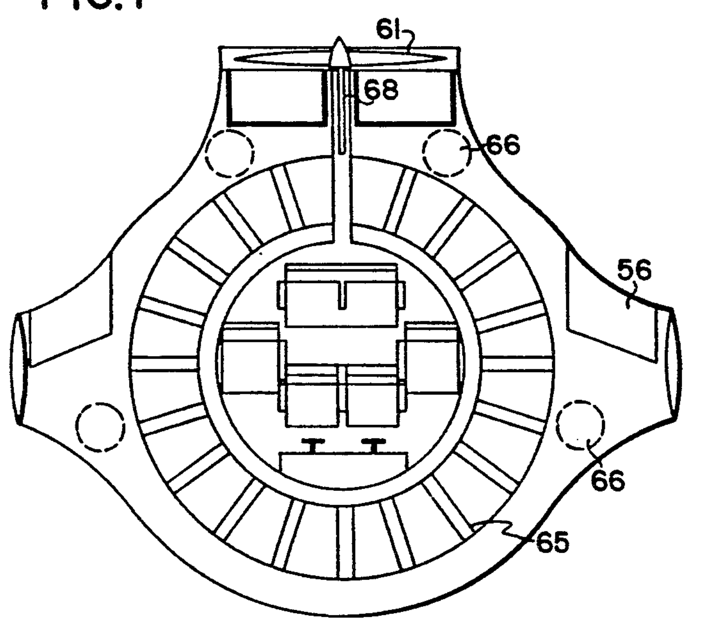


FIG.9

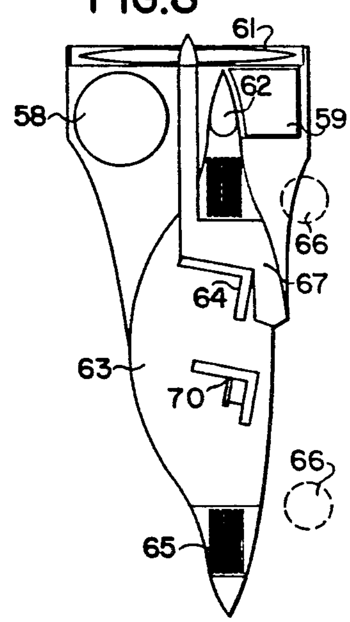


FIG.10

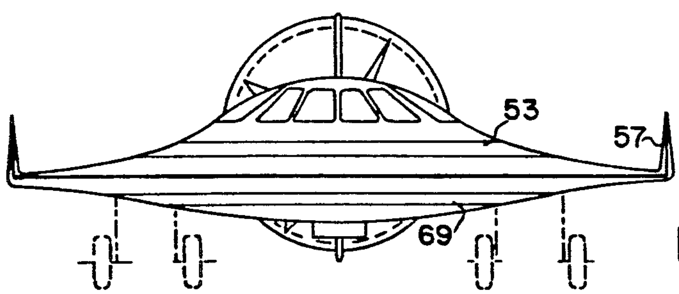


FIG.11

FIG. 12

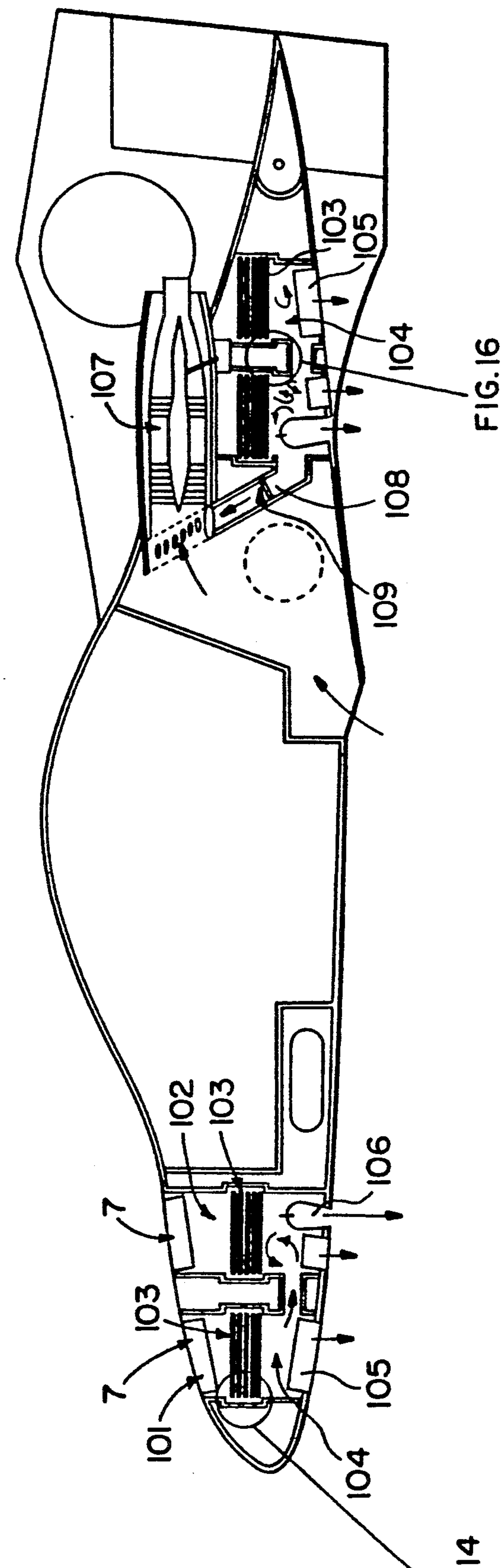

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FIG.16
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FIG.14

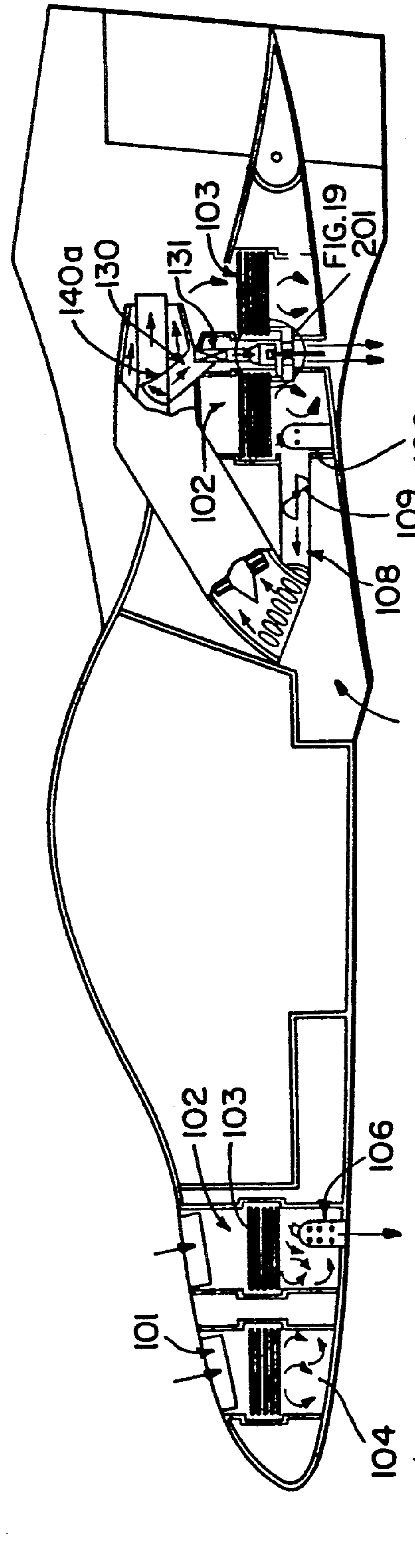

FIG. 13

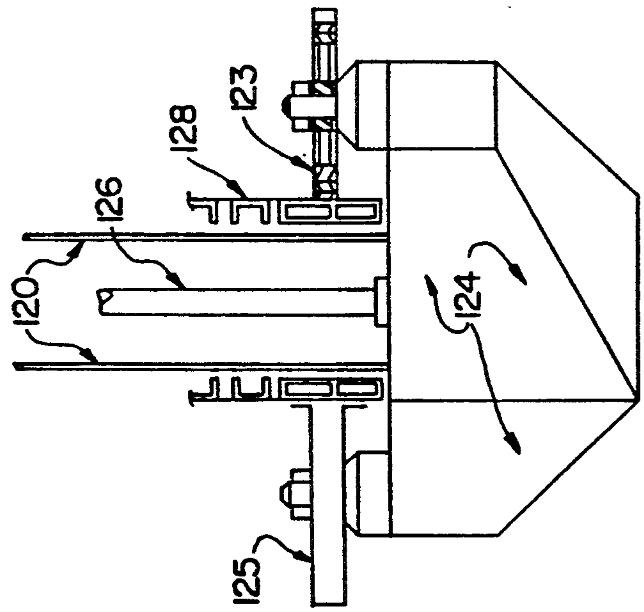

FIG. 16

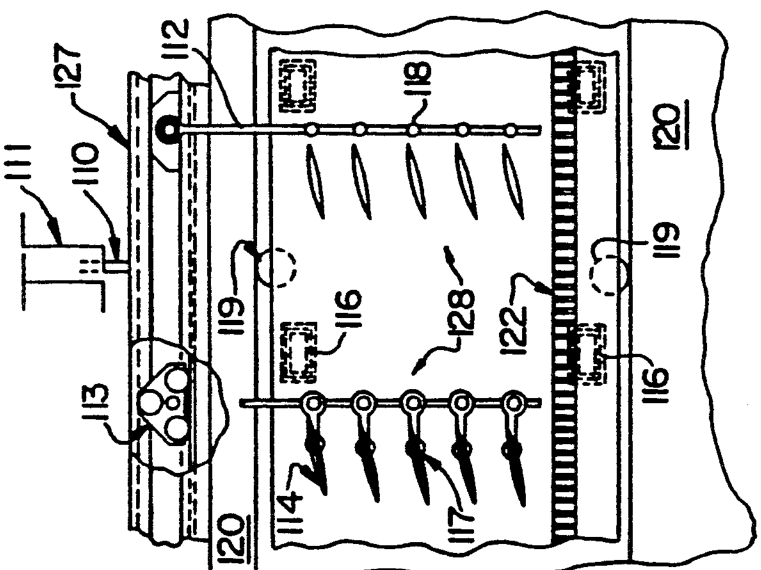

FIG. 15

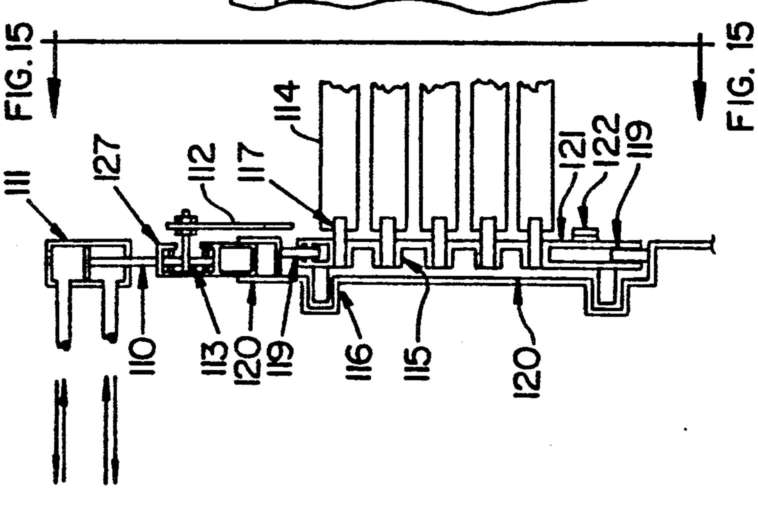

FIG. 14

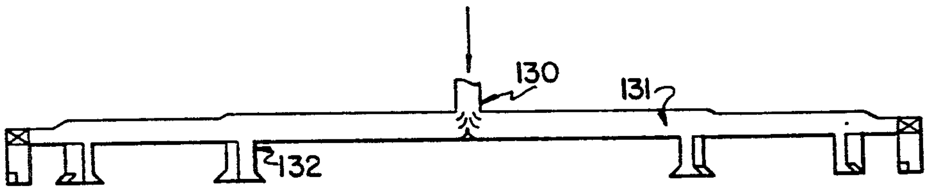

FIG.18

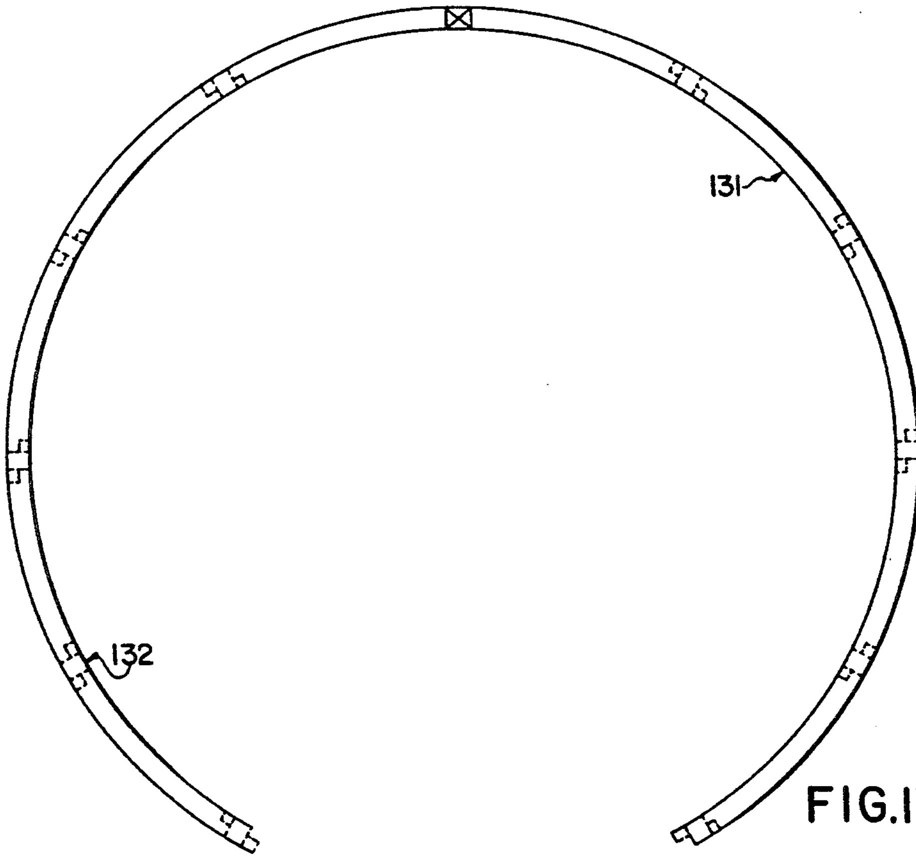

FIG.17

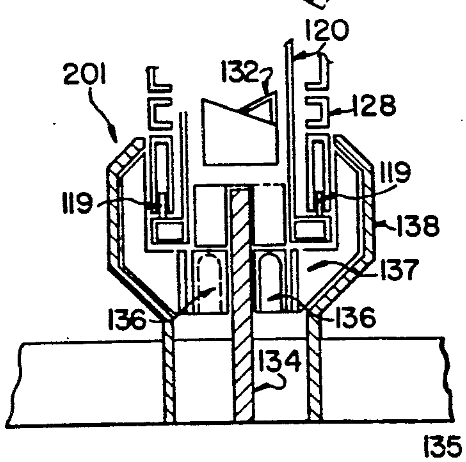

FIG.19

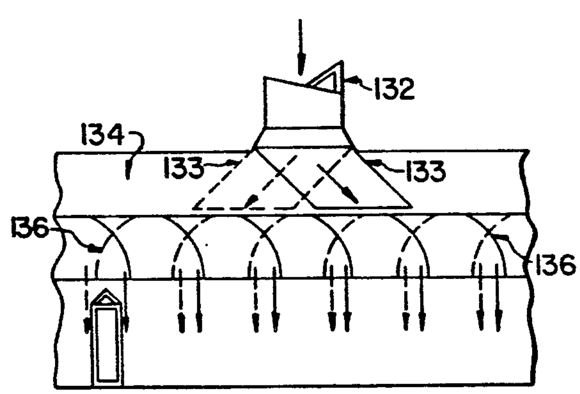

FIG.20

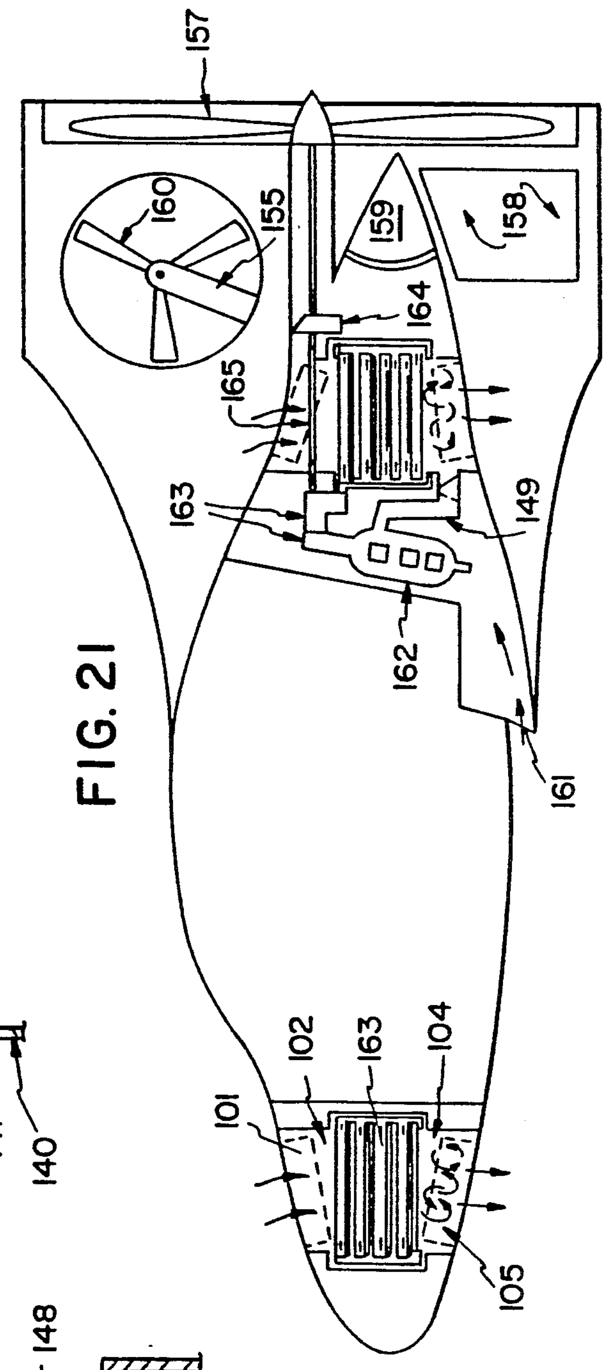
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FIG. 21

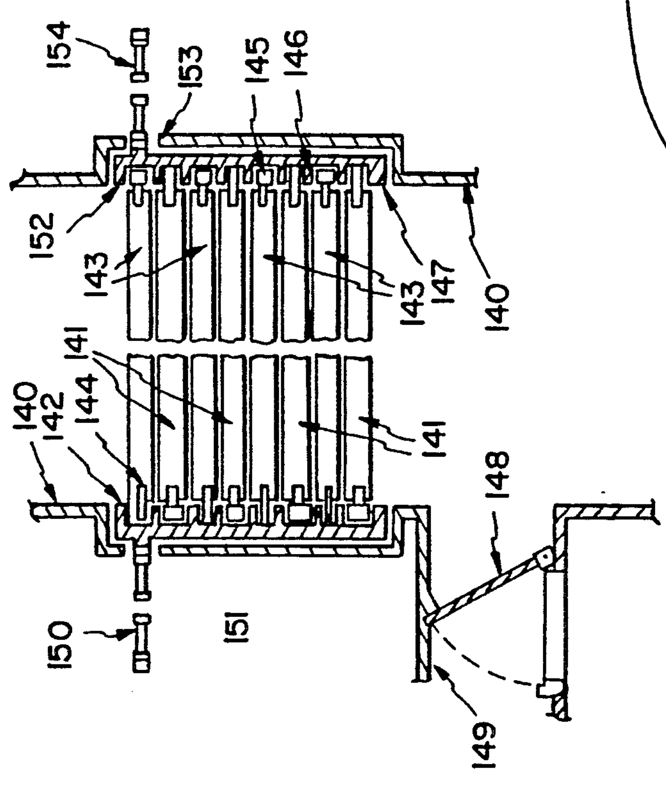
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FIG. 22

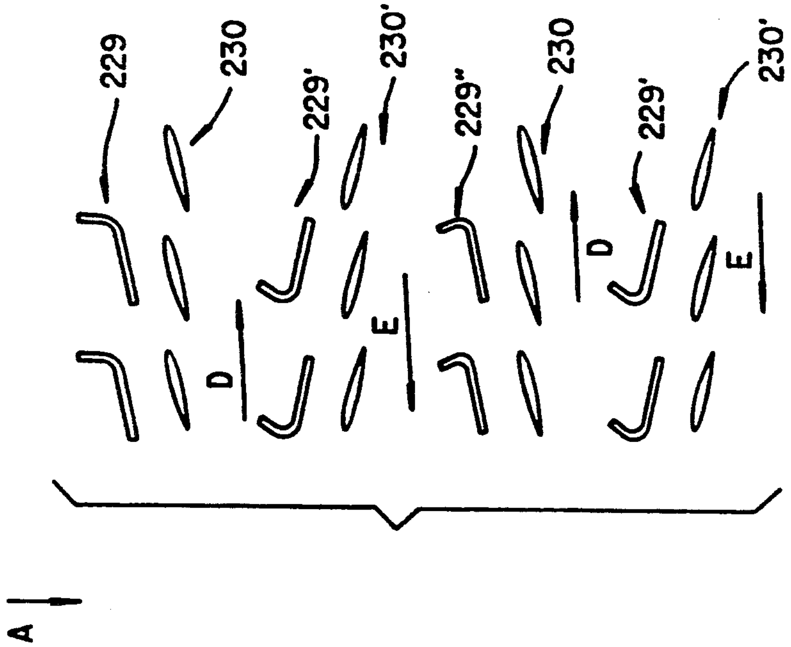

FIG.23b

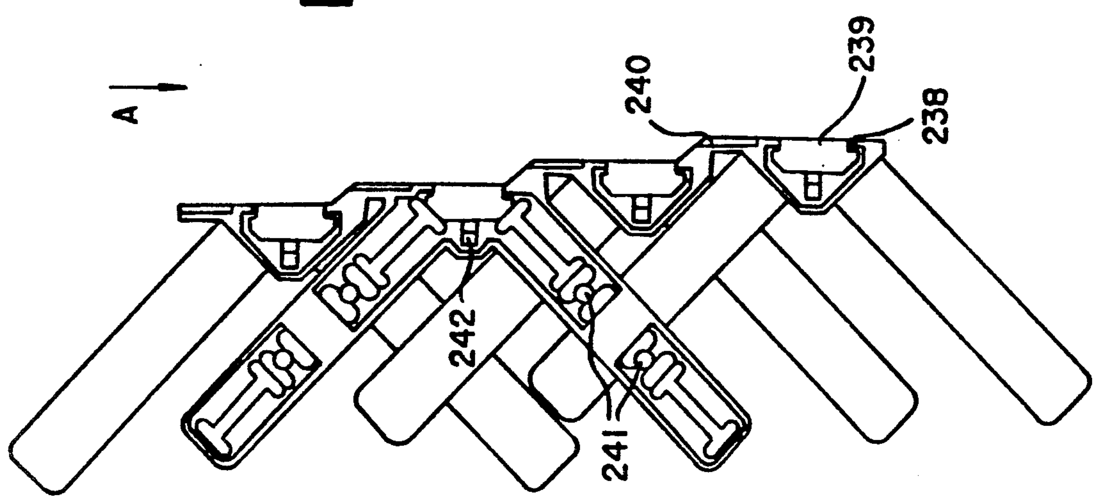

FIG.23a

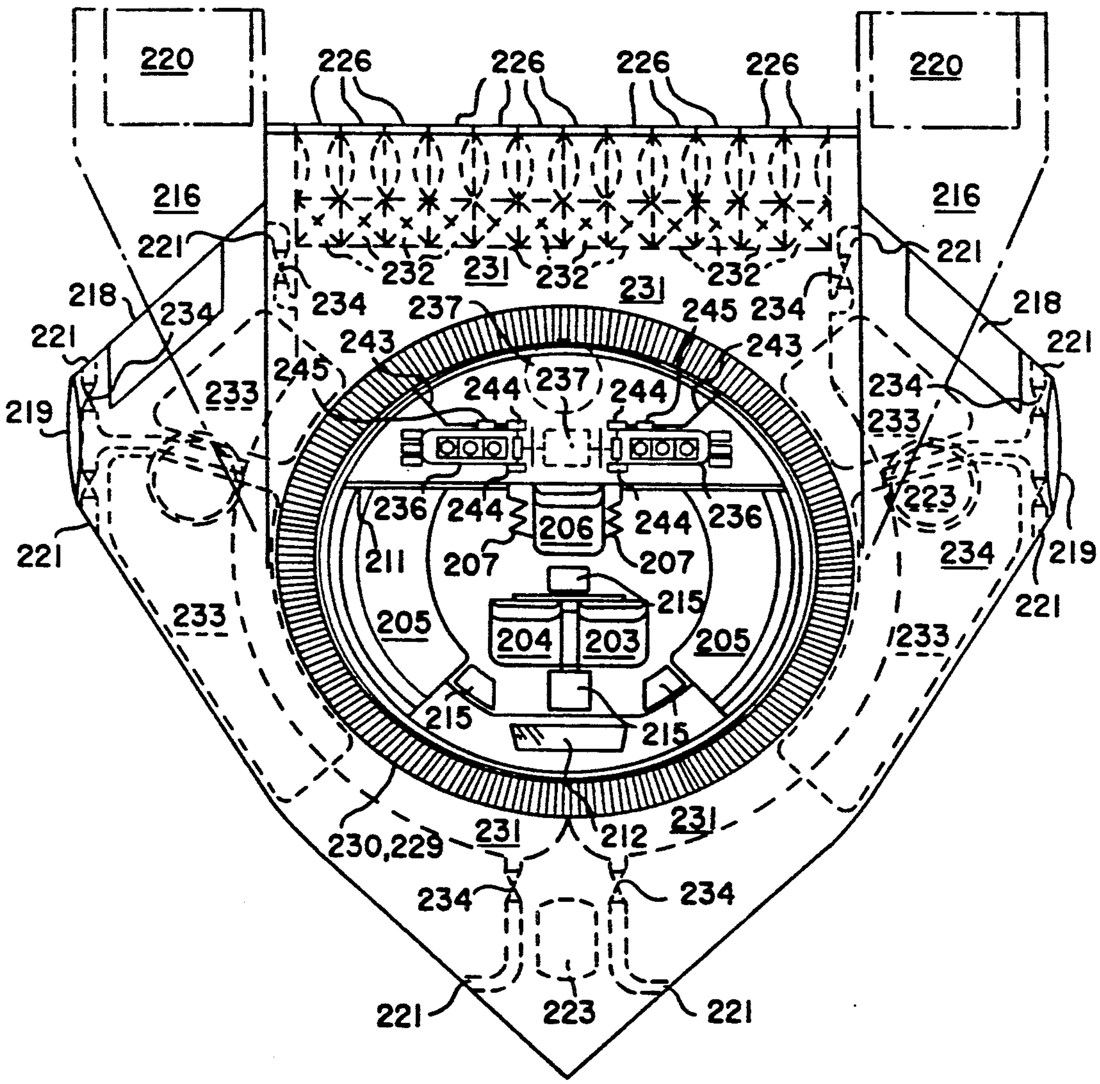
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FIG.24

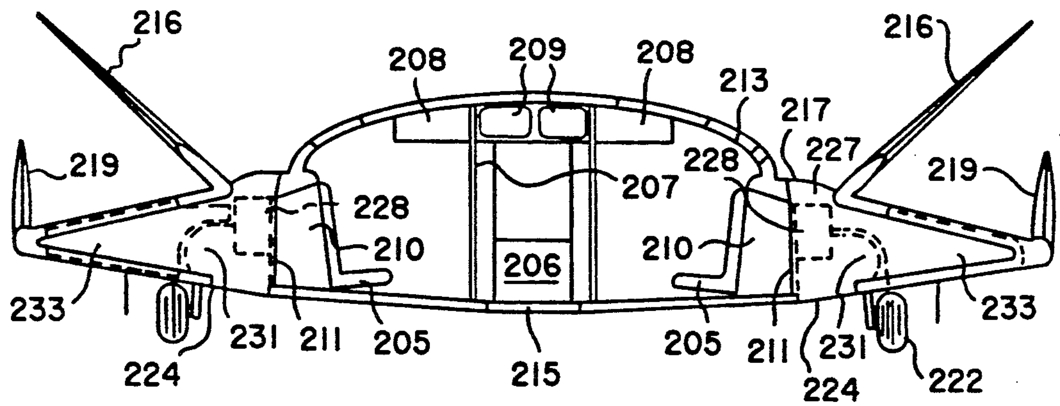
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FIG.25

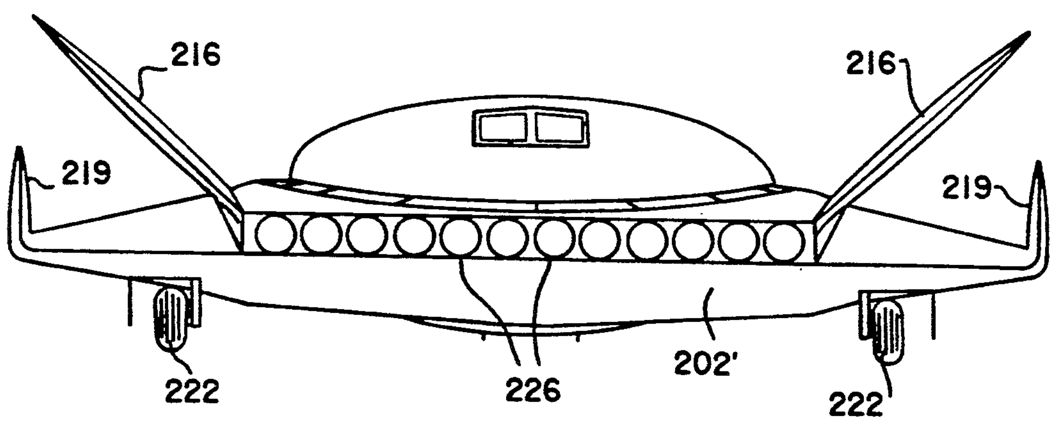
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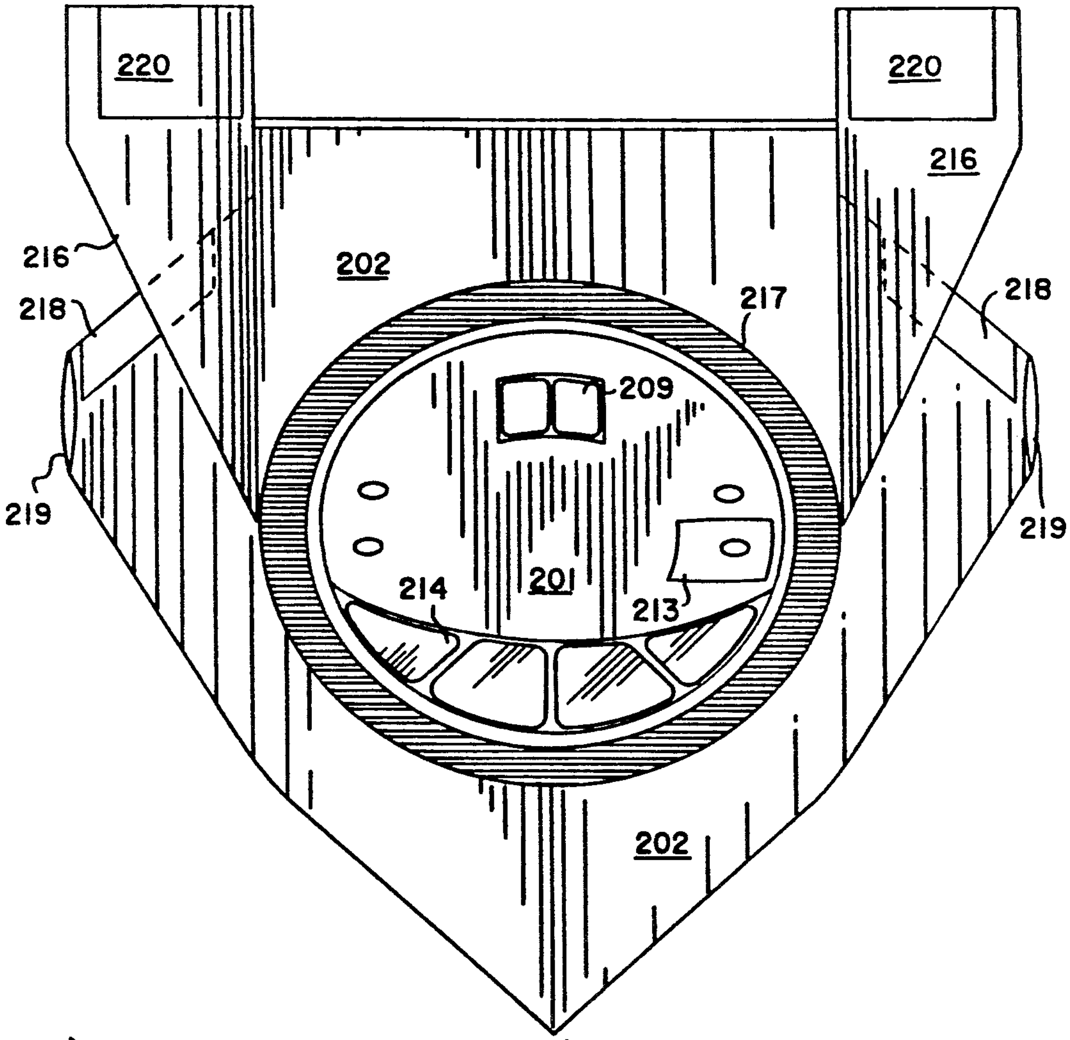
FIG.29

FIG.26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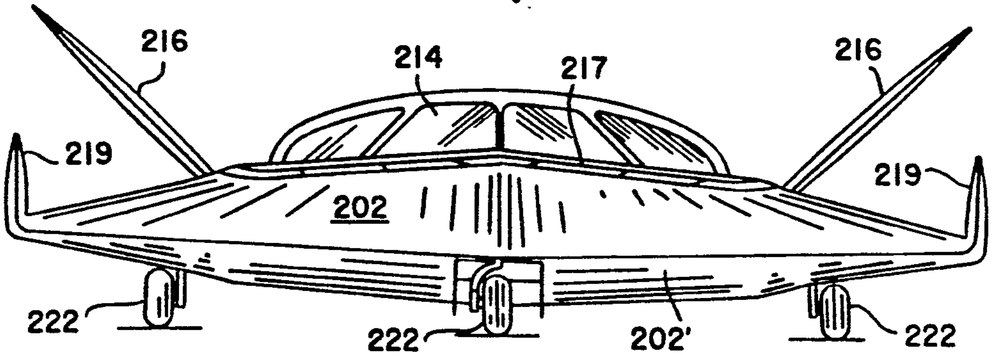
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FIG.27

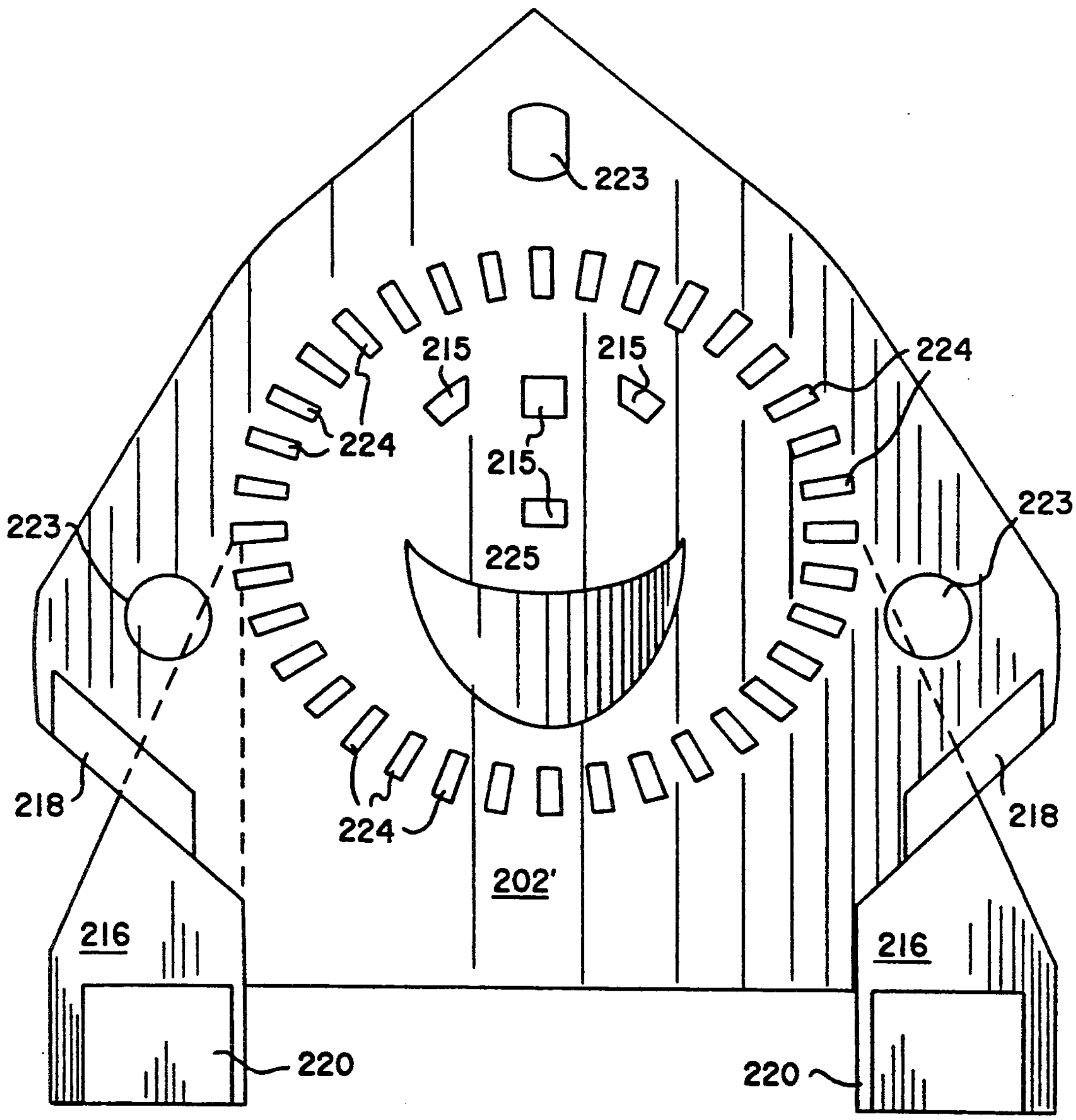
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FIG.28

TURBOCRAFT

The invention relates to a lifting device to lift vehicles from the ground and help them travel through air. Lift is generated by rotating a number of blades with an airfoil section around a circle with enough angular velocity to produce the required lift force capable of lifting the vehicle that contains it.

BACKGROUND OF THE INVENTION

The conversion of energy to effect a translational motion through air is well known in the prior state of the art. Aviation has evolved from simple flying machines early in this century to supersonic flight and rocketry flying beyond the confines of our planet. However, as aviation traffic increases, the number of accidents and near misses increases too. The configuration of present day aircrafts make them vulnerable to the action of thunderstorms and wind shears. In addition, their dynamic stability and balance are heavily compromised and jeopardized when a shift of the center of gravity due to an improper loading arrangement or flight attitude occurs. The recent increase in the size of terminal control areas reduces the freedom of flight by general aviation and intensifies the labor force required to effect adequate traffic separation.

The instant invention provides a novel method of flying in that the counter rotation of airfoil shaped blades is arranged in tandem or side by side or even in a plurality of stages and moving around the outer edge of a saucer shaped vehicle to raise it above ground, and, in effect is capable of attaining a high angle of climb or descent.

This characteristic would render obsolete the present day, essentially flat, takeoff and landing patterns which in turn require very large terminal control areas and runways. In addition, it will allow the reduction in size of present day airports, and along with it a corresponding lessening of the danger of midair collisions, reduction in size of terminal control areas and increases in handling capacity of airports.

In addition, the structurally compact configuration of the instant invention will allow it to resist heavier wind loads, reducing the danger of structural collapse and disintegration in midair when hit by thunderstorms.

SUMMARY OF THE INVENTION

The instant invention is in effect similar to the present day helicopter in the sense that it has rotors (turboblades) that turning around an axis generate the required lifting force to provide an airborne condition. However, a helicopter rotor is a long cantilevered blade attached to an axis and afflicted by inherent disadvantages such as:

1. Structural fatigue of the metal due to continuous repetitive cycles of stress reversal,
2. Inefficiency of lifting power of the rotor as it approaches the axis of rotation,
3. Severe limitations as to its service ceiling and cruising speed due to its high wind loading, and
4. Continuously variable eccentricity between the center of lift and the center of gravity of the vehicle.

The instant invention removes the first three disadvantages almost in their entirety and reduces the fourth to a substantial degree.

In addition, the mechanical design of the instant invention allows it to gradually shift from total lifting power to total thrusting power and vice versa. This condition would allow it to climb to its assigned flying altitude and as it reaches it, it gradually shifts from climbing to thrusting power until it attains the desired cruising speed.

In a further developed of the invention there is provided an aircraft having a body which has a profile in direction of flight as a profile of an airplane wing. It has within its body two concentric counter-rotating turboblade assemblies for effecting a vertically downwardly directed air stream. Through aforesaid assemblies power generating means and coupling means are provided for coupling power from the power generating means to the turboblade assemblies for maintaining them in rotary motion. The aircraft also includes thrusting means coupled to the power generating means for effecting horizontal thrust to the aircraft, and retroboosting devices including a plurality of combustion chambers located below and/or to the rear of the turboblade assemblies for boosting the downwardly directed air stream.

According to a further feature of the invention there is provided a compressed air plenum disposed below the turboblade assemblies which is in fluid communication with the aforesaid combustion combustion chambers, with an intake port of the power generating means, with the lower exhaust air vanes and with rear exhaust air openings for supplying oxygen for sustaining combustion in the combustion chambers, for sustaining combustion in the power generating means, and for provided a vertical lifting force through the lower exhaust air vanes, and for providing a horizontal thrusting force through the rear exhaust air openings.

The aircraft according to the invention further includes upper vanes disposed above the turboblade assemblies for ingesting air, and still further includes respective upper and lower vane rear opening control means.

It is an object of this invention to provide an improved energy conversion system.

It is another object of this invention to provide a system that can be installed within a vehicle in such a manner that it could pivot around any of three axes and in so doing move the vehicle forward, backward, upward, downward and/or sideward much in the same way as aircrafts, rotor crafts or any combination of them could achieve as they exist in the present state of the art, and further to improve on any such motions and if necessary with the air of electronic devices attain complete control of attitude of such vehicle within the atmosphere to carry passengers and/or cargo between geographical points on Earth.

Other objects of this invention will appear from the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** shows a plan view of the invention in turbojet propulsion configuration;

FIG. **2** shows a side elevation;

FIG. **3** shows a horizontal cross section;

FIG. **4** shows a longitudinal cross section;

FIG. **5** shows a front elevation;

FIG. **6** shows a bottom view;

FIGS. 7 shows a piston-propeller propulsion configuration of the instant invention;

FIG. 8 shows a side elevation of the configuration according to FIG. 7;

FIG. 9 shows a horizontal cross section of the configuration according to FIG. 7;

FIG. 10 shows a longitudinal cross section of the configuration according to FIG. 7;

FIG. 11 shows a front elevation of the configuration according to FIG. 7;

FIG. 12 shows a longitudinal cross section of a turboprop/turbojet engine propulsion configuration at a larger scale than FIG. 4;

FIG. 13 shows a turbofan/turbojet engine propulsion configuration at a larger scale than FIG. 4;

FIG. 14 shows a fragmentary cross section of the turbo-blade system;

FIG. 15 shows another fragmentary cross section of the turbo-blade system;

FIG. 16 shows a detail of the mechanical transmission of power to the turbo-blade system;

FIG. 17 shows a plan view of an exhaust manifold;

FIG. 18 shows a cross section of the exhaust manifold according to FIG. 17;

FIG. 19 shows a cross section of the energy transferring exhaust nozzles and blades;

FIG. 20 shows an elevation of the turbo-blade energy transferring exhaust nozzles and blades;

FIG. 21 shows a longitudinal cross section of the piston-propeller propulsion configuration at a larger scale than FIG. 10;

FIG. 22 shows a detail of the counter-rotating turboblade compressor in the tandem configuration.

FIG. 23*a* is a diagrammatic fragmentary, part cross-sectional elevational view of the turboblade assemblies, showing details of the ball bearings supporting the rotating turbo-blades;

FIG. 23*b* is a diagrammatic fragmentary detail view of counter-rotating turboblades with intervening stationary blades;

FIG. 24 is a plan top-down view of the aircraft in a version having a plurality of rearward-facing exhaust air nozzles;

FIG. 25 is an elevational, cross-sectional view of the invention according to FIG. 24 seen from the front;

FIG. 26 is a plan top-down view of the invention showing various features of the upper surfaces of the aircraft, including transversely oriented intake air vanes.

FIG. 27 is an elevational front view of the invention according to FIG. 26.

FIG. 28 is a plan view of the invention seen from the bottom up, showing bottom surface details and radially oriented lower exhaust air vanes; and

FIG. 29 is an elevational rear view of the invention according to FIG. 28, showing rearward facing exhaust air nozzles.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The instant invention is basically a combination of an airplane and a helicopter.

The Wing

As an airplane, the instant invention contains the necessary and sufficient elements for it to fly.

FIGS. 2 and 4 show that the profile of this vehicle has an aerodynamic shape similar to the wing of an airplane, and, consequently capable of generating lift. It is in effect a flying wing. Laterally disposed winglets 16 have been added at the periphery span ends of the wings in order to improve its efficiency.

Shown on FIGS. 1 through 6 are the balance of basic elements required for an airplane to fly, namely ailerons (3), rudder assembly (5) and tail [elevator] (4). The cabin (1) is located at the center of the vehicle with seats for pilot and copilot (17) at the front and the passenger seats (14) distributed elsewhere within the space. At the rear of the passenger area is an engine compartment (13) and on each side of its luggage space (19) with landing gear space (22) under it. Fuel tanks are located around the outer circumference (2). The gas turbine's exhaust shroud (6) is located in back of the cabin enclosing the engine exhaust jet nozzles (18). The air intake (23) is shown on FIG. 6 along with the lower vanes (24) and the retro-boosting jet nozzles (21).

The circular configuration of this vehicle generates a very large wing area and reciprocally a very small wing loading relative to an airplane of similar weight. This means that the vehicle can float in air much better than a comparable airplane. The altitude that can be attained by an airplane in inversely proportional to its wing loading. Therefore, if assisted by enough generating power the airplane according to the instant invention can attain higher flying levels than a comparable airplane.

It is recognized that because of its configuration, total drag (a function of frontal area plus exposed surfaces) generated by this vessel could be higher than a comparable airplane of similar weight. This condition would tend to reduce its cruising speed relative to a comparable airplane when flying at the same altitude. However, since air density diminishes with altitude at a logarithmic rate while the total drag area ratio is constant, a small increase in the service ceiling would suffice in order that both drag forces become equal. Therefore, in attaining a sufficiently higher flying level, total drag generated by this vehicle would be less than that of a comparable airplane. At that point its cruising speed would be greater.

The Turbo-Blade Systems

As a helicopter, the instant invention contains also all necessary elements for it to climb, hover and fly.

FIG. 3 shows a horizontal cross section of the instant invention. A plurality of turbo-blades (15) are arranged within two circles. The inner circle blade set rotates in one direction while the outer circle blade set rotates in the opposite direction. This arrangement is herein called side by side. In the tandem arrangement there would be only one circle within which two sets of blades would rotate. One set would rotate counter to the other, both being vertically separated. A plurality of sets could be built with either arrangement. As in a steam turbine a number of fixed blades could be introduced between blade stages in order to redirect the air flow from one blade stage to the next one.

The advantage of these systems as compared to that of the helicopter are summarized as follows:

1. Each blade is supported at each end like a simple supported beam, as compared with the cantilevered beam concept of the helicopter rotor. No high stress nor stress reversal would exist under this condition but only normal working stress-strain cycles. Given a conservative section modulus to span ratio, the useful life of a blade can be extended indefinitely.

2. A blade's high aspect ratio coupled with its confined end condition will render it a very efficient lifting device. Located at or near the outer edge of the circle that embodies the instant invention's frame, each set of blades develops lift while avoiding the inherent aerodynamic inefficiency of the helicopter's rotor as it approaches its center of rotation.
3. Given its conceptual configuration, the total turbo-blade area of the instant invention can easily double the total rotor area of a similar weight helicopter. When its higher aerodynamic efficiency is added, the resulting lower wing loading will render a powerful lifting platform capable of climbing at a high angle and rate of climb, faster, and sustaining a higher service ceiling than the comparable helicopter.
4. The total drag produced by the projected frontal and exposed surfaces of the turbo-blade assembly of the instant invention is less than that produced by the combined rotor assembly plus fuselage surfaces of the compared helicopter. Therefore, given the same amount of power applied, the linear velocity attained by the instant invention's turbo-blade assembly will be greater than that of the helicopter rotors with the same amount of total drag generated by each. Hence, since lift is a direct function of the linear velocity of the blade, the total lifting power of the turbo-blade assembly will also be higher than that of a comparable helicopter.
5. The counter rotating effect of the turbo-blade system coupled with its location around the outer portions of the circular airframe tends to neutralize the vibrating effect of the variable lifting force pattern. This neutralizing effect compares favorably with the vibration generated by the single rotor system of a comparable helicopter.

The transmission of power between the jet engines and the turbo-blade system may be attained either by transferring the shaft rotating energy of fan-jet engines through mechanical means to the turbo-blades or by diverting the hot air jets of the jet engines through exhaust manifolds to the turbo-blade assembly.

The Lifting Vanes and Yaw Control Systems

In order to convert the instant invention from a climbing attitude to a translational condition it is necessary to operate upper and lower vane system. These systems are shown on FIGS. **1**, **2** and **5** (**7**), and on FIGS. **6** (**24**).

For the rotating turbo-blade system to operate as a helicopter, it is necessary that air flow through them freely. Consequently the upper and lower surface of the wing comprising the area where the turbo-blade system is located, is open to the air. On the other hand, for this vehicle to operate as an airplane, air gas must flow uninterruptedly along the upper and lower surface of the wing.

The upper and lower vane systems are a series of thin flat metal pieces rotatable about a longitudinal axis and installed on the upper and lower surface of the vehicle above and below the turbo-blade system. FIG. **1** shows the lifting vanes **7** arranged parallel to each other and perpendicular to the line of flight. FIG. **6** shows them (**24**) arranged parallel to each other and parallel to the line of flight. A radial arrangement, FIG. **7**, may also be made wherein each vane (**53**) will have a radial configuration.

The yaw control system, used mainly while the vehicle is under a hovering attitude may consist of either one of the following two systems:

Propeller driven

This system consists of one or two propellers **58** installed in the rudder assembly as shown in FIG. **2**. Enough power must be diverted from the engines, or generated through an independent source to activate the propellers and balance the yaw producing torque of the counter rotating turbo-blade systems.

Jet Driven

This system consists of exhaust jet nozzles **20** placed on an angle with the longitudinal axis of the vehicle and located on the exterior face of the horizontal stabilizer as shown in FIG. **2**. Power must be diverted from the engines to activate either one with enough force to balance the yaw producing torque of the counter rotating turbo-blade systems.

The Retro-Boosting System

In addition to the turbo-blade system the instant invention can be fitted with a system that will increase its climbing power. It can be called a retro-boosting system **21**. See FIG. **6**. The turbo-blade system is in effect similar to a multi-stage turbine. It will compress the air entering from above through the upper lifting vane **57**. As it leaves the last stage a portion of this compressed air will be guided into combustion chambers **169** (FIG. **12**) where it will be mixed with fuel and ignited with the resulting hot gases exhausted into the air below. It is recognized that the design of a jet engine is well known in the prior state of the art, therefore no attempt is made herein to include the design details of the retro-boosting system as part of these specifications. However, the concept of its use in the manner described herein and shown on FIG. **6** as boosters **21** is made a part of this invention. A plurality of these boosters **21** may be installed within the compressed air plenum housing and used to shorten the climbing period until the desired cruising level is attained.

The Multi-Directional Control System

Heretofore, the aircraft of the instant invention has been shown to be capable of climbing, hovering, flying forward, turing and descending. This maneuvering capability means that it can roll, pitch and yaw at the discretion of the command pilot. However, in order to achieve complete directional control it is necessary that in addition, the aircraft be capable of moving sidewards and/or backwards while in a hovering attitude. By diverting some of the power of the jet engines into a plurality of nozzles located around the circumference of the vehicle, much in the same way as the jaw control nozzles are located, and spaced appropriately between each other, FIGS. **2** and **6** (**25**), it is possible by firing two or even three nozzles at a time to attain complete motion control in all directions in a horizontal plane.

Compressed Air Plenum

A compressed air plenum provides additional pre-compressed air (and consequently oxygen) to the turbo-fan and/or turbojet engine system in order for them to provide sufficient power to fly at higher altitudes than those attained by the present state of the art aircraft. The reason is that an increase in power will be obtained from the jet engine system if additional oxygen is supplied to it at the point of its maximum service ceiling.

This condition will translate into an increase in both the service ceiling and cruising speed of the aircraft.

FIGS. **12** through **20** illustrate all major systems in greater detail. FIG. **12** represents a turbocraft powered by a turboprop engine system where a power is transferred to the turbo-blade system through mechanical means. FIG. **13** represents a turbocraft powered by a turbojet engine system wherein power is transferred to the turbo-blade system through an exhaust manifold system **201**. Other propulsion means like low and/or high by-pass ratio turbofan engine systems may be used to propel the instant invention, but for reasons of brevity they are not shown herein. The main concern is not within propulsion systems alone but with all the systems that are involved in the instant invention.

Referring to FIG. **12**, outside air enters the system through upper vanes **101** into intake chamber **102**, whereupon it enters the multi-stage compressor (turbo-blade system) **103** where it is compressed. At this point it is necessary to clarify the following:

1) FIG. **12** shows a side-by-side axial multi-stage compressor (turbo-blade system) where the inner compressor rotates in one direction counter to the outer compressor, and,
2) No stator stage is shown as part of this presentation, although it is possible to add it to the system.

The stators could convert the kinetic energy of air into additional pressure increasing the efficiency of the compressor (turbo-blade system). A solution similar to the latter indicated for the tandem type multi-stage compressor (see Piston-Propeller propulsion configuration) wherein one of the two rotating systems is fixedly attached to the structural frame, and therefore, remains stationary while the other rotates can be used.

Compressed air exiting the multi-stage compressor enters the compressed air plenum **104**. Depending on the flying attitude the compressed air may be used for one or more of the following purposes:

1) to lift the vessel from the ground and help it climb through air by exhausting the highly pressurized air through the open lower vane system, with gate valve **109** closed.
2) to feet the combustion chambers and nozzles (**106**) located under the vessel (retro-boosting system) while closing the lower vane system (**105**), closing gate valve **109** and firing the retro-boosting system, in order to attain a much faster rate of climb, and,
3) to feed additional oxygen to the intake chamber of the propulsion system, be it turboprop, turbo-fan or turbojet, while a portion of the upper vane system is open and the lower vane system is closed, through exhaust conduit **109** with gate valve **108** open, in order to attain higher altitudes and cruising speeds.

FIGS. **14** and **15** show a detailed arrangement of the turbo-blade system wherein rotatable housing **121** and **128** is connected to fixed housing **120** through roller bearings **116** and **119**. Blades **114** are attached to rotatable housing **128** through stub shafts **117** mounted on ball bearings **115** at the ends of each blade. At this point two optional conditions have to be clarified. The are as follows:

1) roll and pitch control to be asserted independently and in addition to all exterior surfaces such as ailerons and tail assembly,
2) roll and pitch control to be obtained only through the action of ailerons and tail.

If condition 1 is to be achieved then the lifting capacity of the turbo-blade system would have to vary around the circumference of the vessel. This is accomplished by varying the angle of attack of the blades around the circumference of the turbo-blade system. A lever (not shown) controlled by the pilot in command feeds hydraulic cylinders **11** located at different stations around the periphery of housing **128**, to lower or raise rod and piston **110** a small amount. Rod **110** is fixed to guide **127** designed to be capable of such small vertical movements. Guide **127** contains bearing assembly **113** to which connecting rod **112** is attached. Each blade is connected to rod **112** through connecting pin **118**. By raising rod **112** the set of blades at that station would increase its angle of attack and consequently its lifting power, while the set of blades diametrically opposed to that station would reduce its angle of attack and consequently its lifting power. The result of this action would be a rolling effect around an axis perpendicular to a vertical plane containing the two stations. This system may be connected to an automatic pilot system in order to maintain level flight at all times even under hovering conditions.

If condition 2 is to be achieved, then the turbo-blade system is to be directly attached and fixed to the inner housing **128**. Due to the gyroscopic effect of the rotating compressor blades, much of the levelling characteristics of the craft will be inherently maintained but the pitch and roll control will have to depend on other sources.

FIG. **16** shows in greater detail the mechanical transmission of power from the engine compartment through shaft **126** into clutch and transmission box **124**. This box has two terminal gears **123** connected to continuous gear **122** fixed to inner housing **128**, each gear **123** rotating counter to the other and generating the counter rotating movement of the side-by-side turbo-blade system.

FIG. **13** shows a turbocraft powered by a turbojet engine system wherein power is transferred to the turbo-blade system through an exhaust manifold system. After the turbojet engine system is started the pilot in command will actuate gate valve **140** located in the tail pipe section of the jet engine. At the pilot's discretion a portion of the hot gases is diverted into exhaust main **130** shown in FIG. **18**, and then into exhaust manifold **131**. From there the hot gases are distributed around the circumference of the manifold through vertical outlets **132** shown in FIGS. **17, 18, 19** and **20**. From there the hot gases are diverted into nozzles **133** exhausting in two opposite directions and transferring all its kinetic energy to blades **136** which are fixed through gusset plates **137** to rotatable housings **128** containing the turbo-blade system. Diaphragm **134**, strut **135** and housing **138** shown on FIGS. **19** and **20** are a part of the structural frame.

The design and operation of the turbocraft could be summarized into ten basic propulsion-transmission-compression modes as follows:

1) the turbofan-turbojet propulsion/hot gas exhaust manifold transmission mode with retroboosting system and side-by-side compression mode;
2) the turboprop propulsion/hot gas exhaust manifold transmission mode with retro-boosting system and side-by-side compression mode;
3) the turboprop propulsion/mechanical transmission with retro-boosting and side-by-side compression mode;

4) Mode 1, but with tandem type compression in lieu of side by side mode;
5) Mode 2, but with tandem type compression in lieu of side-by-side mode;
6) Mode 3, but with tandem type compression in lieu of side-by-side mode;
7) the reciprocating propulsion/mechanical transmission with retro-boosting and side-by-side compression mode;
8) the reciprocating propulsion/mechanical transmission with retro-boosting and tandem type compression mode;
9) the reciprocating propulsion/mechanical transmission without retro-boosting but with tandem type compression mode;
10) Mode 1, 2, 3 and 7 but with stator blades in the side-by-side compression mode;

The reciprocating propulsion configuration is explained hereinafter as the piston-propellor propulsion configuration.

The operation of the turbocraft under modes 1, 2, 4, 5 and 10 can be summarized as follows: When the pilot in command is ready to initiate the take-off he actuates valve **140***a* (FIG. **13**). connecting the exhausting hot gases with the compressor (turbo-blade system) and increases power to initiate the take-off roll. The roll is required in order not to scorch the tarmac with the vertically exhausting hot gases. In so doing, the upper and lower vane systems are open allowing as much air as possible to flow through the compressor. With the engine system blasting at full power and gate valve **140***a* set so as to transfer most power to the compressor, the compressor blades gain sufficient speed so that enough pressurized air is generated and exhausted through the lower vanes, and along with the hot gases from the exhaust manifold transmission lift-off is attained. After reaching a prudent altitude, the pilot in command fires the retro-boosting system while at the same time closing the lower vane system and a portion of the upper vanes and setting valve **140***a* to transfer a higher thrusting power to increase the forward speed of the vessel until the proper rate of climb is attained. Under these conditions an altitude will be reached at which the air density will not allow the engine system to generate sufficient power to keep climbing. At that point the pilot in command closes the retro-boosting system and actuating gate valve **109** diverts enough pressurized air into the jet engine's intake chamber, and in so doing increases the power of the engines until a higher altitude and cruising speeds are attained. At this point the vessel will be flying with a portion of the upper vanes fully open, lower vane system closed, retro-boosting system closed, gate valve **140***a* partly open, with a low power setting to feed and maintain the compressor delivering enough compressed air to the engines through gate valve **109**, and a high power setting for thrusting power. In the landing attitude the procedure will be as follows: As the vehicle approaches its destination, power is reduced, turbo-blade (compressor) deactivated, upper and lower vanes fully closed, gate valve **140***a* closed to the bypass, and open to thrusting power, gate valve **109** closed so that outside air cannot be diverted into the compressed air plenum and vessel pitch increased until proper gliding speed is attained. As the pattern altitude is reached, upper and lower vanes are opened, power is increased and diverted through valve **140***a* in order to activate the compressor, valve **109** continues to be closed and retro-boosting system shut and closed. Lifting power is increased and forward speed reduced until pre-determined parameters are reached. At this point the pilot will apply power and/or maneuver the vessel toward the designated landing area, and land substantially in the same way as a helicopter would do. Additional thrust can be provided by means of rocket devices suitably mounted on the aircraft structure. Such rockets could advantageously be powered by liquid fuel or solid fuel, and serve to provide further climbing power to reach higher altitudes.

ANOTHER TURBO-CRAFT VERSION

The Piston-Propeller Propulsion Configuration

The instant invention as described heretofore is energized and propelled by one or more jet engines. However, the use of one or more reciprocating engines to energize and drive the turbo-blade system coupled to one or more propellers for thrusting power in lieu of the jet engine system constitutes another version of the instant version.

FIGS. **7** through **11** show the cabin (**51**), windshield and windows (**52**), entrance doors (**71**), upper and lower vanes (**53**), propeller protecting shroud (**54**), tail (**55**), ailerons (**56**), winglets (**57**), yaw control propeller (**58**), rudder (**59**), vertical stabilizer (**60**), propeller (**61**), pitch control surface (tail) (**62**), cabin interior (**63**), passenger seats (**64**), turbo-blade system (**65**), landing gear (**66**), reciprocating engine compartment (**67**), propeller shaft (**68**), lower vanes (**69**), and propeller shaft protecting shroud (**70**).

Also, FIGS. **21** and **22** show some of these systems in greater detail. FIG. **21** shows the upper vane system in dotted line (**101**) in the open position. The closed condition is indicated as a solid line following the contour of the wing. Air enters through the upper vane system into the intake chamber (**102**). It travels through the counter-rotating compressor (turbo-blade system) (**141, 143**) shown in FIG. **22**. These blades are similar in shape as those shown as **117** in FIG. **15**, and are supported by shafts **144** mounted on roller bearing **145** at one end and semi-fixed bearings **146** at the other end. Turbo-blade system **143** is attached to rotatable housing **142** and turbo-blade system **141** to rotatable housing **152**. These two housings are mounted on inner and outer fixed housings **140** by means of ball bearings **147**. These ball bearings being designed to accept a certain degree of resiliency in order to accommodate the centrifugal forces and heat generated by the rotation of the compressor blades (turbo-blade system). Continuous circumferential gear **151** is attached to the outer surface of housing **142** and activated through gear **150** attached to transmission gear **163**. Similarly gear **153** is attached to housing **152** and activated through gear **154** in a contour rotating motion. Transmission gear and clutch assembly **163** transfer main power of engine through shaft **165** to transmission gear and clutch assembly **164**, and through gear **150** to rotatable housing **147**, and, similarly transmission gear and clutch assembly **164** transfer rotating power through shaft **155** to yaw control propeller **160**, and through shaft **156** to propeller **157** for thrusting power, and through gear **154** to gear **153** and housing **152**.

As air is compressed and exits the turbo-blade systems **141** and **143** it enters the compressed air plenum **104**. Similarly to what happens with the turbo-fan or turbojet propulsion configurations, this plenum is connected to the turbo charger of the piston engine through exhaust conduit **149** and possibly to a retro-boosting system (not shown in FIG. **21** for clarity). The function of this plenum is threefold, each one depending on the turbocraft's flying attitude. As explained heretofore, in a take-off attitude the turbocraft would initiate the take-off roll with a small power setting for the thrusting propeller and high engine power diverted to the compressor (turbo-blade system) and with both vane systems fully open. The compressed air would flow through the lower vane system (**105**) into the open air below with enough pressure to lift the turbo-craft from the ground. As soon as the turbo-craft attains a prudent altitude the retro-boosting system (optional) would be fired and the low vane system would be fully closed. At that point power would be diverted from the retro-boosting system to the thrusting propeller at the command pilot's discretion until the desired rate of climb is attained. In order to reach higher service ceilings than those attained by the present turbocharged piston-propeller aircrafts, the instant invention provides the following innovation. As the turbocraft climbs, additional oxygen is required by the piston engine in order to burn the proper air-fuel ratio and maintain the required power. This is provided by connecting the pre-compressed air from the compressed air plenum through exhaust conduit **149** and valve **148** to the turbocharger attached to the piston engine. By receiving pre-compressed air the turbocharger would be capable of delivering enough oxygen to the piston engine injectors to maintain power at a higher altitude. An additional operation would be required to complement the proper functioning of this system. Because the turbocraft wing loading is very low, a rather big upper section of the wing could be opened to the air without destroying the flying capacity of the wing. Therefore, a section of the upper vanes would have to be opened to the air so that enough air be handled by the compressor (turbo-blade system) in order to compress the required air volume. The lower vane system would be closed and the retro-boosting system deactivated.

The turbo-blade system shown on FIGS. **7** through **11**, **21** and **22** is the tandem type. The operation (climbing, hovering, flying and landing) of this configuration would be similar to that of the turbo-fan and turbojet engine propulsion mode.

An Improved Turbocraft Version

FIG. **23*a*** shows details of the counter-rotating turboblade assemblies wherein the air stream is flowing downward as shown by arrows A. The reference numerals of all elements shown in FIGS. **23*a*–29** are all incremented by 200 to distinguish them from elements shown in the preceding figures and disclosure.

In FIG. **23*a*** alternating stator stages **229** and rotating rotor stages **230** are shown drawing air vertically downward in direction of arrows A through the rotating blade assemblies. A rotor assembly is indicated at **239** with an adjacent stator assembly **240**. Ball bearings **241** support the perimeter of the rotor assemblies against upward lifting forces and possibly against precisional forces created during changing attitudes of the aircraft. Packings **238** insure against loss of air flow and oil pressure along the perimeter of the rotor assemblies. The rotor assembly operates as a rotary compressor. FIG. **23*b*** shows diagrammatically the individual blades of the rotor assemblies, wherein blades **229** are stator blades, followed in downward direction by rotor blades **23** turning in direction indicated by arrow D, followed again by a set of stator blades **229'** followed by rotor blades **230'** moving in direction indicated by arrow E, again followed by stator blades **229''**, rotor blades **230** moving in direction D, and stator blades **229'**, and rotor blades **230** moving in direction E.

FIGS. **24** and **25** show respective cross-sectional top-down and front views of the invention with the major internal parts indicated in phantom lines. The cabin interior **201** holds pilot seats **203**, **204**, with an instrument panel **212** in front of them, and a cabin floor window in front and behind them.

Passenger seats **205** are positioned inside the turboblade assemblies **229**, **230**, e.g. in the form of semi-circular seats. A pantry and refrigerator space **208** is located behind the pilot seats **204**, **203**.

The engines **236** are located in the rear section of the cabin area. The engines may be reciprocating engines, turbojet engines, or turboshaft engines. A transmission gear **237** is coupled by suitable means such as gear wheels or hydrostatic transmission to the turboblade rotor assemblies **229**,**230** to maintain their rotation during flight. In case the engines are reciprocating engines they may be equipped with turbochargers **244** to boost engine power when needed for climbing or flight at high altitudes.

A washroom **206** is located immediately behind the pilot's seats, enclosed in folding doors **207**. Cabin windows **209** are located at the rear of the cabin **201**. Luggage space **210** is provided behind the passenger seats **205**.

A firewall **211** separates the cabin **201** from the engine room **235**, the turboblade assembly (compressor) **228** and the compressed air plenum **231**.

A plurality of horizontal exhaust flap valves **232** operate to control a rearward downward air stream from the air plenum to provide forward propulsion of the aircraft.

A pair of stabilizers **216** provide horizontal stability of the aircraft, and have each a conventional rudder **220** attached to the trailing edges of the stabilizers **216**.

A plurality of intake air vanes **217** are positioned in the top surface of the aircraft, as seen in FIG. **26**. The vanes are controllable by control linkage from the pilot's seats as described above. As seen in FIGS. **26**,**27** and **29** the entire upper surfaces **202** of the aircraft combine with the bottom surfaces **202'** to form a profile like an airplane wing in the direction of flight of the aircraft. The rear edges of the aircraft body have pivotable ailerons **218**, controlled in conventional manner from the pilot's seat in order to bank the aircraft or maintain proper attitude during turns.

Upstanding winglets **219** are provided at respective extreme points at the sides of the aircraft to provide improved wing efficiency. Controllable, directional control nozzles **221** are provided at various points along the perimeter of the aircraft body for controlling yaw, pitch and roll of the aircraft at all attitudes and at all times during flight and also during hovering. The directional control nozzles **221** are in fluid communication with a compressed air plenum **231** disposed below the rotating turboblade assemblies. The air plenum **231** receives the downward compressed air stream, from where the compressed air is distributed to perform various functions relating to the operation of the aircraft as described below.

Part of the compressed air can be released through lower exhaust air vanes **224**, best seen in FIG. **28**, which are controlled from the pilots' seats in such a way that the aircraft is controlled in various modes. For example, opening the air vanes **224** to direct the outgoing air stream downward imparts a lifting thrust to the aircraft. By allowing the air stream to flow directly downward, a lifting force is generated.

By directing part of the air stream from the plenum to selected ones of the directional control nozzles **221** which are fixedly mounted in different directions or can be vectored in different directions by means of control available to the pilot in command, the aircraft can be turned about any of the three axes for which purpose directional control valves **234** are provided. The details of the vectoring arrangement are now shown for the sake of clarity.

Retractable landing gear including a nose wheel **223** and two mains wheels **222** are provided for maneuvering the aircraft on the ground.

An engine air intake **225** is provided at the bottom of the aircraft for supplying the engines **236** with air.

A plurality of rearward-facing exhaust air nozzles **226** on the rear side of the aircraft provide forward thrust for the aircraft by means of air supplied by the plenum **231**, under control of the horizontal exhaust flap valves **232**.

Fuel cells **233**, best seen in FIGS. **24** and **25** are located in the low profile parts of the aircraft body. For combustion of the fuel in the engines **236**, compressed air is taken from the air plenum **231** via a compressed air line **243** to air coolers **245** before it enters the engines **236**.

In operation of the aircraft the compressed air in the plenum **231** is directed either downward to provide lift or backward to provide forward thrust, or the air can be divided between the downward and backward direction to provide both lift and forward motion. An amount of the compressed air from the plenum is directed to the engines' air intakes to provide air for the combustion in the engines. During normal horizontal flight the compressed air is exhausted via the rearward facing nozzles **226**. These rearward facing nozzles can be adjustable so that all or part of the forward thrust can be derived from these nozzles, optionally augmented by a propeller (or propellers) driven by the engine(s) **236**.

In case a turbofan engine is used to power the aircraft, part of the compressed air from the plenum is used to feed the combustion in the engine(s), and part of the air may be used to by-pass the engines as is known from the conventional turbofan engine, although in the present case the bypass air will be pre-compressed. In case turbo engines are used, their forward-facing air intakes operate to provide additional air pressure due to the ram-effect.

The instant invention has been shown and described herein in what is considered to be the most practical and preferred embodiment. It is recognized, however, that departures may be made therefrom within the scope of the invention and that obvious modifications will occur to a person skilled in the art.

In summary the instant invention is based on a process of utilizing the energy delivered by the power generating means to improve those in use by the present state of the art whereby:

1. Air enters the system through controllable openings placed in the body of the aircraft and is transferred to a compressor.
2. This compressor can be structured with features as any of the following:
   - 2a. Type: Axial, radial, centrifugal, toroidal, reciprocating or any other type known to date;
   - 2b. Position: Vertical, horizontal, inclined or any position that would perform the function required by design the construction of the aircraft;
   - 2c. Location: Attached to the outside of the aircraft or within its body;
   - 2d. Number: Any number required to provide the required air pressure;
   - 2e. Configuration: Rotating, counter-rotating, with or without stators, with airfoil design blades or any other shape required, including one stage or multiple stages.

The compressed air is delivered from the compressor into a plenum.

3. This plenum may, depending upon control settings, deliver the compressed air as required to:
   - 3a. the bottom of the aircraft and into the air below, to effect the required thrust in order to attain lift, descent or a hovering attitude;
   - 3b. the rear of the aircraft and into the air behind it in order to effect a forward movement;
   - 3c. the power generating means in order to maintain the help maintain the required air-fuel mixture;
   - 3d. combustion chambers directed downward or rearward in order to increase the lifting and/or forward movement of the aircraft;
   - 3e. the directional control system in order to maintain the proper directional control or to effect various maneuvers of the aircraft;
   - 3f. any additional system or systems wherein compressed air may be required, through controllable openings having the required designed shapes.

In addition, air may be diverted from the exhaust of power generating means to aid in directional control, lifting control and thrusting control of the aircraft.

Furthermore, the power generating means may be of any type known at the present state of the art such as reciprocating, turboshaft, turbojet, fanjet, rocket, electromagnetic or nuclear and the like, and may be positioned at any location attached to or within the body of the aircraft and directed in any way required to perform the required functions.

The instant invention has been shown and described herein in what is considered to be the most practical and preferred embodiments. It is recognized, however, that departures may be made therefrom within the scope of the invention and that obvious modifications will occur to a person skilled in the art.

I claim:

1. An aircraft comprising a substantially circular body having a profile in the direction of flight as a profile of an airplane wing, at least two concentric counter-rotating turbo-blade assemblies disposed within said body for effecting a vertical lifting air stream through said assemblies, power generating means having an intake portion, means for coupling said power generating means to said turbo-blade assemblies for maintaining them in rotary motion, thrusting means coupled to said power generating means for applying horizontal thrust to said aircraft, retro-boosting means including a plurality of combustion chambers disposed proximal to said turbo-blade assemblies for boosting said vertical lifting airstream, a compressed air plenum in fluid communication with said combustion chambers and with the intake portion of said power generating means for supplying oxygen for sustaining combustion in said combustion chambers and for sustaining power in said power generating means, upper vanes disposed above said turbo-blade assemblies for ingesting air, and lower vanes disposed below said compressed air plenum for exhausting air, and respective upper and lower vane control means.

2. Aircraft according to claim 1 including means for injecting fuel into said combustion chambers, and means for igniting a compressed fuel-air mixture in said combustion chambers.

3. Aircraft according to claim 1, wherein said means for coupling said power generating means include gear wheel assemblies having drive input and drive output respectively engaging said power generating means to said turbo-blade assemblies.

4. Aircraft according to claim 1, including at least one jet engine system in said power generating means, wherein said means for coupling said power generating means include a gate valve disposed in a tail pipe section of said jet engine system for diverting a portion of jet engine exhaust gases, a circular exhaust manifold in fluid communication with said gate valve, and a plurality of nozzles disposed along said circular exhaust manifold for projecting said portion of jet engine exhaust gases toward blades disposed on said turbo-blade assemblies.

5. Aircraft according to claim 1, including a propeller in said horizontal thrusting means, wherein said power operating means include a power shaft coupled to said propeller.

6. Aircraft according to claim 4, wherein said horizontal thrusting means include an exhaust gas manifold in fluid communication with said jet engine system for effecting a horizontal thrust in said aircraft.

7. Aircraft according to claim 1, including a plurality of radially extending rotor blades on said turbo-blade assemblies disposed circumferentially on said turbo-blade assemblies, and rotating means for rotating said rotor blades about a radially extending axis for controlling said vertical lifting airstream.

8. Aircraft according to claim 7, including rotor blade control means, wherein said turbo-blade assemblies are divided into sectors defined by planes through said vertical axis, and steering means coupled to said rotor blade control means for independently controlling said rotating means in each of said sectors for controlling pitch and roll of said aircraft.

9. Aircraft according to claim 1, wherein said at least two counter-rotating turbo-blade assemblies are stacked vertically separated from one another.

10. Aircraft according to claim 1, wherein said at least two counter-rotating turbo-blade assemblies are disposed concentrically within at least one common plane perpendicular to the vertical axis of the circular body.

11. Aircraft according to claim 10, including at least two stator-blade assemblies fixed to the aircraft structure, disposed under said counter-rotating blade assemblies for redirecting the airstream.

12. Aircraft according to claim 11, wherein each rotating blade of said turbo-blade assemblies is supported at each end.

13. Aircraft according to claim 1, including wings extending radially from said substantially circular body, ailerons pivotally attached to said extensions, and winglets extending vertically at an angle from the ends of said wings.

14. Aircraft according to claim 1, including horizontal stabilizing surfaces disposed at the rear of said substantially circular body, elevator means pivotally attached to said stabilizing surfaces, and rudder means attached at the rear of said substantially circular body.

15. Aircraft according to claim 3, including a yaw control propeller disposed in a vertical plane, and coupling means for variably coupling said yaw control propeller to said power generating means.

16. Aircraft according to claim 4, including exhaust nozzles in said motion control means, disposed at the periphery of said circular body, and means to control said exhaust nozzles.

17. Aircraft according to claim 1, including a rocket system disposed at the rear of said aircraft to increase said horizontal thrusting power, and means to control said rocket system.

18. Aircraft according to claim 1 including at least one reciprocating engine in said power generating means.

19. An aircraft having an aircraft body having a profile in direction of flight as a profile of an airplane wing, comprising at least two counter-rotating turboblade assemblies within said body for effecting a vertical lifting air stream through said assemblies; power generating means; coupling means for coupling said power generating means to said turboblade assemblies for maintaining them in rotary motion; thrusting means coupled to the power generating means for applying horizontal thrust to the aircraft; a compressed air plenum disposed downstream of said turboblade assemblies in fluid communication with said power generating means for supporting combustion in said power generating means; a plurality of rearward facing exhaust air vanes in fluid communication with said compressed air plenum for imparting forward thrust to the aircraft; a plurality of adjustable lower exhaust air vanes in fluid communication with said compressed air plenum for selectively imparting lifting and forward thrust to the aircraft; a plurality of upper vanes for ingesting air to said turboblade assemblies; and control means for controlling said upper and lower vanes and said rearward facing nozzles.

20. An aircraft according to claim 19, having a retroboosting arrangement which includes at least one combustion chamber having a compressed air intake in fluid communication with said compressed air plenum, fuel-injection means for creating a combustible fuel-air mixture in said combustion chamber, ignition means for igniting said combustible fuel air mixture, and a downward and/or rearward facing exhaust nozzle for expelling combusted fuel-air mixture for creating increased lift and/or horizontal thrust.

21. An aircraft according to claim 19 including a plurality of directional control nozzles disposed at selected points at the periphery of said aircraft body, said directional control nozzles in fluid communication with said compressed air plenum, and control valves in said directional nozzles for controlling airborne attitude of said aircraft.

22. An aircraft according to claim 21, having a pilot's position including means for vectoring said control nozzles and including nozzle control linkage connecting the pilot's position with said control nozzles.

23. An aircraft comprising: a body having a profile in direction of flight as a profile of an airplane wing; a part of the body having a plurality of air intake openings; at least one air compressor in said body having an air inlet fluidly communicating with said air intake openings and an outlet; a compressed air plenum having an air intake

port fluidly communicating with said outlet of the air compressor; a plurality of rearward facing exhaust openings rearward facing from said body fluidly communicating with said air plenum for effecting horizontal thrust of said aircraft; a plurality of bottom air exhaust outlets fluidly communicating with said air plenum; power generating means drivingly coupled to said air compressor having combustion air intake ports fluidly communicating with said air plenum; a plurality of control air outlets disposed at selected points of the periphery of said body fluidly communicating with said air plenum for controlling airborne attitude of said aircraft; and control linkage for controlling air flow at said air intake openings, said rearward facing exhaust openings, said combustion air intake means, said control outlets and said bottom air exhaust outlets.

24. A method of controlling an aircraft having a body with a profile in direction of flight like an airplane wing, a compressor in the body receiving airflow from air intake openings in the body, a compressed air plenum receiving air from the air intake openings, a power generator coupled to the compressor, the method which comprises the steps of:

driving the compressor with the power generator;

drawing air into the compressor from the air intake openings;

compressing with the compressor air in the compressed air plenum;

exhausting air from the air plenum through rearward facing exhaust openings for generating thrust to the aircraft;

exhausting air from the air plenum through bottom openings in the body for generating lift to the aircraft;

exhausting air from the air plenum to the power generator for sustaining combustion in the power generator;

exhausting air through control air outlets for controlling airborne attitude of the aircraft; and

controlling with control linkage the flow of air from said air intake openings, air flow to said power generating means, said bottom exhaust outlets, said rearward facing exhaust openings and said control air outlets.

* * * * *

US005170963A

United States Patent [19]

Beck, Jr.

[11] Patent Number: 5,170,963

[45] Date of Patent: Dec. 15, 1992

[54] VTOL AIRCRAFT

[75] Inventor: August H. Beck, Jr., San Antonio, Tex.

[73] Assignee: August H. Beck Foundation Company, San Antonio, Tex.

[21] Appl. No.: 764,806

[22] Filed: Sep. 24, 1991

[51] Int. Cl.[5] B64C 29/02

[52] U.S. Cl. .... 244/12.2; 244/23 C; 244/73 C

[58] Field of Search .... 244/12.2, 236, 23 C, 244/34 A, 73 C

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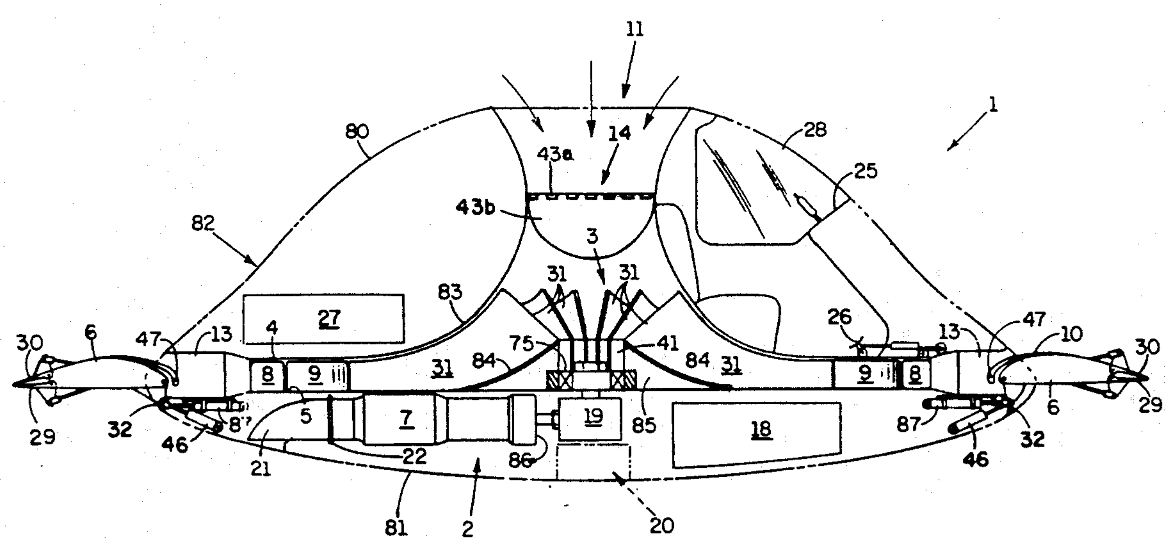
Primary Examiner—Galen Barefoot
Assistant Examiner—Virna Lissi Ansley
Attorney, Agent, or Firm—Charles W. Hanor

[57] ABSTRACT

The present invention provides a vertical takeoff and landing aircraft vehicle in which a ducted fan with upwardly directed inlet discharges air generally horizontally across a segmented circular wing. Said wing segments are individually controllable in pitch and each includes a spoiler and split flaps to increase effectiveness and sensitivity in lifting and controlling the aircraft. Directional stability and thrust for horizontal movement is provided by controls directing different proportions of total airflow to the various segments around the aircraft and varying the direction of said airflow both radially and vertically. Power failure protection is provided by means for maintaining free rotation of the fan until needed to provide lift at touchdown.

13 Claims, 8 Drawing Sheets



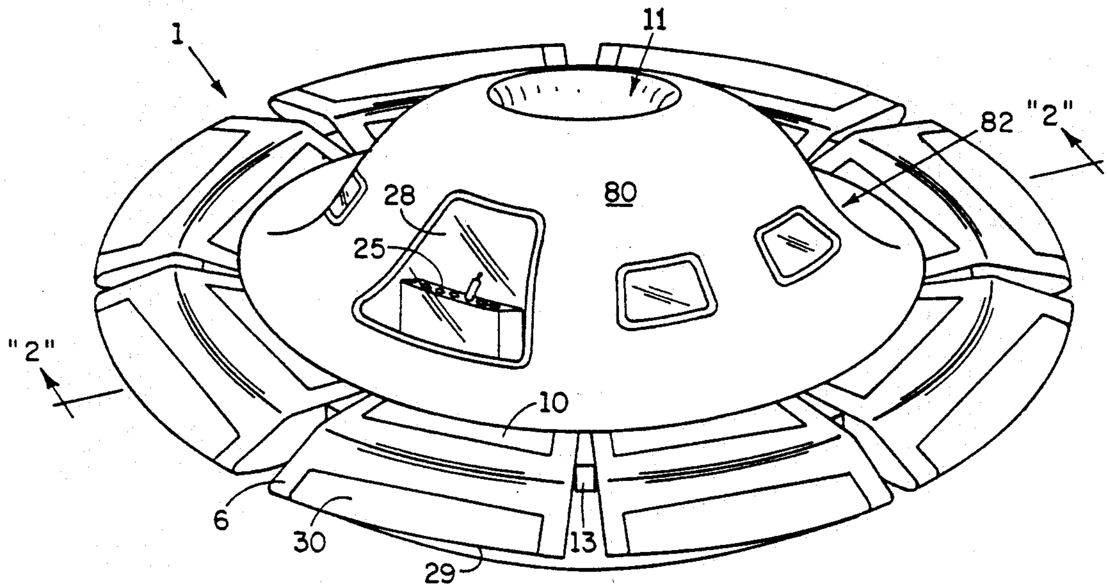


FIG. 1

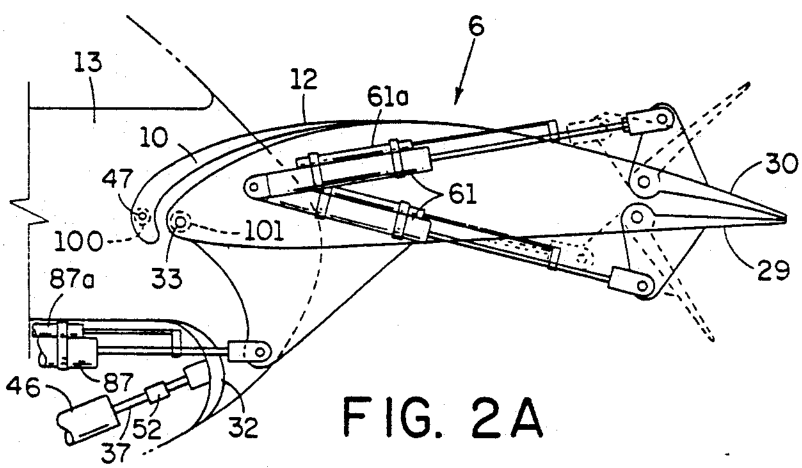


FIG. 2A

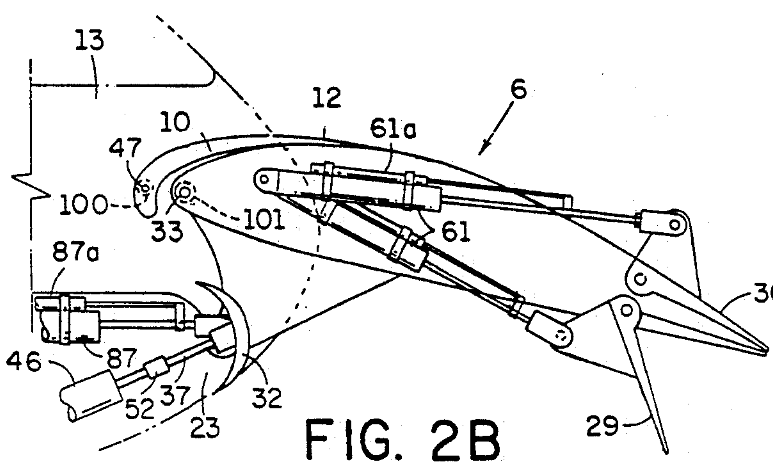


FIG. 2B

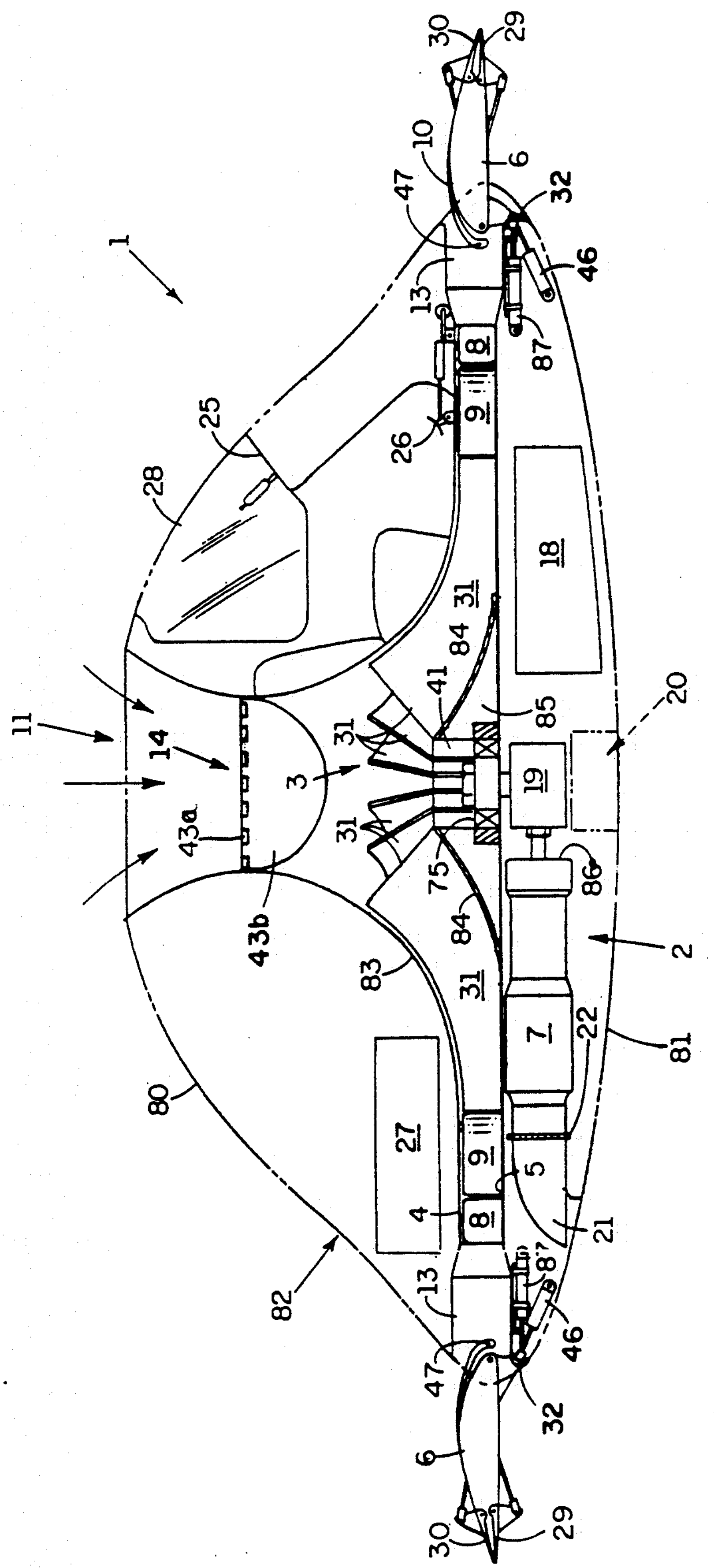

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FIG. 2

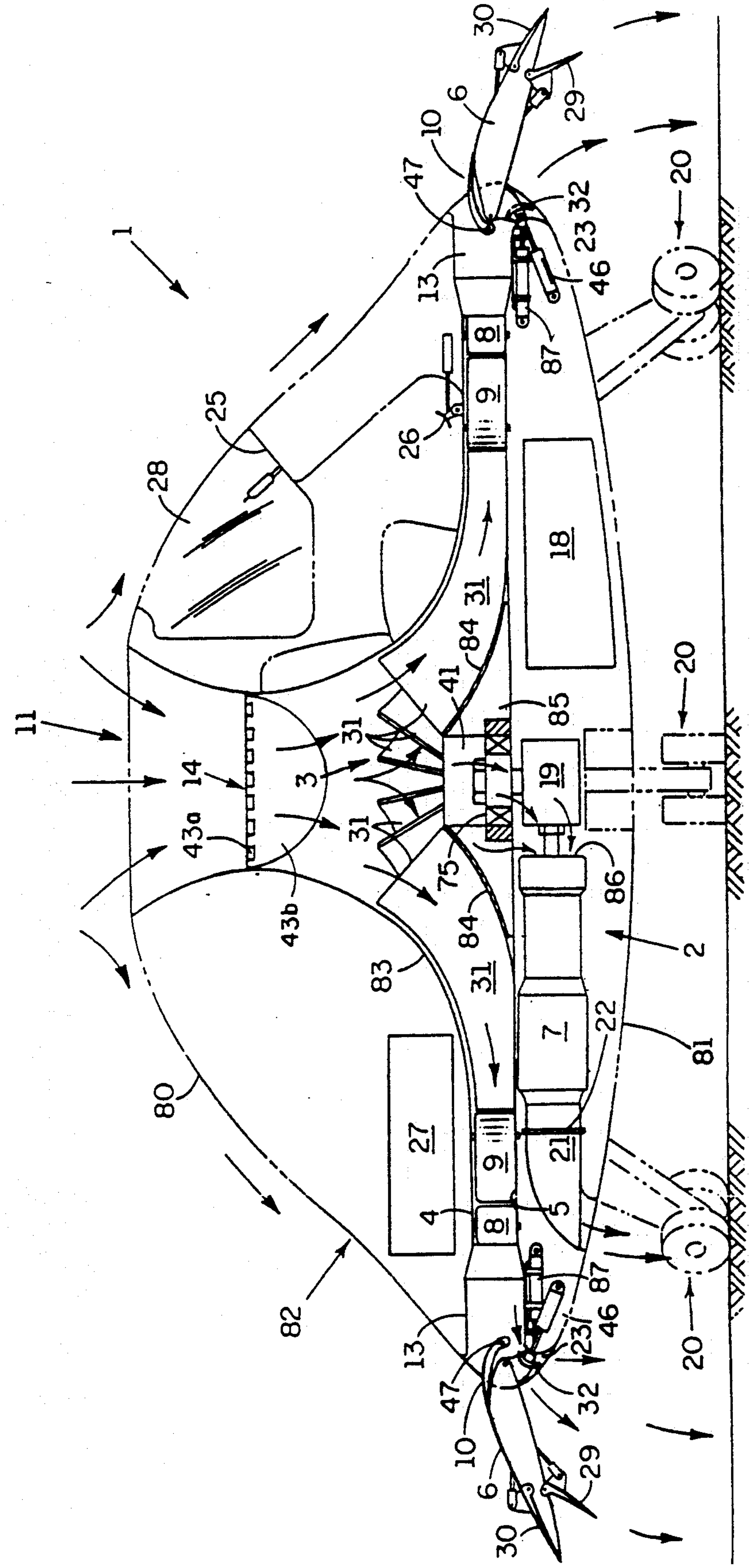
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FIG. 3

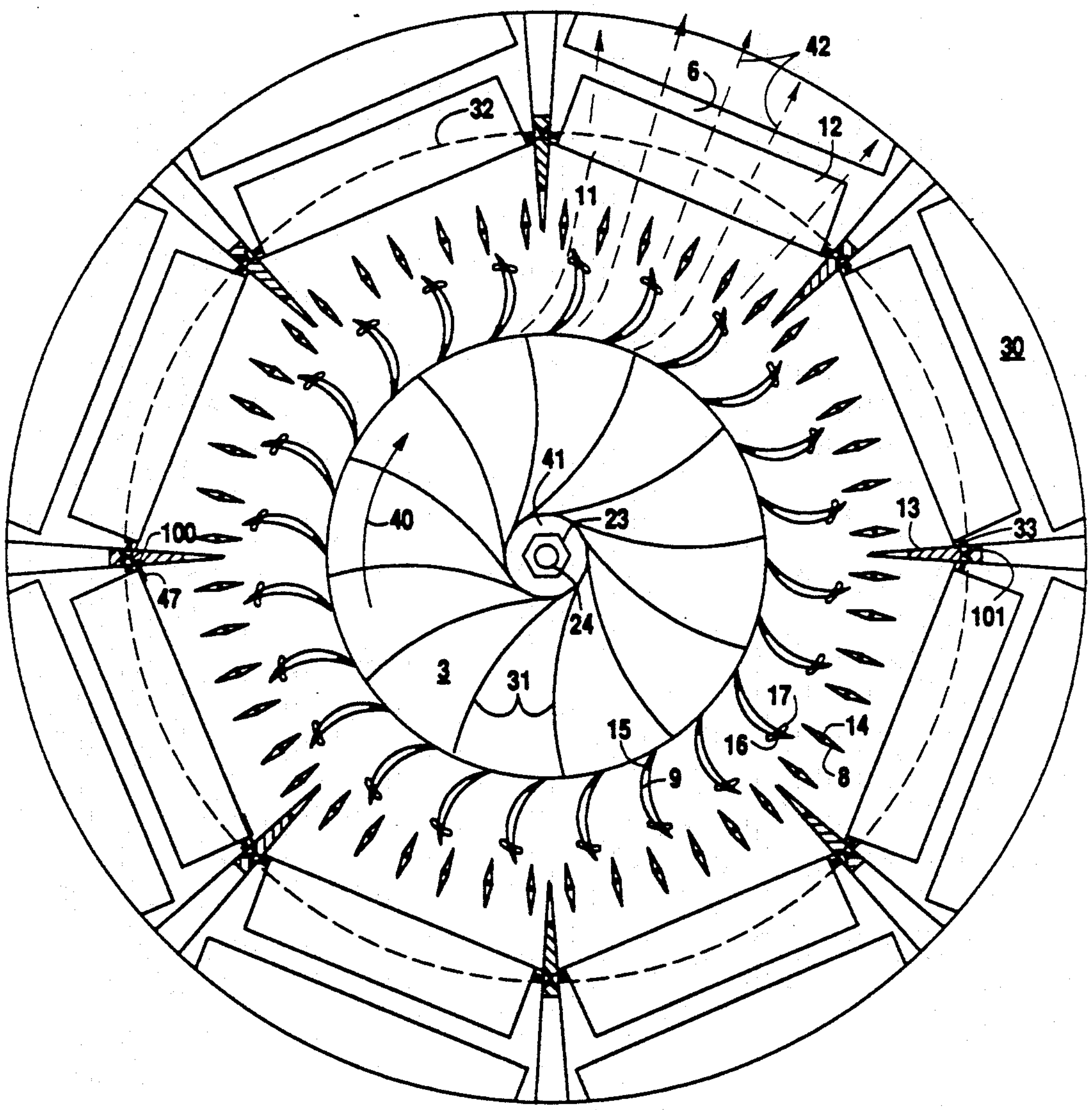

FIG. 4A

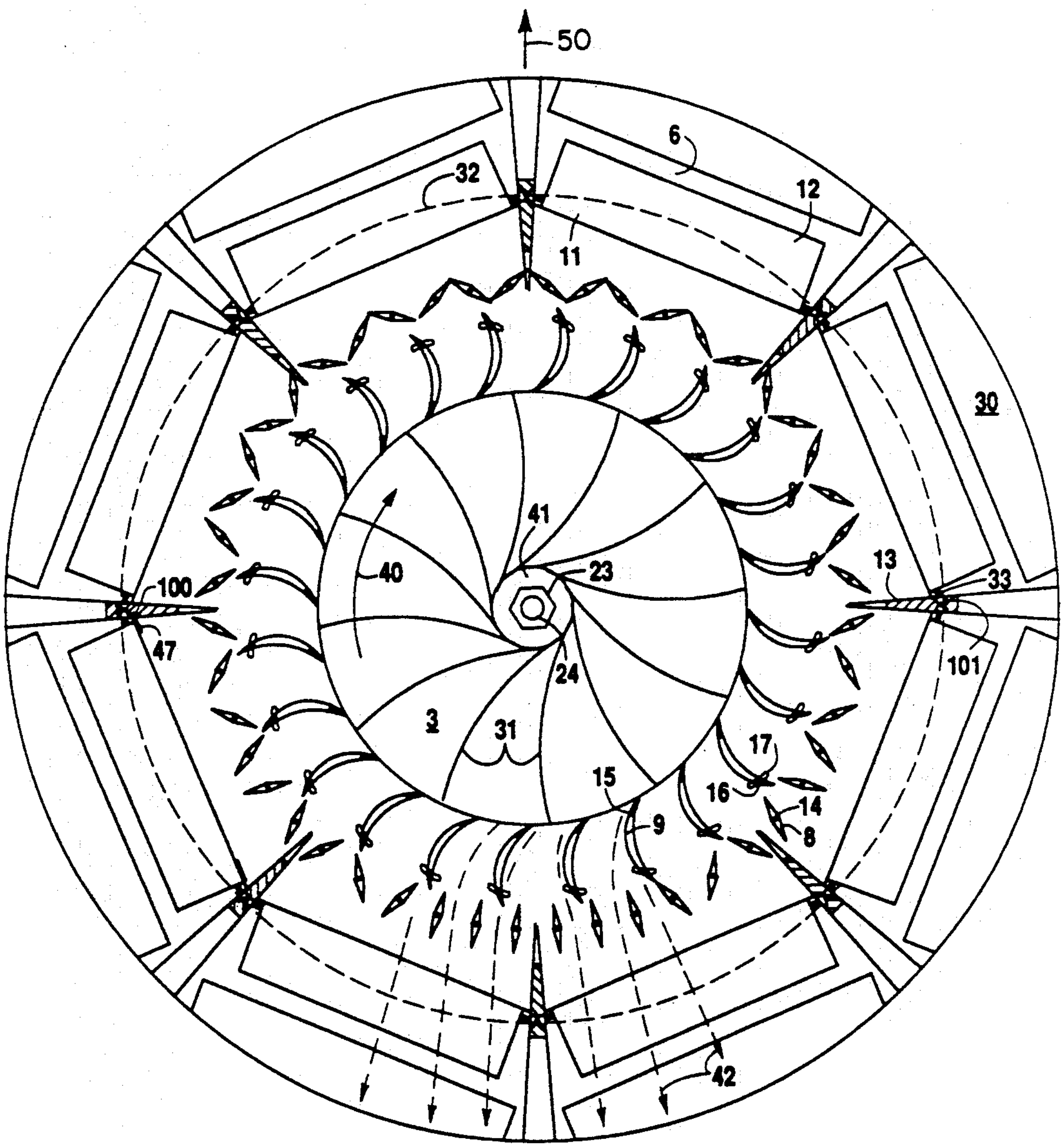

FIG. 4B

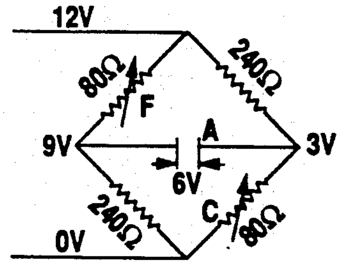

FIG. 5A

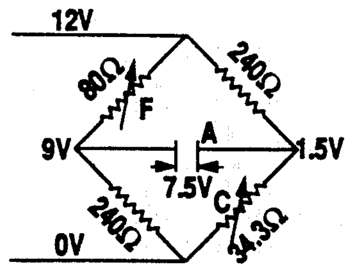

FIG. 5B

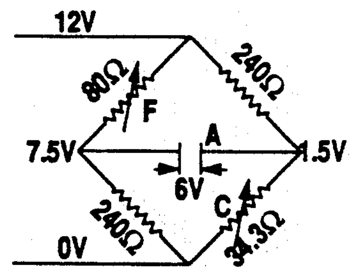

FIG. 5C

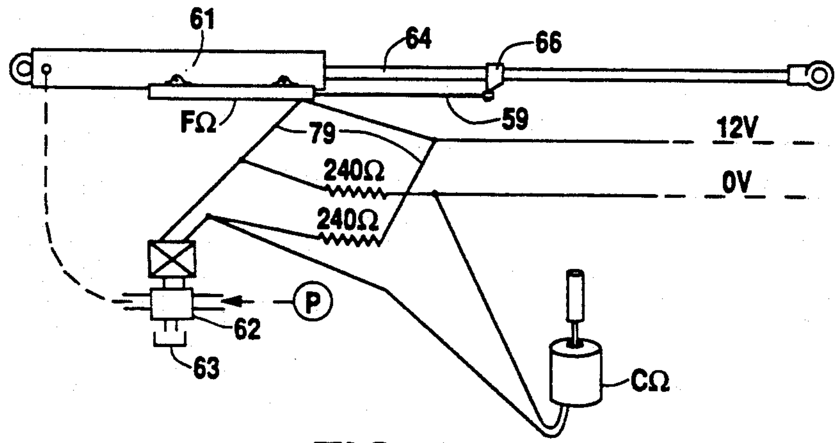

FIG. 6

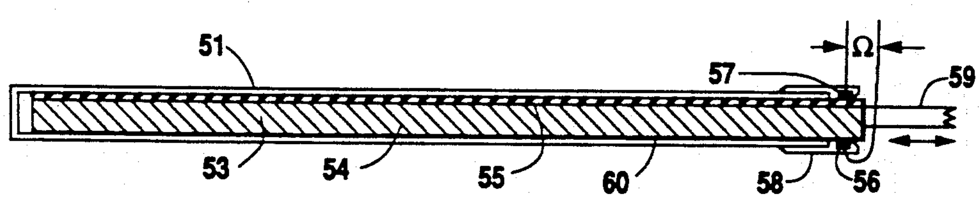

FIG. 7A

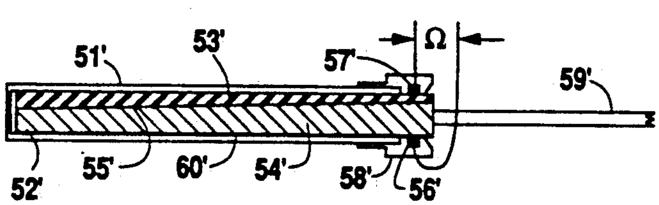

FIG. 7B

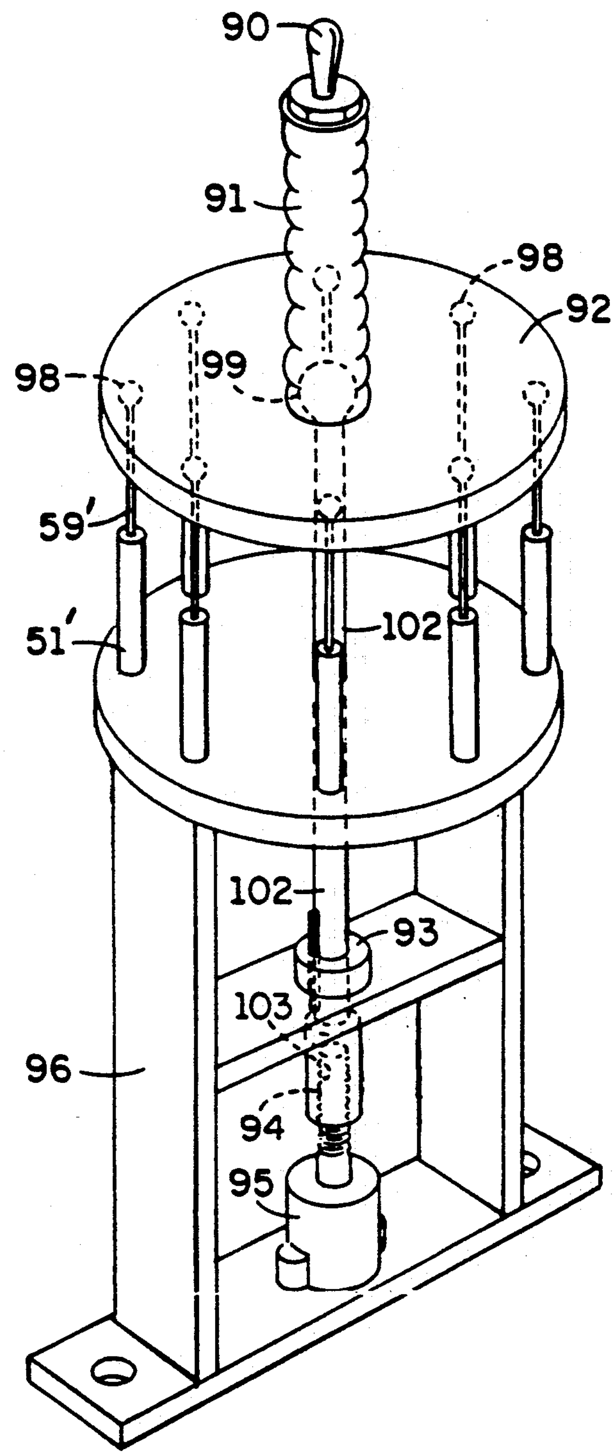

FIG. 7

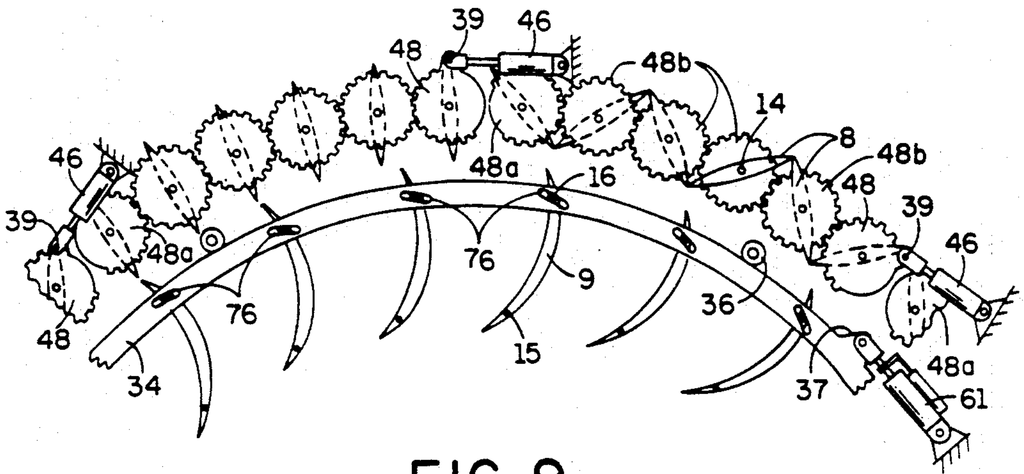

FIG. 9

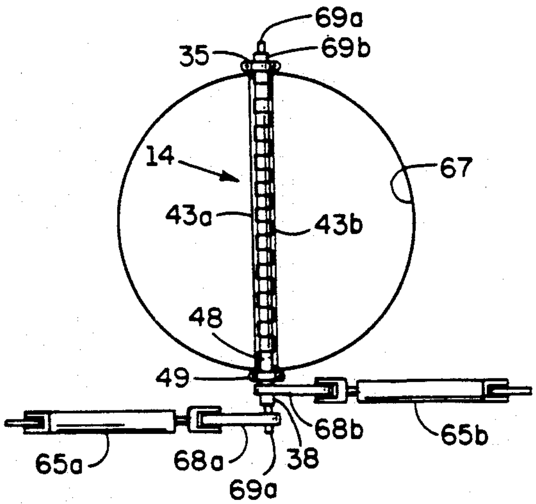

FIG. 8

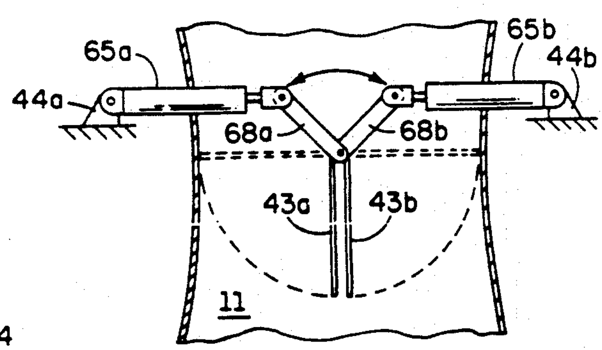

FIG. 8A

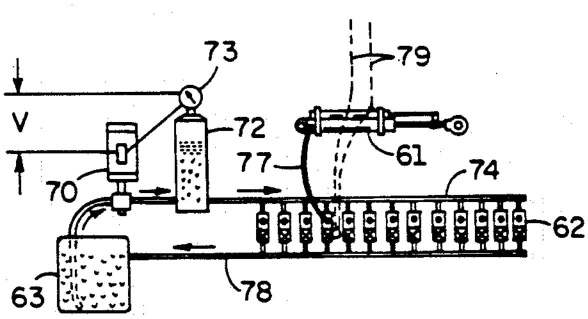

FIG. 10

VTOL AIRCRAFT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The field of the present invention is general aviation and, more particularly, the class of aircraft capable of vertical takeoff and landing (VTOL). The present invention further belongs to that subclass of VTOL aircraft with generally radial symmetry, designed for relatively low speed flight at low altitudes, suitable for use as an airport-to-downtown shuttle, home-to-office commuter, etc.

2. Related Art

The most common and widely employed vertical takeoff and landing (VTOL) aircraft is the helicopter. The success of this vehicle is due to the urgent need for this VTOL capability rather than to any particular distinction inherent in the genus. A short list of undesirable characteristics of helicopters include: long rotating blades which are a hazard to personnel and to the aircraft itself should they strike anything in the area, requirement for a remotely mounted propeller to counteract torque reaction of the airframe to the drive of the main rotor, complicated and relatively fragile rotor blade attack-angle controls, high maintenance requirements and rotor blades which must be long, thin, and relatively light and thus are flexible and subject to fatigue problems. Add to this incomplete list the fact that failure of any one of these components is likely to have catastrophic consequences for the aircraft and all on board and it is evident that an alternative design is desirable.

Man first flew in hot air balloons which, of course, are VTOL. The quest for heavier-than-air vehicles with this capability is approximately as old as any segment of the aircraft industry, but has accelerated since the end of World War II, and especially after the Vietnam War following the major role of helicopters in the latter conflict. A number of patents in the field of generally radially symmetrical aircraft have been granted, but it is not known that any have become successful in the market.

This may be due to the fact that these designs, while including many worthwhile ideas, did not integrate enough of them in any single concept, along with proven aircraft technology, to produce a practical product.

A significant problem which must be overcome in any VTOL aircraft is generation of sufficient "lift" to raise the vehicle off the ground.

A second problem is instability. Without the unidirectional airflow that exists across wings and tail surfaces under takeoff conditions in conventional aircraft, directional and stability problems become important. In the present invention gyroscopic effects of the large rotating fan increase stability and reduce said problems to a level well within the scope of pilot control.

Generation of a portion of the required lift is based on Bernoulli's Theorem which states that the energy of a fluid (such as air) is present in three separate energy forms; potential, pressure, and velocity, any one of which may be converted into any other.

In an airfoil section, the shape of said airfoil forces air flowing over the top to take a longer path than that of air flowing below said airfoil so that the air is forced to speed up, increasing its velocity energy. Since under these conditions, potential energy is relatively unaffected, the energy increase due to increase in speed is matched by a pressure decrease in said air.

Aircraft generally utilize this principle by incorporating an airfoil structure or "wing" which will produce this lowered air pressure on its upper surface when moved through the air. Air flowing under said wing is more or less unaffected, so that said average pressure decrease above said wing multiplied by the area of said wing appears as a net lifting force.

A second form of lift is generated by acceleration of a mass of air by a fan, propeller, wing, or other system. When a mass of air is changed from rest to a given velocity in a downward direction, an upwardly directed reaction force proportional to the mass times the velocity change, is produced. The more vertically the air is directed, the more effective this force becomes in producing lift.

A third means of producing lift when close to the ground, effective in takeoff and landing, is "Ground Effect." This is roughly equivalent to creating a zone of very slight compression in the air between the vehicle and the ground and using that pressure times the bottom area of the vehicle to help support said vehicle. This effect becomes stronger as the ground is approached and becomes negligible as the vehicle lifts away from the ground.

The present invention comprises a rational assembly of appropriate technology combined with integrated control systems to produce a practical aircraft. It is an object of the invention to provide a VTOL aircraft which is low in maintenance and relatively safe and simple to operate. It is an object of the invention to provide a VTOL aircraft that has performance characteristics similar to helicopters but without the shortcomings of a helicopter.

SHORT DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the present invention well above the ground in level flight.

FIG. 2 is a cross sectioned side view of plane "A—A" of FIG. 1.

FIG. 2A is a detail of the control cylinders, flaps, spoiler, linkages and air diverting device located in the area of airfoils 6 and set for level flight.

FIG. 2B shows the same details as in 2A but with settings changed to give maximum lift and divert a portion of the fan discharge into the area beneath the aircraft.

FIG. 3 is a side sectioned view of Plane "A—A" with airfoils, flaps, spoilers and engine exhaust deflector set for takeoff or landing.

FIG. 4A is a top view of the ducted fan air handling system showing uniform air flow over all airfoils.

FIG. 4B is a top view of said air handling system showing the air cutoff and air redirecting vanes set for forward propulsion.

FIGS. 5A, 5B, and 5C show a "wheatstone-bridge" arrangement of fixed and variable resistors across a base voltage from which control signals and positive control element positioning are derived.

FIG. 6 illustrates one method for hydraulic power positioning of control elements suitable for this application.

FIG. 7 shows the airfoil positioning control illustrating the means by which it coordinates the positioning of a number of elements. FIG. 7A shows a feedback resistor element suitable for use with the control unit of

FIG. 7. This resistor element would be mounted on the driven cylinder.

FIGS. 7A and 7B show control resistor elements suitable for use with the positioning control of FIG. 7, indicated there by 51 and 59.

FIG. 8 shows a top view of the components and the control linkage for the intake air duct cut-off system.

FIG. 8A is a side view of FIG. 8 showing how vanes 43A and 43B move to close off the air inlet duct.

FIG. 9 shows air control vanes for both controlling volume of flow (vanes 8) and directing the flow outward across the airfoils (vanes 9) and their respective control elements.

FIG. 10 shows a suitable hydraulic arrangement for the independent hydraulic control of a large number of elements from one hydraulic source.

SUMMARY OF THE INVENTION

The present invention comprises a compilation of developments in the art of heavier-than-air flight, including principles of lift generation, power sources, construction materials and controls. A foremost design objective is to integrate said factors, along with relative intangibles such as safety and ease-of-operation in order to produce a practical VTOL aircraft without the serious problems characteristic of helicopters. A totally enclosed ducted fan discharging air into pilot-controlled redirecting vanes for essentially radial outflow may eliminate those problems imposed by rotor blades and torque reaction.

Generation of lift includes the principal of Bernoulli, both on the circular wing airfoils and upon the entire upper surface of the airframe due to the flow of induced air while hovering and to both induced airflow and forward speed when under propulsion. Some lift also results from acceleration of air mass in a downward direction through the air handling system and through the generation of "ground effect" when close to the surface. It is believed that most of the lift will come from the wing airfoils. Pilot control of the relatively large number of aircraft control elements is made practical through the use of devices integrating many power driven elements to one control motion. This concept includes the automatic deployment of secondary control elements as primary control elements approach their limits of travel.

The present invention includes utilization of a propjet engine primarily selected for its maximized power-to-weight ratio, but which also produces benefits in other areas; added lift created by intake through fan inlet duct, added propulsion resulting from rearward exhaust and by deflecting exhaust downward for hovering, taking off and landing, a partial cancellation of the low pressure effect created by radial outflow of fan air.

Other aspects of this invention include the use of state-of-the art materials such as honeycomb sandwich panels and glass or boron fiber skins with rigid foam cores in the construction of airframe and wing segments. Close attention to weight control in remaining components of the aircraft lead to a reduction in power and overall size requirements for any given payload.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the aircraft of the present invention, generally designated by 1, in level flight well above the ground. "Lift" for flight is generated on the airframe from airflow resulting from forward motion and from airflow induced over the upper surfaces by air being drawn into fan inlet 11 and expelled over the perimeter airfoils 6. The lift resulting from forward motion is most effective toward the front of the aircraft, while the fan induced airflow is most effective on rear areas since the greater part of total fan outflow is expelled toward the rear, increasing induced airflow over said areas. An additional lift component, produced by the lowered pressure resulting from air ingestion by fan 3 (See FIG. 2), acts directly over said fan inlet in the center of the aircraft. Lift produced by fan discharge air over circular wing segments 6 may be more effective toward the rear during forward flight, which may result in unbalanced lift tending to raise the rear of the aircraft. This factor is easily controlled, however, as the pilot has command of the "attack angle" of all airfoil segments 6 and can thereby maintain desired aircraft attitude through modification of lift forces all around the aircraft and through conventional "elevator effect" produced by controlled deflection of the airstream at each wing segment 6.

FIG. 1 includes the indication of a vertical plane (A—A) which is 22½° off the fore and aft centerline of the aircraft and thus perpendicular to airfoil sections 6 which it bisects (in this eight-airfoil representation of the invention.)

Forward propulsion is produced by thrust derived from rearward exhaust of propjet engine 7 and from predominantly rearward exhaust of air from fan 3.

FIG. 2 is a cross section view of aircraft I from plane "A—A", comprising an airframe upper surface formed by a relatively high domed section 80 of generally radial symmetry with a lower section 82 incorporating a reflex curvature toward the horizontal. A hole defining an air passage (fan inlet duct 11) existing in the upper center of said dome, and said fan inlet 11 connected to the outer perimeter of section 80–82 by fan duct structural element 83 incorporating said element's lower extension plate 4.

Aircraft 1 also includes a lower surface of relatively low domed relief 81 connected at its outer perimeter to a generally flat floor plate 5 which defines the lower surface of the internal fan duct of aircraft 1 as well as the upper surface of the lower airframe section 2 housing engine 7, fuel tank 18, gearbox 19 and landing gear 20 (See FIG. 3). Upper and lower airframe sections are spaced apart and held in a rigid relationship by structural pillars 13 which also act to divide and contain airstreams directed outward over airfoils 6. Said pillars 13 further contain pivot bearings 101 (See FIG. 2A) for shafts 33 of airfoils 6 and contain anchor locations 47 for spoilers 10, as well as hydraulic lines for actuation of airfoil flaps 29 and 30 (not shown). Propjet engine 7 supplies power to right angle drive gearbox 19 to rotate fan 3 within the air duct formed between duct elements 83 with its lower extension 4 and duct floorplate 5. The lower curved structural floorplate 84 of fan 3 defines the remaining sector of the fan duct inboard of floorplate 5 and opposite duct element 83.

Fan 3, comprising hub structure 85, structural floorplate 84 and a multiplicity of curved fan blades 31 may be mounted to the output shaft of gearbox 19 through one-way clutch 75, enabling engine 7 to drive fan 3 in its designated direction of rotation 40 (See FIG. 4A) while allowing it to rotate free of drag from either engine 7 or gearbox 19 in the event of loss of power or other drive-train malfunction.

Hub structure **85** is an open spoke type to allow free entry of air passing through open center **41** of fan **3**, thence through said hub **85** into the lower airframe section of aircraft **1** and thence into air intake **86** of engine **7**.

Rotation of fan **3** utilizes the mass of air (rotating with the fan because it is trapped between blades **31**) to throw said air outward due to centrifugal force developed therein. Air thus discharged passes by redirecting vanes **9** and volume control vanes **8** before being passed over and under wing segments **6**. Air thus discharged is replenished by a flow into fan inlet **11** due to the pressure reduction created in said inlet by action of said fan.

In a unit of modest size such as that illustrated in FIG. **2**, a fan diameter of approximately 9 ft., rotating at 625 RPM would discharge air at a velocity of approximately 200 miles per hour. This velocity is sufficient to produce desired effects of lift, propulsion and control. Split clamshell type exhaust deflectors **21** open on hinges **22** to allow exhaust to exit directly rearward or close to deflect said exhaust generally downward. Exhaust deflection may be applied gradually or rapidly and may be given any setting between fully open and closed. FIG. **2** also indicates generally locations for fuel tank **18**, hydraulic components **27** (valves, pumps, tanks, etc.), landing gears **20**, control panel **25**, windscreen **28**, rudder pedals **26** and other non-critical items which are peripherally involved with the invention. Components more central to the invention are detailed with reference to their individual drawings. Additional power sources such as a plurality of ram jets placed around the perimeter of the fan are also contemplated.

FIG. **2** shows airfoil sections **6** approximately as they would appear in level flight. Fan discharge is approximately horizontal, elevator flaps **29** and **30** and spoiler **10** are in normal (closed) position. Vanes **43A** and **43B** located in fan inlet **11** are fully open. Split clamshell exhaust deflectors **21** are shown closed, deflecting exhaust downward which suggests that aircraft **1** is moving slowly or hovering and is using the increased lift resulting from said exhaust deflection.

FIG. **3** shows aircraft **1** in a landing (or take-off) configuration. Airfoils **6** are depressed and spoilers **10** are extended to achieve maximum lifting effort.

Air flow diverters **32** (detailed in FIGS. **2A** and **2B**) are shown in extended position. Said diverters **32** are located around the outer perimeter of lower aircraft body section **2** and are spaced to more or less fill the gaps between airfoil control cylinders **87**. As said cylinders **87** are attached midway along the length of airfoils **6**, said airflow diverters extend across the hinge area between said airfoils **6** and approximately halfway along the length of each of the said airfoils **6** mounted to the pillar **13** in the hinge area. In consequence, the number of diverters **32** matches the number of airfoils **6**, eight each in this embodiment. Said diverts **32** form a smooth aerodynamic portion of the aircraft's lower body unit **2** and are supported on a plurality of parallel shafts **37** slidably mounted in bearings **52** of body unit **2**.

Diverter **32** is held against body unit **2** or extended out to the position shown in FIG. **2B** and/or intermediate positions by hydraulic cylinder **46**, under pilot control. The shaft of cylinder **46** also passes through a bearing **52** and forms one of the several shafts **37** which guide and position diverter **32**.

When diverter **32** is extended, air channel **23** is formed. The position of diverter **32**, now partially blocking the airflow area below airfoils **6** causes a portion of the air passing therethrough to be redirected through the diversion slot **23** and to be discharged directly beneath the aircraft where it combines with engine **7** exhaust flow to counter the tendency of radial outflow of air from fan **3** to reduce air pressure below the aircraft when close to the ground. This condition must be maintained for several feet above the ground because low pressure zones result if air from below is entrained into a more or less horizontal flow outward over the circular wing when this air cannot be readily supplied from below due to close proximity to a surface.

Automatic deployment of spoiler **10** is illustrated in FIG. **3**. Locating pin **47** of spoiler **10** fits into cavity **100** in pillar **13**. When spoiler **6** pivots down about shaft **33** contained in shaft anchor **101**, the front surface of spoiler **10** stays in its center-of-the-duct location by extending along the upper surface of airfoil **6**. The upper extension **12** of spoiler **10** tapers to a narrow edge and blends into the upper surface of airfoil **6**. Close contact between said spoiler extension **12** and the top surface of spoiler **6** may be maintained by longitudinal dovetail slots in airfoil **6** matching dovetail studs on the spoiler extension **12** or similar means.

Flaps **29** and **30** are extended by cylinders **61** and **61*a*** controlled by the pilot through the use of electro-hydraulic proportioning means linking manual devices to positioning of aircraft control elements as detailed in FIG. **6**.

FIG. **4A** shows a top view of the air handling system of the present invention. Fan **3**, driven by the output shaft **24** of gearbox **19** rotates in the direction shown by arrow **40**. Air entering from above the center areas of fan **3** is centrifugally discharged and leaves the fan more or less tangentally as indicated by airflow lines **42**. Said discharge air is deflected radially outward by redirecting vanes **9** so as to pass more or less radially outward across airfoil sections **6**. Said redirecting vanes are adjusted by the pilot to control the vehicle's radial orientation; a shift of airflow slightly clockwise of radial will cause a reaction turning the aircraft counter-clockwise and vice-versa.

Air flowing past redirecting vanes **9** and cutoff vanes **8** enters a zone between pillars **13** and thence flows out above and below airfoils **6**, resulting in lift and/or drag effects under the control of the pilot through his ability to adjust airfoil attack angles and extend flaps **29** and/or **30** as desired.

FIG. **4B** shows vanes **8** adjusted for near maximum propulsive reaction in the direction of arrow **50**, as forward vanes **8** are fully cut off and rearward vanes **8** are fully open. Intermediate vanes are partially open to either add propulsive effect (for those sectors rearward of the aircraft's transverse centerline) and/or to provide lift necessary for flight and stabilization.

The rotation of Fan **3** not only produces a flow of air over the circular wing but it also acts as a large gyroscope. This gyroscopic action makes the craft very stable and able to counter outside forces caused by wind currents in the atmosphere. Precession of the gyroscope is corrected by the craft operator by means of coordinated movement of the moveable sections of the circular wing in order to maintain a level attitude of the craft.

In the event of an engine malfunction the craft will begin to descend and reach a very low terminal velocity because of the circular design of the craft. This gives it a parachute drag effect and the craft is maintained in a horizontal attitude (e.g., the descent of a frisbee) by the gyroscopic action of the relatively heavy fan. To maintain fan RPM in the event of power fialure, fan inlet air may be closed off by vanes 43A and 43B, reducing fan drag and allowing Fan 3 to freewheel by disengagement from the engine. This condition would remain until the craft descends to a pre-determined altitude above the ground. At this point the air intake vanes **43***a* and **43***b* would be opened, thus giving the circular wing lift and the aircraft controllability for a relatively soft touch down.

FIGS. **8** and **8**A show the inlet duct cut-off system including its actuating linkage. Vanes **43***a* and **43***b* are hinged along a centerline over shaft **69***a* which entends through the entire hinge area **14** and is supported by bearing **50** and indirectly by bearing **49**. (Bearing **49** holds hinge tab **38** of vane **43***b* and shaft **69***a* rides concentrically within tab **48**.) A lever **68***a* is fastened to shaft **69***a* in the angular relationship shown, such that a thrust from cylinder **65***a* will rotate vane **43***a* from its position shown in solid lines to the position shown in dotted lines in FIG. **8**A. Cylinder **65***a* is mounted to the aircraft frame through lug **44***a*.

The opposite side of the hinge, vane **43***b*, is similar to the arrangement shown for vane **43***a* except that vane **43***b* is slideably mounted over shaft **69***a* and may rotate independently. The rotation of vane **43***b* is controlled by the lever **68***b* mounted to the extended hinge tab **48** and actuated by cylinder **65***b* anchored to lug **44***b*.

When cylinders **65***a* and **65***b* are extended, said vanes **43***a* and **43***b* form a circular plug with a circular outside diameter **67** which may tightly close the circular inlet duct **11**. Retraction of said cylinders leaves said duct fully open except for a narrow strip occupied by hinge **14** of vanes **43***a* and **43***b*. The vanes themselves may lie entirely within the vertical space below said hinge.

As said vanes are never set in an intermediate mode, they may be controlled by cylinders lacking proportioning characteristics.

Hydraulic valves are available which respond to a D.C. voltage signal. For example, a DANFOSS PVG 32 hydraulic valve may be inactive at an impressed voltage of 6 volts D.C., while directing flow for cylinder extension at voltages above 6 v, and retraction below 6 v. Said electro-hydraulic valves do not power themselves directly from control voltage signals, but use said signals to operate commercially available electronic amplifiers to supply power for the actual shifting of said hydraulic valves. For clarity, and because there is no substantive difference in the operation, this intermediate stage will be ignored in subsequent descriptions.

Reference to FIGS. **5**A, **5**B, and **5**C will illustrate the means by which control voltage is provided for the operation of hydraulic devices positioning aircraft control elements.

FIG. **5**A shows a classic Wheatstone Bridge placed across a 12 volt D.C. power supply. This "Bridge" comprises two fixed resistors and two variable resistors. With resistance valves as shown, and since all current through 80 OHM variable/resistor F must also pass through the 240 OHM fixed resistor in the same conductor path $(80/(80+240)\times 12\text{ v})$ 3 volts will be "dropped" through 80 OHM variable resistor F, so that 9 volts appear on the left side of control voltage A. At the same time the current in the right side of the bridge passes through the 240 OHM fixed resistor before passing through the 80 OHM variable resistor so that $(240/(240+80)\times 12\text{ v})$ 9 volts will be "dropped" through the 240 OHM fixed resistor and 3 volts appear on the right side of control voltage A. Control voltage is now $(9\text{ v}-3\text{ V})$ 6 volts.

FIG. **5**B shows the same "bridge" with variable resistor C reduced to 34.3 OHMS. The left side of the bridge is unchanged so that 9 volts still appears there. On the right side, where the ratio of fixed to variable resistance was 3 to 1 in FIG. **5**A, it is now 7 to 1. Once again, current through both resistors must be the same since they constitute the only electrial pathway, hence a voltage drop ratio of 7 to 1 will result. $(12\times\frac{7}{8})$ $10\frac{1}{2}$ volts are now dropped through the 240 OHM fixed resistor, therefore $1\frac{1}{2}$ volts appears on the right side of A. Control voltage is now $(9\text{ v}-1\frac{1}{2}\text{ v})$ $7\frac{1}{2}$ volts.

Balance (6 v. control voltage) can be reachieved in the "bridge" arrangement of FIG. **5**C if all other factors are held constant only by increasing variable resistor F in order to "drop" more voltage through it until the left side voltage is reduced to $7\frac{1}{2}$ volts, $(7\frac{1}{2}\text{ v.}-1\frac{1}{2}\text{ v.}=6\text{ v.})$ This point exists at F=144 OHMS. $144/(240+144)\times 12\text{ v}=4\frac{1}{2}$ volts drop through variable resistor F. $12\text{ v}-4\frac{1}{2}\text{ v}=7\frac{1}{2}$ volts on the left side of control voltage A, minus $1\frac{1}{2}$ volts (unchanged) on the right side, re-establishes the "neutral" or inactive control voltage (6 v.).

FIG. **6** shows an arrangement of variable and fixed resistors which will link a specific resistance of an element C to a specific position of an aircraft control element F remotely operated by hydraulic means in response to said resistance of element C.

61 is a hydraulically extended, spring returned cylinder which has a variable (feedback) resistor F attached thereto with shaft **64** of cylinder **61** and shaft **59** of resistor F aligned in parallel relationship. Attachment **66** ties motions of said shafts together so that any given extension of shaft **64** will correspond to a specific resistance value of variable resistor F.

FIG. **7**A and **7**B show a design for variable resistors suitable for use in this control system. FIG. **7**A is a relatively long variable resistor suitable for use as resistor F mounted on hydraulic cylinder **61**. **51** is an electrically insulated case surrounding the resistive plunger **53** which is square or rectangular in cross section to prevent rotation in case **51**. Said plunger **53** comprises a structural insulator core **54** with a conductive strip **60** along the length of one side and across one end near the attachment of control shaft **59**.

Resistive material **55** is bonded to conductive strip **60** at said shaft end and lies along the side opposite said conductive strip for the length of the plunger **53**.

Said resistive material may be tapered as shown in FIG. **7**A in order to increase its resistance in a non-linear fashion. The unit illustrated will increase resistance at a rate greater than linear as it is withdrawn, as current must pass through material which decreases in cross section as plunger **53** moves outwardly.

Electrical contacts are designated **56** for the "line" contact and **57** for the resistive element contact. Both are held in insulated head **58**, bonded or fastened to case **51**. In this arrangement, control wiring is fixed in place and does not move as adjustments in resistance values occur.

FIG. **7**B is similar to FIG. **7**A except that the unit is illustrated in a shorter configuration and the conductive strip **60**' is bonded to the resistive material **55** at the base of the plunger, resulting in a unit that decreases in resistance as plunger **53**' is withdrawn, with that decrease occurring at a greater-than-linear rate.

It is obvious from these examples that variable resistors can be fitted to requirements of control conditions by manipulation of the shape, resistivity, length and attachment conditions of resistive materials therein.

In FIG. 6 electro-hydraulic valve 62 is a three-way valve which connects with the hydraulic supply P through one port, cylinder 61 through a second port and a third port returns oil to hydraulic tank 63.

Valve 62 is electrically actuated, existing in one state of internal porting at signal voltages above a set value, a second state at or very near said voltage, and a third internal porting state at signal voltages below said voltage.

In FIG. 6 the valve 62 passes hydraulic pressure to cylinder 61 to extend rod 64 when the signal voltage is below said valve's neutral setting (assume 6 volts "neutral").

At or very near said neutral signal value, valve 62 blocks pressure from P and the return flow from cylinder 61 so that the aircraft control device activated by said cylinder is maintained in position.

When signal voltage is above said neutral signal value, pressure from the hydraulic supply P remains blocked but return oil flow from cylinder 61 to tank 63 is opened. Thereby, the internal spring contained between piston and head-gland of cylinder 61 retracts said cylinder. Cylinders are also available which are spring-extend, hydraulic return. The type used depends chiefly on which motion requires the greater force. Said greatest force motion is commonly supplied by the hydraulic pressure phase. Yet another option is to use 4-way valves with the same type of control. This option yields hydraulic force both for "extend" and "retract" motions but carries the penalty of larger and heavier valves and extra valve-to-cylinder hoses.

With an understanding of the operating characteristics of the components of the system. We can now describe the functioning of the control configuration of FIG. 6.

Assume cylinder 61 is shown at the center of its stroke with resistor F (feedback) at 80 OHMS and resistor C (manual control) at 80 OHMS. This results in a signal voltage of 6 v (FIG. 5A) and therefore cylinder 61 is blocked and the controlled aircraft component is held in position.

The pilot moves the handle of the control element to reposition the plunger of variable resistor C to a point yielding a new resistance of 34.3 OHMS. This results in the "bridge" conditions of FIG. 5B and a voltage signal greater than 6 volts; therefore the valve 62 will shift to a new condition. Assume the valve shifts to admit oil from P into cylinder 61. This will extend shaft 64 and its attached shaft 59 of resistor F (FIG. 7A) extending the shaft of resistor F increases the resistive value of said resistor and thereby reduces the control voltage across the valve 62 until a neutral point of 6 v. is reachieved. This takes place at a value of 144 OHMS in the "feedback" resistor F (FIG. 5C), corresponding to a specific extension distance. All intermediate values of control resistor C correspond to specific intermediate values of feedback resistor F and thereby to a specific extension distance. The foregoing sequence works equally and oppositely should the control resistor be increased in value rather than decreased as it was in this example.

With the foregoing example understood, the control of a multiplicity of control resistors (and aircraft control elements driven by systems similar to that of FIG. 6) may be illustrated with reference to FIG. 7.

In the manual control device of FIG. 7 control handle 91 is fitted with a self-centering 3-position momentary toggle switch 90 which the pilot may deflect right or left with the thumb of the hand holding said handle. At the base of said handle and integral with it is wobble plate 92 pivotally supported at its center on ball joint 99. Depending from said wobble plate are a multiplicity of resistor element control shafts 59′, uniformly spaced in both radial angle and distance from the center of ball joint 99. Said control shafts connect to wobble plate 92 through ball joints 98. Thus, when the handle is moved, forcing any shaft to extend or retract, its opposite element will move equally and oppositely and intermediate elements will also extend or retract proportionally, provided that the bodies 51′ of the resistor units are maintained in their original positions. This is accomplished in the control unit of FIG. 7 by attaching the body 51′ of said variable resistor units to frame 96 of said control.

Slide connection 93 is formed between shaft 102 and frame 96 and may be either square, keyed, or otherwise constructed to allow linear motion without rotation. Said linear motion results from the rotation of threaded shaft 94 within the threaded interior 103 of shaft 102, powered by low speed gearmotor 95 also mounted to frame 96 and controlled by thumb switch 90 of handle 91.

An example of the manner in which the control assembly of FIG. 7 may be linked to the attack angles of several airfoils 6 will be described in order to illustrate basic principles employed in the control of aircraft 1.

In order to counteract pitch or roll of aircraft 1 away from the horizontal, a movement of handle 91 in the direction of the correcting motion desired will cause greatest extension of control resistors C on the side directly opposite the direction of motion of handle 91 and maximum depression in those resistors C toward which the motion is directed. All intermediate resistors C will react in proportion to their angular relation to the axis of said motion. If each resistor C of said manual control is spaced to coincide radially with the elevator which it controls (taking into consideration the laws of gyroscopic precession) and if the control relationships of signal voltage and hydraulic action are correctly linked, a motion of handle 91 will depress elevators at a proper angular offset from the direction of motion required and raise those on the opposite side thereby tilting aircraft 1 in the direction of said handle motion. If the pilot desires to reduce lift, he is able to raise all elevators at once by depressing all resistor C units together. This is accomplished by thumb switch 90 lowering the wobble-plate 92 with respect to the resistor bodies 51 mounted on frame 96. Gearmotor 95 controlled by thumb switch 90 turns threaded shaft 94 to lower or raise shaft 102 through slip-joint 93 to achieve this control effect. Raising said wobble plate increases lift by lowering elevators together.

The effect just described does not proscribe the previous effect of "tilting" the control handle to reapportion lifting forces around the aircraft, it superimposes a new "neutral" position, either above or below the previous airfoil attack angle. Should any controlled aircraft element reach its limit of travel before said motion can restore electrical balance in the system, said controlled element "stalls" against said limit until the pilot's control calls for a new setting within said controlled element's range of action. This allows vanes to close against stops under pressure, insuring tight seals, and further allows voltages to be impressed directly (as by emergency push-buttons) for maximum speed reactions bypassing lowered proportional flow rates as "feedback" resistors begin to restore control voltage balance.

Utilization of the wobble-plate principal for proportioning relative motion of airfoils **6** around aircraft **1** and control of the "average attack angle" of all airfoils **6** considered together, gives a pilot control of aircraft altitude and lift over the range of capabilities of said aircraft through the motions of one hand.

FIG. **9** shows vanes and control linkages suitable for use in the fan discharge air duct of the present invention. Air passes from the fan first through redirecting vanes **9** and then through volume control vanes **8** (FIG. **4**).

Volume control vanes **8** are mounted on shafts **14** which pass through bearing holes in upper duct plate **4** and lower duct plate **5** (not shown in this drawing for clarity), shafts **14** thereby hold said vanes **8** in a circular, uniformly spaced pattern and allow only a rotating action integral with said shafts. Gears **48***a*, partially stripped gears **48** and **48***b* are mounted and locked to said shafts **14** to engage each other and to maintain each gear group in a specific rotational relationship as shown in FIG. **9**. When any one of the vanes **8** in a specific group is rotated, each alternative vane of that group rotates the same direction and to the same degree. Intermediate vanes also rotate to the same degree but in the opposite direction. Thus the 6-vane group located left-of-center in FIG. **9** having all vanes set for maximum "open" condition (radially outward) will, on full retraction of group cylinder **46**, assume the configuration of the group to the right-of-center which has sealed off the duct air passage by touching vane tips. All gears are located outside the air duct on shaft **14** extensions beyond floorplate **5** (which is invisible in this drawing). Any intermediate position may be set and held by the control system previously described. The control illustrated in FIG. **7** is suitable for control of vanes **8**, if the number of control resistors and their radial orientation correspond with the areas controlled by each of the several vane **8** groups as iluustrated in FIG. **9**. Average opening would be controlled by thomb switch **90**. The control for vanes **8** would be set up to provide propulsion in the direction of and in proportion to the degree of control handle "tilt", with average opening regulating the proportion of total airflow diverted from "lift" to produce said propulsion.

FIG. **9** also shows a linkage suitable for control of air redirecting vanes **9**. Vanes **9** incorporate shafts **15** through floorplate **5** and upper duct plate **4** and each has an additional shaft lug **16** passing upward through slot **17** (see FIG. **4**) in fan duct upper plate **4** to allow vanes **9** a narrow range in which to pivot about shafts **15**. Slotted ring **34** fits over said slots **17** and receives shaft lugs through radial slots **76**. Ring **34** is confined to rotation without lateral movement by a multiplicity of grooved rollers **36** situated around its outer edge. Air escape through slots **17** is largely prevented by fitting ring **34** closely over said slots and largely filling the intersection of slots **17** and **76** with shaft lug **16**. Control of vanes **9** is accomplished by a single cylinder **61**" controlled by foot pedals **26** or may be controlled in an alternate embodiment by direct mechanical linkage to said foot pedals as in conventional rudder controls. (Vanes **9** in this aircraft correspond to the action of rudders in conventional designs).

FIG. **10** shows a means by which a multiplicity of devices may be powered and controlled from a single hydraulic source. Oil is drawn from tank **71** by pump-motor unit **70** and is forced into accumulator **72** until gasses trapped in said accumulator's upper chamber compress sufficiently to open pressure switch **73** and stop said pump-motor unit, so that a quantity of hydraulic oil under pressure is available upon demand from valves situated along accumulator outlet manifold **74**. These valves **62** block all flow from said manifold except when they direct it to a cylinder through hose **77** to produce motion as called for by the pilot. Flow to any cylinder cannot exceed its barrel cross-section times its stroke, a maximum of a few cubic inches for small control cylinders (indicated at **61**)

Cylinder strokes in the spring-return phases of control motions use no hydraulic supply, but return previously supplied oil from the cylinders to hydraulic tank **63** through hose **77**, valve **62**, and return manifold **78**.

When total oil supplied to control cylinders is sufficient to lower pressure in accumulator **72**, pump/motor **70** is restarted and runs until accumulator **72** again fills to the upper setting of switch **73** and stops said pump-/motor. Control wiring **79** links valves **62**, cylinder **61**, and the control elements in the hands of the pilot.

Hydraulic oil to power said flap-control cylinders and control wiring to feedback elements of said cylinders passes into airfoils **6** near pivot shafts **33**, or may enter through said shafts by making them hollow.

The descriptions given are examples of means which may be used to achieve this invention, and are not to be interpreted as limiting but only as illustrating a coherent plan to produce a practical, economical and safe aircraft.

It will be apparent to those skilled in the art that various modifications and variations can be made in the foregoing method and apparatus of the present invention and in the construction of the foregoing method and apparatus of the present invention without departing from the scope or spirit of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention, provided they come within the scope of the appended claims and their equivalents.

I claim:

1. A vertical take off and landing aircraft comprising:

an airframe of generally radial symmetry about a central located ducted fan ingesting air from above said aircraft and discharging said air generally horizontally toward the outer perimeter of said aircraft through a duct defined by an upper and a lower plate extending to the perimeter of the aircraft body;

a plurality of curved airflow redirecting vanes pivotally mounted within said duct outboard of and adjacent to the discharge of said fan and adjustable for redirection of said fan discharge into essentially radial airflow;

a plurality of flow-restricting vanes pivotally mounted in said duct outboard of and adjacent to said airflow redirecting vanes;

a generally circular wing comprised of a plurality of similar airfoil segments pivotally mounted in the air discharge of said duct in such a relationship that said air discharge flows generally evenly above and below the airfoil segments of said wing;

a control means for operably linking and controlling the relative positioning of said airfoil segments;

said circular wing airfoil segments are equipped with automatically deployed and retracted spoilers;

said circular wing airfoil segments are equipped with split flap.

2. The aircraft of claim 1, wherein: the control means includes means to control the positioning of the said airfoil elements by wrist and thumb movements of one hand of an operator.

3. The aircraft of claim 1, wherein: the ducted fan provides a gyroscopic effect to stabilize the aircraft.

4. The aircraft of claim 1, wherein: air cutoff vanes are mounted in the fan inlet duct.

5. The aircraft of claim 1, wherein: engine air enters through the intake of said ducted fan and thence through openings in the floorplate of said ducted fan.

6. The aircraft of claim 5, wherein: the power is supplied by an engine driving said ducted fan through a gearbox equipped with a one-way clutch at its output stage.

7. The aircraft of claim 6, wherein: the engine exhaust may be deflected downward during hovering, takeoffs and landings and discharged rearwardly for forward propulsion.

8. The aircraft of claim 1, wherein: the horizontal heading of said aircraft is controlled by foot pedals linked to said redirecting vanes.

9. The aircraft of claim 1, wherein: the forward propulsion of said aircraft is controlled by the selective redistribution of discharge air around the perimeter of the aircraft by means of said flow restricting vanes.

10. The aircraft of claim 7, wherein: said split flaps are controlled to increase drag and thereby to control side to side drive during hovering.

11. The aircraft of claim 1, wherein: the controls are electro-hydraulic, integrated with position-sensitive feedback sensors linked to the driven elements.

12. The aircraft of claim 1, wherein: the controls are servo-hydraulic.

13. The aircraft of claim 1, wherein: power failure protection means provides for free rotation of the fan until needed to provide lift at touchdown.

* * * * *

US005178344A

United States Patent [19]

Dlouhy

[11] Patent Number: 5,178,344

[45] Date of Patent: Jan. 12, 1993

[54] **VTOL AIRCRAFT**

[76] Inventor: **Vaclav Dlouhy**, 6561 Frietchie Row, Columbia, Md. 21045

[21] Appl. No.: **759,515**

[22] Filed: **Sep. 13, 1991**

[51] **Int. Cl.**[5] **B64C 29/00**

[52] **U.S. Cl.** .... **244/12.2**; 244/12.4; 244/23 C; 244/73 B

[58] **Field of Search** .... 244/12.1, 12.2, 12.4, 244/23 C, 26, 73 B, 73 C; 416/108, 110, 111, 119

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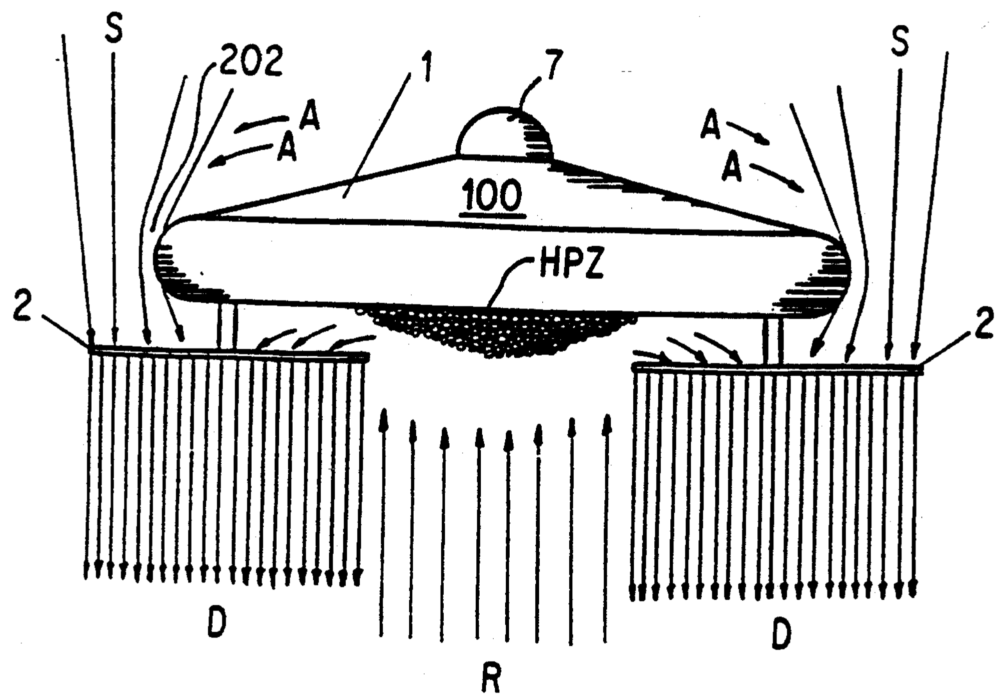
Primary Examiner—Joseph F. Peters, Jr.
Assistant Examiner—Anne E. Bidwell
Attorney, Agent, or Firm—Morton J. Rosenberg; David I. Klein

[57] **ABSTRACT**

A VTOL aircraft (**100**) is provided having a plurality of rotor blade sets (**2**) disposed at least partially beneath the fuselage (**1**). The aircraft is propelled vertically by means of the thrust generated from the rotating sets of rotor blades (**2**), and augmented by suction generated aerodynamic lift. At least a portion of the suction airflow (A) is displaced from the upper surface of fuselage (**1**), creating a region of low pressure. The negative pressure, or suction generated from the portion of the rotor blades (**2**) disposed beneath the fuselage (**1**) causes a column of air to be accelerated upwardly toward the central portion of the fuselage bottom surface (**205**). The upwardly directed airflow (R) contacts the fuselage bottom surface (**205**) and flows thereacross toward respective rotor blades (**2**), generating a layer of high pressure air in juxtaposition with the lower surface (**205**) of fuselage (**1**). The pressure differential between the upper and lower surfaces of fuselage (**1**) provides an aerodynamic lift which augments the thrust generated by the rotor blades (**2**).

21 Claims, 6 Drawing Sheets



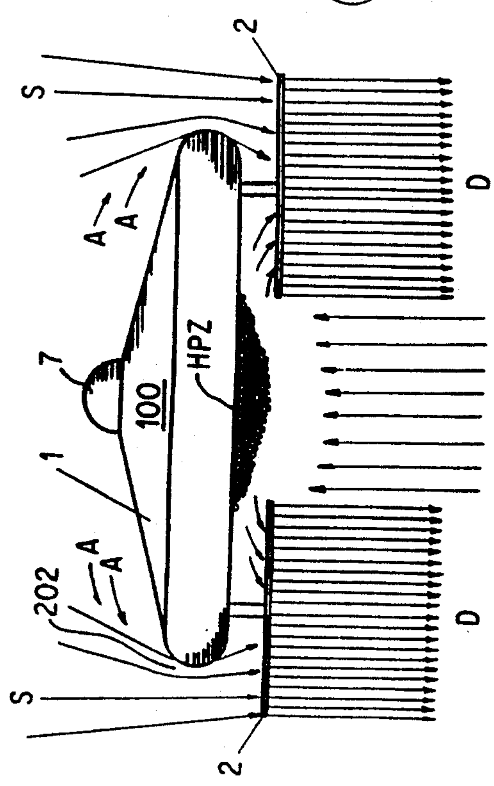


FIG. 1

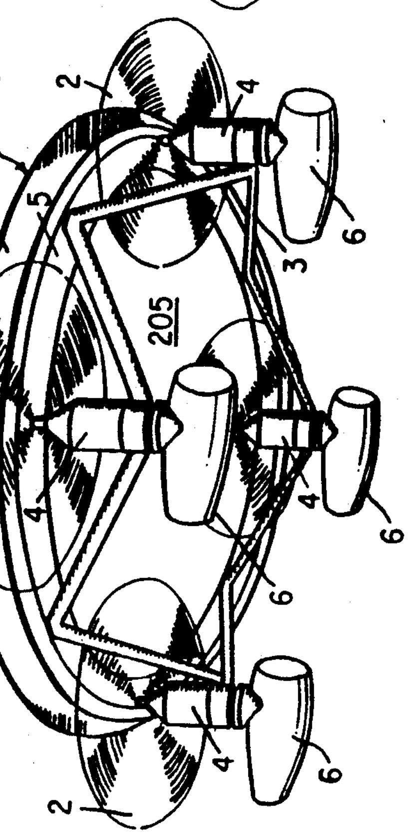


FIG. 2

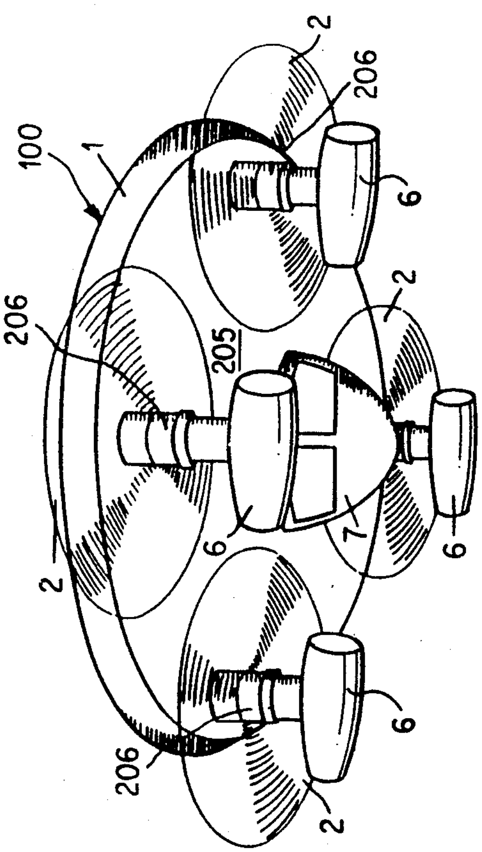


FIG. 3

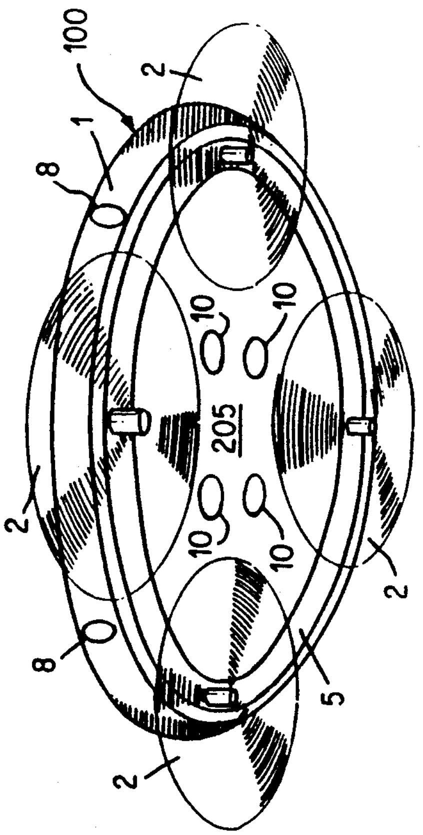


FIG. 4

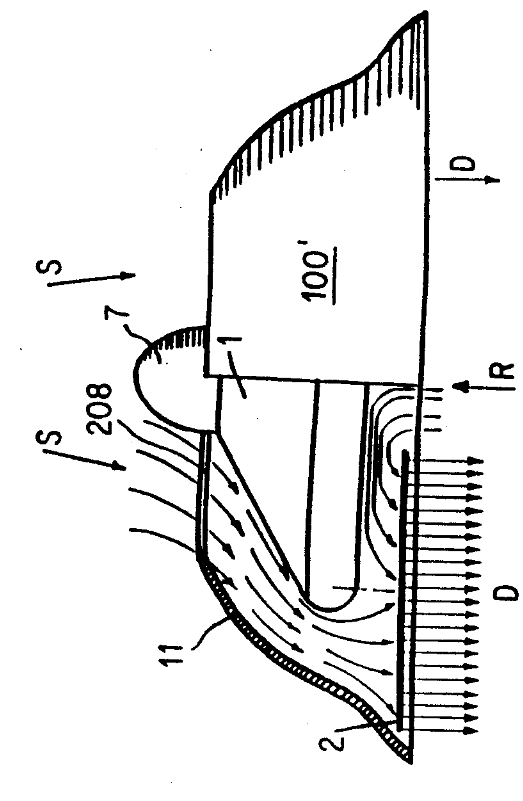


FIG. 5

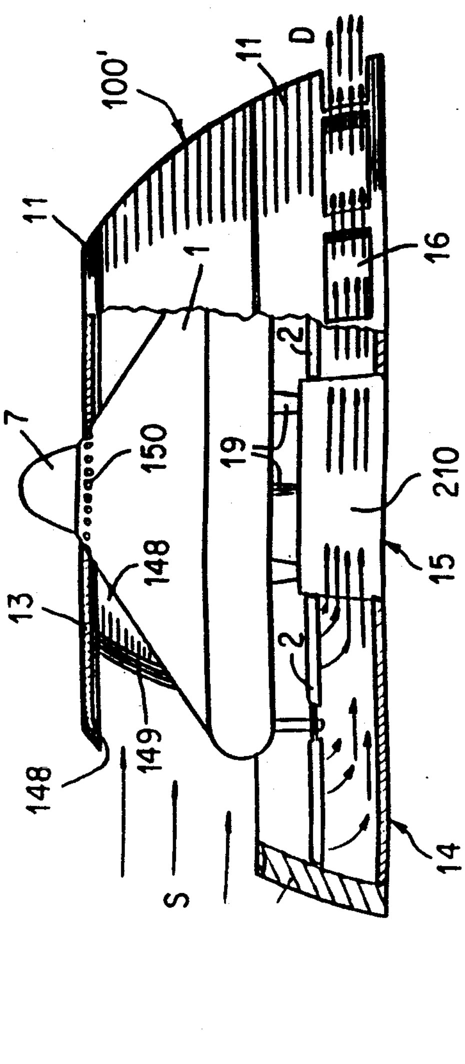


FIG. 6

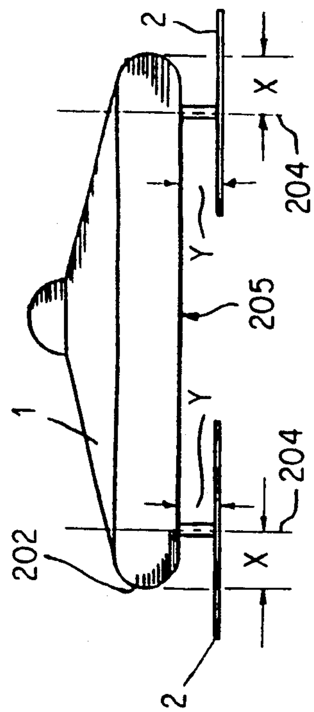


FIG. 7

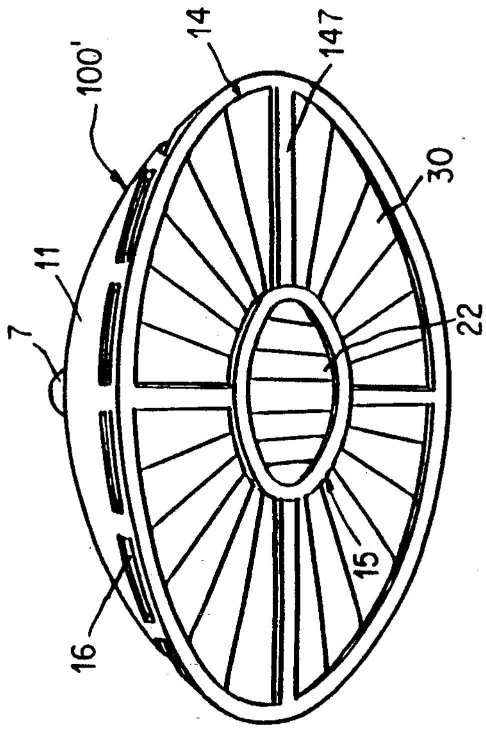


FIG. 8

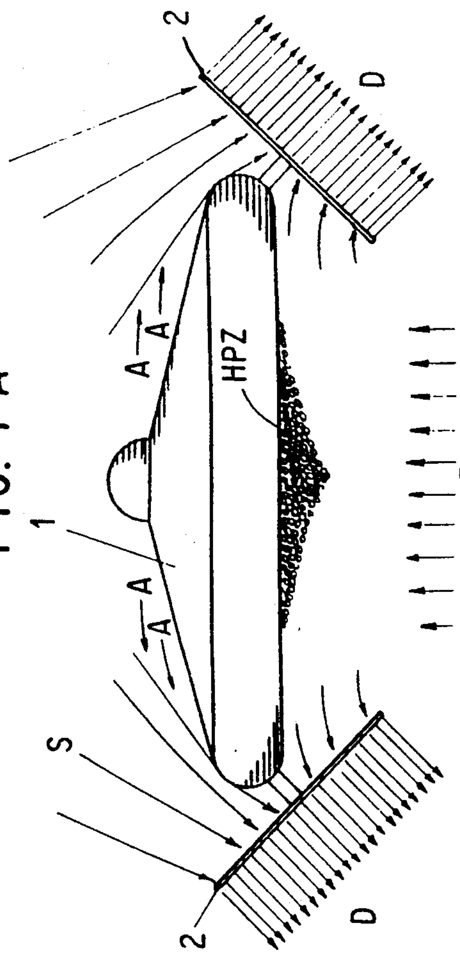


FIG. 7A

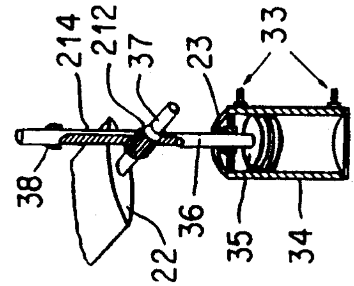


FIG. 14

FIG. 12

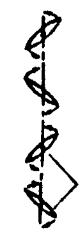


FIG. 13

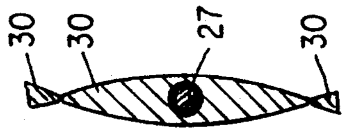


FIG. 11

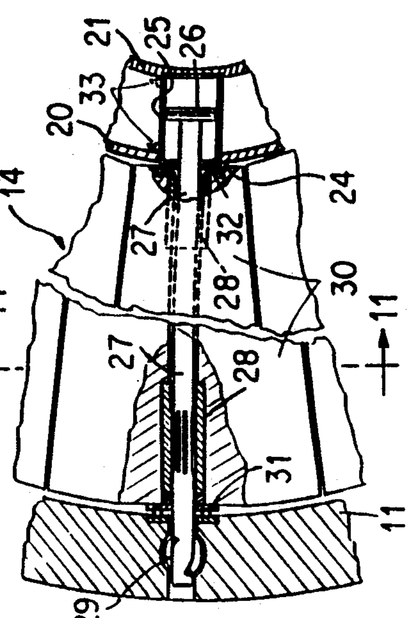


FIG. 10

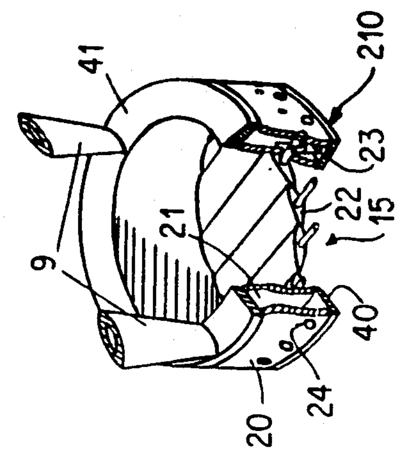


FIG. 9

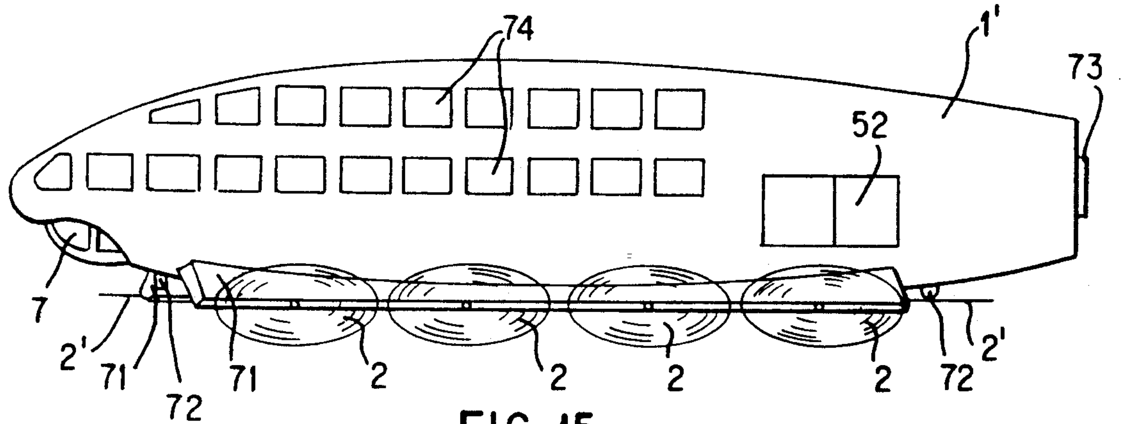


FIG. 15

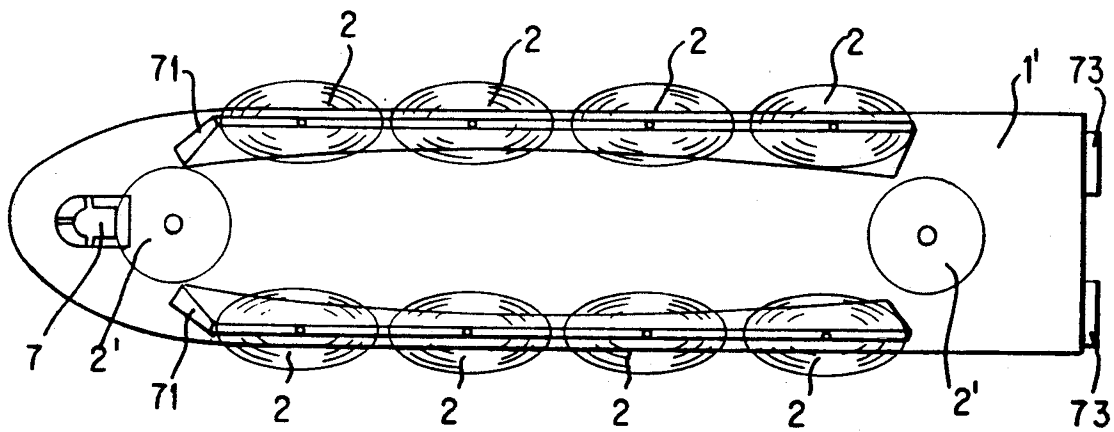


FIG. 16

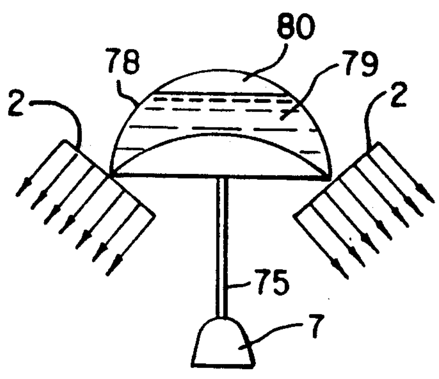


FIG.19

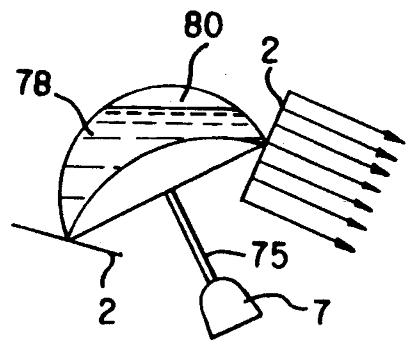


FIG.20

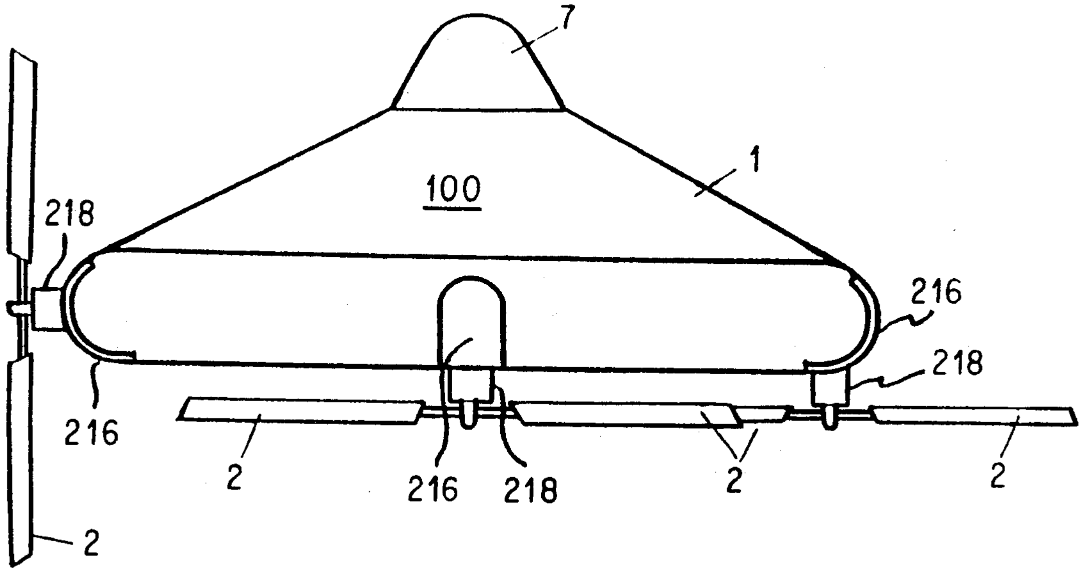

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FIG. 17

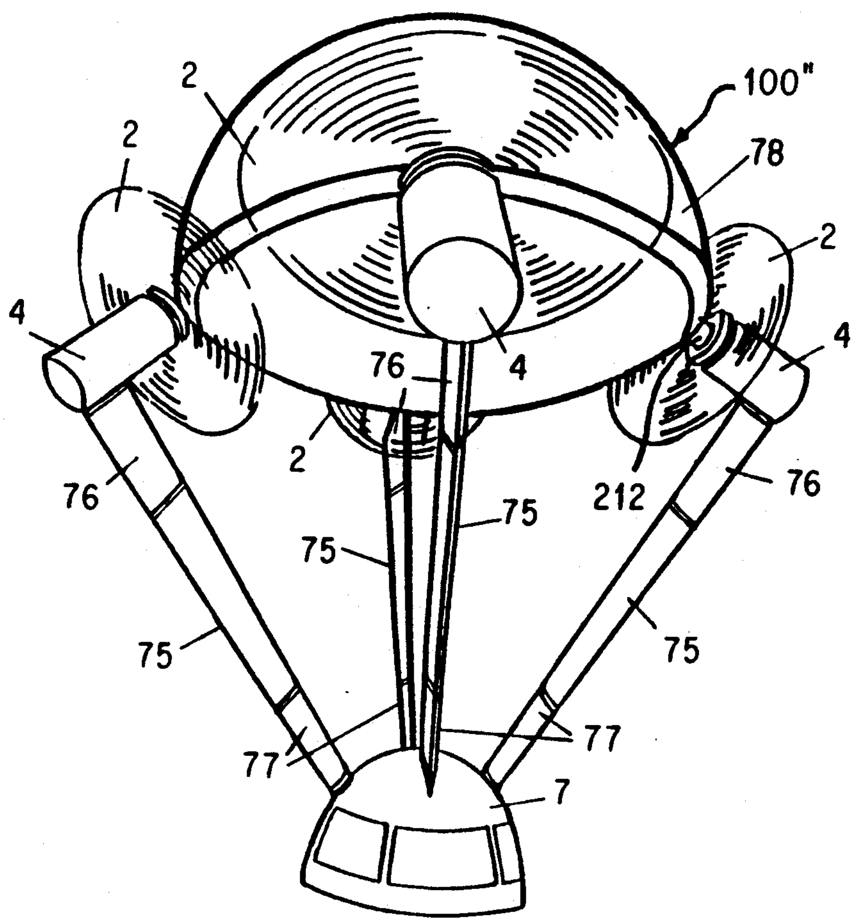
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FIG. 18

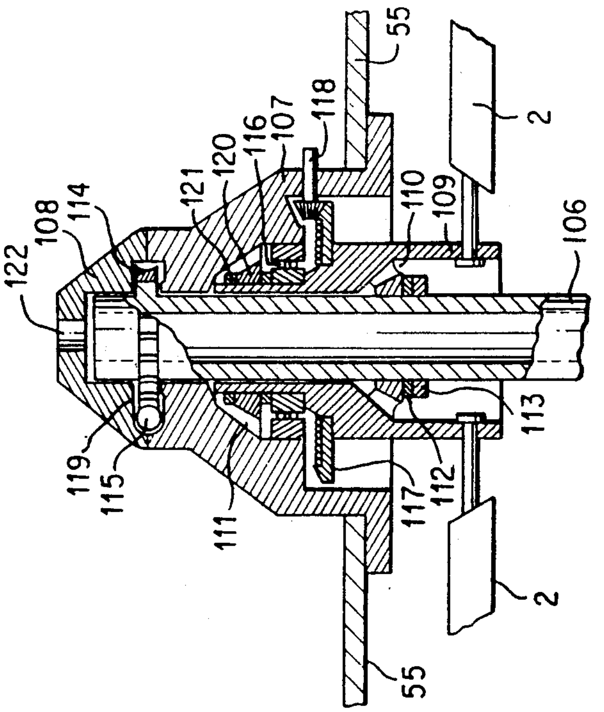

FIG. 22

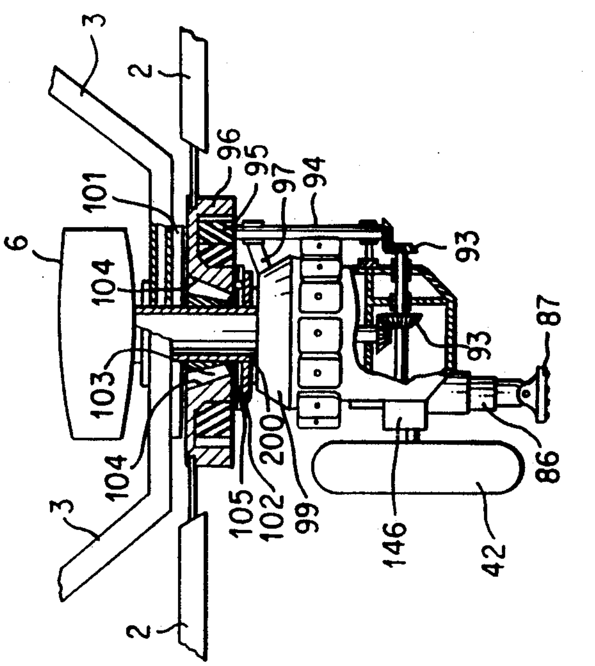

FIG. 21

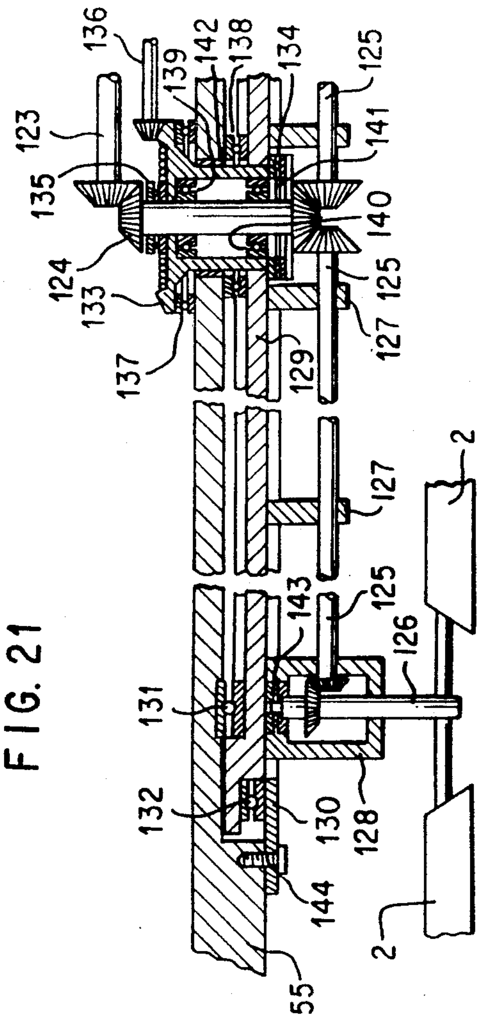

FIG. 23

VTOL AIRCRAFT

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention directs itself to aircraft systems for vertical take-off and landings. In particular, this invention directs itself to a VTOL aircraft having vertical thrust augmented by suction generated aerodynamic lift. Further, this invention is directed to a VTOL Aircraft having a plurality of rotors extending beneath a portion of the fuselage for displacing air downwardly therefrom. More in particular, a portion of the airflow on the suction side of the rotor blades is displaced from above the fuselage for creating a low pressure region thereabove. The remaining portion of the suction airflow is drawn from a central portion of the underside of the fuselage, thereby creating an updraft of rising air which is accelerated by the rotor blade suction so as to contact the fuselage bottom surface and flow thereover to create a high pressure region in juxtaposition therewith. The low pressure region on the upper surface of the fuselage and the high pressure layer on the bottom surface, together in combination provide an aerodynamic lift.

2. Prior Art

Vertical take-off and landing aircraft are well known in the art. The best prior art known to the Applicant is disclosed in U.S. Pat. Nos. 1,405,035; 1,816,707; 3,752,417; 3,117,747; 3,054,578; 3,525,485; 3,172,116; 3,424,404; 3,372,891; 4,187,999; 4,941,628; 2,967,029; 4,202,518; 3,829,043; 2,308,477; 3,514,053; 2,912,188; 3,155,342; 3,199,809; 3,633,849; 3,767,141; 3,414,077; 2,922,277; 3,278,138; 3,284,027; 3,469,804; and, 3,632,065.

In some prior art systems, such as that disclosed in U.S. Pat. No. 1,405,035, aircraft are disclosed which are capable of ascending and descending vertically. In such systems a rotor may be mounted beneath the fuselage to provide the lifting power for a vertical ascent, or for controlling the vertical descent. However, such systems do not disclose or suggest the augmentation of the lifting thrust using suction generated aerodynamic lift.

In other systems, such as that disclosed in U.S. Pat. Nos. 1,816,707 or 3,752,417, vertical take-off and landings are made possible by propeller generated lift. The rotor blades are disposed in duct-like structures formed in the fuselage, for directing the airflow downward to create the thrust utilized to lift the aircraft. Here again, such fans are not augmented by suction generated aerodynamic lift, as provided by the instant invention.

In another prior art system shown in U.S. Pat. No. 2,912,188 engine thrust output is selectively changed between horizontal and vertical directions. However, the weight to lift ratio has been found to be unacceptably low and fuel consumption and noise levels are high. As in previously described references the vertical thrust is not augmented by the suction generated aerodynamic lift.

SUMMARY OF THE INVENTION

A VTOL aircraft is provided having a fuselage whose upper and lower surfaces together form a predetermined surface contour defining a lifting body. The VTOL aircraft further includes at least one propulsion assembly coupled to the lower surface of the fuselage for displacing the aircraft in a substantially vertical direction by (1) displacing air from the area juxtaposed to the upper surface of the fuselage, and (2) displacing air for contact with a central portion of the lower surface of the fuselage. Thus, a low pressure region is formed above the fuselage and a high pressure region is formed adjacent the central lower surface portion of the fuselage to create an aerodynamic lifting force.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view of the VTOL aircraft;

FIG. **2** is a perspective view of one configuration of a first embodiment of the VTOL aircraft;

FIG. **3** is a perspective view of an alternate configuration of the first embodiment of the VTOL aircraft;

FIG. **4** is a perspective view of a second alternate configuration for the first embodiment of the VTOL aircraft;

FIG. **5** is a schematic view for a second embodiment of the VTOL aircraft;

FIG. **6** is an elevation view in partial cutaway of the second embodiment of the VTOL aircraft;

FIG. **7** is a schematic view of the VTOL aircraft showing dimensional relations;

FIG. 7A is an elevational schematic view of the VTOL aircraft showing the rotors inclined at a predetermined angle;

FIG. **8** is a perspective view of the second embodiment of the VTOL aircraft;

FIG. **9** is an enlarged detail of the rising air directing structure for the second embodiment of the VTOL aircraft;

FIG. **10** is an enlarged detail of the closure system for the downwash air channel;

FIG. **11** is a cross-sectional view of the shutter panel taken along the section line **11**—**11** of FIG. **10**;

FIG. **12** is a schematic diagram of the shutter panels in an open condition;

FIG. **13** is a schematic diagram of the shutters in a partially closed condition;

FIG. **14** is an enlarged detail of the return air shutter servosystem;

FIG. **15** is an elevation view of an embodiment of the VTOL aircraft having an elongated fuselage;

FIG. **16** is a bottom view of the VTOL aircraft embodiment of FIG. **15**;

FIG. **17** is an elevation view of a first embodiment of the VTOL aircraft having pivotable engine units;

FIG. **18** is a fourth embodiment of the VTOL aircraft having a concave fuselage bottom surface;

FIG. **19** is a schematic diagram of the thrust vectors for vertical takeoff and landing of the embodiment of FIG. **18**;

FIG. **20** is a schematic diagram for the VTOL aircraft embodiment of FIG. **18** showing thrust vectors for horizontal flight;

FIG. **21** is an enlarged detail in partial cutaway of an engine mounting structure;

FIG. **22** is an enlarged cross-sectional detail of a rotor drive and horizontal thrust engine support; and,

FIG. **23** is an enlarged cross-sectional detail of a rotor drive and gyration assembly.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the Figures, there is shown VTOL aircraft **100** having at least four rotor blade sets **2** rotatively driven beneath at least a portion of the fuselage **1** for producing suction generated aerodynamic lift. As will be seen in following paragraphs, VTOL aircraft **100** is specifically directed to the concept of providing an aircraft and propulsion system combination wherein the engine thrust is augmented by aerodynamic lift for propelling the aircraft in a vertical direction. The augmented lift being a byproduct of the thrust generation and the fluid flow path of the air being drawn by the rotor blades **2**. The contour of fuselage **1** is that of a lifting body, such that in transition to horizontal flight, sufficient air is displaced over the fuselage surfaces to create conventional aerodynamic lift. The vehicle thereby transitioning from engine borne lift to the equivalent of wing borne lift, by virtue of the lifting body fuselage contour.

Horizontal propulsion may be generated through the following actions:

1. tilting one or more vertical propulsion units into a horizontal direction;
2. through application of one or more horizontal propulsion units;
3. vectoring of thrust vertical propulsion units; and/or;
4. directing suction and discharge air in a horizontal direction by means of providing the suction mantle with discharge and intake orifices as well as throttling and closing devices.

Although not restricted to military or commercial aircraft applications, VTOL aircraft **100** is particularly adapted to conveying passengers between selected sites, which may not be accessible to standard fixed wing aircraft, while providing safer, more efficient, and higher speed transportation than available utilizing helicopters. The disclosed principle of suction generated aerodynamic lift is applicable to a large variety of aircraft designs and configurations, each particularly adapted for a respective intended application, such as search and rescue, surveillance, commercial cargo, commercial passenger service, or the like.

The provision of rotor blades **2** for generating vertical lift and use of jet engines for propulsion once the aircraft **100** is positioned at the desired flight altitude and provides significant advantages for take-off and landing at inter-city airports. Since the jet engines are not used for taking-off or landing, there is a lower level of noise emitted by the aircraft. Since the rotor blades **2** extend beneath the fuselage **1**, the hot engine exhaust gases can be directed at the rotor blades, serving a deicing function in the winter months.

Vertical ascent to a cruising altitude as well as a vertical landing substantially eliminates dangers associated with high speed take-off and landing of conventional aircraft as has been well documented in the state of the art.

An additional danger which is substantially reduced is the occurrence of windshear air currents. Since the subject VTOL aircraft of this invention concept travels through the windshear air currents in a vertical displacement, such can compensate for windshear influence by thrust readjustment of individual rotors. As is known in the art, this may be done automatically by processors and computers when attached sensors detect a deviation in the VTOL aircraft's horizontal attitude or in a preset rate of ascent or descent. Additionally, in known aircraft, a collision and intake a birds or other flying species is a disadvantage. In the manner as hereinbefore been described in the subject VTOL aircraft diminishes the possibility of bird or other flying species intake or collision. Obviously, by use of the subject VTOL aircraft any problems associated with a plurality of airplanes colliding on the same runway will be substantially diminished.

Referring now to FIGS. **1** and **7**, there is shown a schematic view of the airflow patterns generated with respect to VTOL aircraft **100**. The rotors **2** are driven by one or more sources of motive force, such as from turbines or piston operated engines. The rotational axis **204** for each of the sets of rotor blades **2** are located a distance X from the peripheral edge **202** of the fuselage **1**. The rotor blades **2** are disposed a distance Y from the bottom surface **205** of fuselage **1**. The dimension X is chosen to provide a sufficient portion of the rotor blades **2** extended beyond the fuselage peripheral edge **202** in order to draw sufficient airflow A from above the fuselage surface, for creating an area of low pressure thereat. Similarly, the location of the rotor blade **2** with respect to the bottom surface **205** of fuselage **1** is defined by dimension Y for sufficient generation of the column of upwardly directed air R of sufficient inertia to contact the bottom surface **205** and flow thereover toward a respective set of the rotor blades **2**. If the rotor blades **2** are disposed too close to the bottom surface **205** of fuselage **1**, the portion of the rotor blades **2** under the fuselage will be unable to generate the necessary suction to create the high velocity airflow R. Likewise, if the rotor blades **2** are disposed greater than a predetermined distance from the bottom surface **205** of fuselage **1**, too little of the suction air R will contact the fuselage bottom surface **205**, thereby failing to create the necessary high pressure region required to generate the augmented aerodynamic lift for augmenting the thrust generated by the rotor blades.

The new concept of suction generated aerodynamic lift takes advantage of airflow patterns A and R induced by the rotor blades **2** in conjunction with the fuselage **1**. By displacing air from the upper surface of the fuselage, such creates a low pressure region in the direction which the aircraft is to be displaced. High velocity air R directed toward a central portion of the fuselage is induced by the plurality of sets of rotor blades **2** utilized for the aircraft **100**. However, it will be understood that three rotors may be used although the controls are simplified and safety enhanced when a four rotor arrangement is used. A major portion of the high velocity air R will have sufficient inertia to contact the bottom surface **205** and form a high pressure layer thereon. The suction airflow S in the vicinity of the fuselage perimeter edge **202** is displaced, thereby creating a displacement of the air A above the fuselage upper surface. In this manner, air is drawn into the airstream S. By virtue of the plurality of sets of rotor blades **2**, as well as the gyration thereof, to be described in following paragraphs, produces an annulus of low atmospheric pressure above the fuselage, and an annulus of discharge airflow D below the rotors **2**. Likewise, the suction effect of the rotor blade portions disposed beneath the fuselage induces the suction airflow R. The suction pressure which draws the airflow R is a product of all of the sets of rotor blades **2**, which provide sufficient acceleration and inertia to the airstream for creating a zone of high pressure in the central area of the lower fuselage surface **205**.

In various types of aircraft without gyration, a larger number of rotors than four may be more desirable, in order to reduce gaps, between the rotors' tips. Such will undoubtedly improve efficiency of the suction generated lift by limiting the leakage between airflows of differing pressure and directional flow. Substantially complete elimination of leakage may be achieved by the gyration of the rotors.

In craft not having a suction mantle, the gyration of rotors may be used during ascent or hovering. During horizontal flight, annular plate **5** may be locked in a fixed position, to enable rotors **2** to control flight maneuvers.

Referring more in detail to FIG. **1**, such schematically shows the airflow and the resulting effect on the fuselage. The suction effect of rotors **2**, which are substantially equally spaced under the fuselage, and adjacent to the periphery as shown, creates airflow S and R.

The rising airflow R impinges and pushes fuselage **1** in a vertically upward direction. The airflow S, being displaced in a vertically downward direction toward rotors **2**, act as a barrier for any suction of shielded portions of rotors **2**, and force rotors **2** to displace or suck the air from the central zone beneath the fuselage. Airflow S is formed around the periphery of fuselage **1** by suction applied through the protruding portions of rotors **2** around the periphery of fuselage **1**.

Gyration forms the airflow S and D around fuselage **1** in the overall contour of an annulus. The airflow S reduces the atmospheric pressure above fuselage **1** by displacing or sucking the air in direction A as shown in FIG. **1**. The suction effect of the shielded portions of rotors **2** sucks the air from the center zone below fuselage **1**. This air is instantly replaced by air being displaced from below by atmospheric pressure between the downward airflows D as shown.

Rising airflow R impinges and collides with the bottom of fuselage **1** prior to being displaced or sucked in by rotors **2**.

The collision creates a zone of higher pressure HPZ below fuselage **1**. The higher pressure zone is present as long as rotors **2** generate the suction displacement. The blades of rotors **2** may have adjustable pitch as is known in conventional propeller systems. In order to control flight maneuvers relating to hovering and descent of the aircraft.

The distance of the rotors **2** from the fuselage **1** is of a predetermined dimension, such that the rising airflow is maintained at its peak pressure value. When the distance is excessive, the suction effect of the shielded portions of rotors **2** would suck the air from all directions, and suction from the center zone would have a weaker effect. When the distance is too small, the quantity of air would be insufficient for proper functioning of the shielded portions of rotors **2**.

It is to be understood that the graphic representation of high pressure zone HPZ is provided to merely show the positional location of the high pressure zone and not represent a limit or contour of the high pressure zone.

Referring now to FIG. **7A**, there is shown a schematic view of airflow patterns generated with respect to VTOL aircraft **100**. In this representation rotors **2** are tilted or inclined to a 45 degree position. Tilting of rotors to direct the suction flows S an A from the zone above the craft's center is more efficient in reducing air pressure above the aircraft. Reduced air pressure above the fuselage offers less resistance to the craft's displacement during ascent. The high pressure zone HPZ is larger or greater than in a craft with a horizontal plane of rotation of rotors **2** due to the larger passage for rising airflow R.

As is clear, the rotors are tilted or inclined after a safe distance above the ground is reached. Such must be returned to their horizontal position before horizontal flight or landing is actuated.

Referring now to FIG. **2**, there is shown a first embodiment of the VTOL aircraft **100** having a saucer-shaped fuselage **1** with a substantially planar bottom surface **205**, from which is suspended a sub-fuselage frame **3**. The vertical thrust engines **4**, which drive the rotor blades **2**, are mounted to the sub-fuselage frame **3**. Additionally, the sub-fuselage frame **3** supports a plurality of horizontal thrust engines **6**. In this particular embodiment, the pilot's cabin **7** is located on the upper portion of the fuselage, as shown in FIG. **1**, or alternately may be coupled to the bottom surface **205**, or supported by the sub-fuselage frame **3**, and thereby separate from the fuselage **1**.

The sub-fuselage frame **3** is fixedly coupled to an annular plate member **5**, disposed on the bottom surface of the fuselage. Annular plate member **5** is rotatably displaceable with respect to the bottom surface **205** of fuselage **1**, such that the propulsion systems **4** and **6** rotate with respect to a central vertical axis of fuselage **1**. Thus, by rotating the rotational axes of the rotor blades **2** about the circular path defined by the plate member **5**, a continuous annular curtain of air is created about the central suction zone, which conducts the airflow R. The sub-fuselage frame **3** may be connected directly to the bottom surface **205** without use of annular plate **5**. This may be done if the augmented lift is not needed for a particular aircraft and simplification of the overall design is preferred. Such a connection may be required when a cabin is mounted to the sub-fuselage frame **3**, to avoid exposing the aircraft operators to centrifugal force, which would occur if the gyration were used. In addition to the thrust generated by the rotor blades **2**, the thrust generated by the engines **6** can be directed vertically for added vertical lifting force. The thrust of the engines **6** can be directed through thrust vectoring, pivotal rotation of the engines, or a combination thereof. While engines **6** are depicted as jet type engines, obviously other sources of thrust may be utilized.

In transitioning to horizontal flight, the thrust of the vertical thrust engines **4** is reduced, while the thrust of the horizontal thrust engines **6** is increased, after their alignment with the desired flight direction.

Transition from vertical to horizontal flight requires precise control of the rotational speed of the plurality of rotor blades **2**, and the pitch thereof, while at the same time adding thrust from the horizontal thrust engines **6**. This process is made more complex, when it is desired to vector the aircraft at some angle with respect to the horizontal plane. Obviously, manual control of the engine thrust, providing thrust from a particular engine when it is in a particular position with respect to fuselage **1**, would not be practical. Therefore, such control is handled by a computer system, wherein the thrust of the engines **4** and **6** are varied in accordance with their relative position about the fuselage **1**, responsive to the selected direction in which the craft is to fly. Similarly, the pitch of the rotor blades and the RPM of the respective engines are varied in accordance with the pitch, yaw, and bank angle at which the aircraft is to be positioned, or for maintaining the aircraft in a horizontal plane, despite changes in atmospheric conditions, which might otherwise disturb the orientation of the aircraft.

Turning now to FIG. **3**, there is shown an alternate configuration for aircraft **100**. In this configuration, the power source for rotors **2** is located within the fuselage

1, and may be a single power source driving all of the sets of rotor blades 2, or individual power plants for each of the vertical thrust systems. Each of the horizontal thrust engines 6 is supported by a respective pylon 206, which powers the drive elements for the respective rotor blades 2.

Referring now to FIG. 22, there is shown, the rotor drive assembly and pivotal support for a horizontal thrust engine 6. The rotor blades 2 are pivotably coupled to the hub 109. The pitch adjusting mechanism for the rotor blades 2 is omitted from this drawing, for purposes of simplification, since such mechanisms are well known in the art for pitch adjustment of propeller blades, there is no requirement to discuss such mechanisms in detail. Power is transmitted from a central motive power source by means of a beveled pinion gear coupled to the drive shaft 118 for meshing engagement with the beveled ring gear 117, which is fixedly coupled to the hub 109. The horizontal thrust engine 6 is supported by the hollow shaft 106, which is rotated by means of the gear 114 coupled to the shaft 106. A worm gear 115 is coupled to a servomotor (not shown), for controlling the position of shaft 106, and thereby the direction to which the thrust from the engine 6 is directed. The fuel lines and control cables for engine 6 are passed through the opening 122, formed in the gear cover 108, and through the hollow passage formed in the shaft 106. The hub 109 is pivotedly supported by the shaft 106 through the beveled ring 112 and bearing 110, secured by the adjustment means 113. The hub 109 is pivotedly supported within the rotor drive case 107 by means of the ball bearing assembly 116, the beveled ring 120, and respective bearing 111, secured by the end plate adjustment means 121. The rotor drive case 107 is secured to a fuselage structural member 55 (fuselage bottom surface 205 is omitted for clarity).

Referring now to FIG. 4, there is shown another configuration for the VTOL aircraft 100. In this variation, the engines for supplying both vertical and horizontal thrust are enclosed within fuselage 1. The horizontal thrust engines are equally spaced about the periphery of the fuselage 1, having respective exhaust nozzles 8 extending therethrough. The vertical thrust motive power source, or sources, have their air intake openings formed in the upper surface of the fuselage (not shown), such that aircraft 100 is capable of operating in dust laden environments, such as during low altitude flight above the desert, or other sandy environments.

In order to obtain vertical ascent of aircraft 100 to very high altitudes, which would otherwise be unobtainable utilizing rotor blades 2, since the air density would be insufficient to generate the necessary thrust, aircraft 100 may be provided with a plurality of rocket engines having nozzles 10 extending through the bottom surface 205 of fuselage 1. The rocket engines are symmetrically located in the central portion of the fuselage for adding the necessary thrust to propel the vehicle to the desired altitude.

Rotor blades 2 are coupled to the motive power source through shafts extending through the annular rotatable plate 5, utilized for gyration of the rotor assemblies.

It is understood that this type of aircraft may also be designed without gyration and without the annular plate 5 as is clearly shown in FIG. 3 in order to lessen the complexity of the aircraft assemblage and to further diminish any dust disadvantages.

Referring now to FIG. 5, there is shown the airflow patterns for a VTOL aircraft 100' wherein the fuselage 1 is enclosed within a suction mantle 11. The mantle 11 surrounds the fuselage 1, with an opening 208 being formed at the upper portion through which the pilot's cabin 7 protrudes. An annular space through which the suction airflow S passes is defined by the opening 208 and the fuselage 1. As before, the suction generated by the rotor blades 2 create a low pressure region above the fuselage, in this case above the opening 208. As previously discussed, the suction generated aerodynamic lift is created by the pressure differential between the upper and lower surfaces of the fuselage, a high pressure region being formed by the centrally disposed airflow column R which forms a high pressure layer of air in juxtaposition with the central portion of the fuselage bottom surface. Thus the thrust of the downward directed airflow D is augmented by the suction generated aerodynamic lift, resulting from the low pressure region above the opening 208 and the high pressure region beneath the fuselage 1.

Referring now to FIGS. 5, 6, and 8, there is shown VTOL aircraft 100' having a suction mantle 11 adapted to utilize the thrust from rotors 2 for both horizontal and vertical flight. The easiest method by which the rotor's thrust can be utilized to propel the vehicle in an other than vertical direction is to change the balance of thrust between opposed rotors. Thus, by reducing the thrust of the rotor adjacent the desired direction of flight, and increasing the thrust of the rotor in a diametrically opposed position, the aircraft 100' will pitch downward, and be propelled in a horizontal direction. The generation of differential thrust between the multiple rotors is easily accomplished by adjusting the pitch of the rotor blades 2, by conventional means, under computer control. Once the attitude of the aircraft has been changed, the thrust of the rotors is effectively vectored, and all can be controlled to propel the vehicle in the desired direction. The aircraft shown in FIG. 5 may be airborne by only thrust of its rotors and augmented by suction generated aerodynamic lift. The use of this embodiment aircraft may be limited to lifting and hovering, as for a flying crane, as well as for short of mid-distance travelling.

In a preferred arrangement, as shown in FIGS. 6 and 8, the mantle 11 is adapted for re-routing the airflow of rotors 2, in order to propel the vehicle in a substantially non-vertical direction. In order to achieve this airflow, the gyration of rotors 2 have to be used during horizontal flight, to maintain air at a high pressure below rotors 2. Here again, the mantle 11 with closing devices 14 and 15 in a closed position, defines a lifting body for supplying aerodynamic lift for the craft as it is propelled in other than a substantially vertical direction. The mantle 11 is coupled to the fuselage 1 by means of a plurality of structural members 147, disposed at the bottom of mantle 11, and a plurality of structural members similarly disposed at the upper portion, not shown. The lower portion of mantle 11 is provided with a plurality of discharge orifices 16, through which the downwash airflow from the rotors is discharged to generate horizontally directed thrust. The discharge orifices 16 are selectively opened in synchronism with the closing of the discharge opening area, between the mantle and the return airflow directing structure 210, centrally disposed beneath the fuselage, to be further described in following paragraphs. The annular opening in the mantle below the rotor blades 2 is provided with a closing device **14**, having a plurality of shutter panels **30**, which permit the gradual transfer of thrust from a vertical direction to a horizontal one. Similarly, an intake orifice **148** can be selectively opened by means of the telescoping panels **149**, to permit the suction airflow to enter from the direction of travel. As was the case for the lower discharge opening, the upper mantle opening **208** is provided with a closing device **13** of similar construction to that of closing device **14**.

During the transition from hovering to horizontal flight, the thrust of the rotors must be temporarily increased, to provide additional thrust for initiation of the horizontal flight.

Once in a substantially non-vertical direction of flight, there is no requirement for rising air to be directed upward through the central portion of the mantle **11**, defined by the structure **210**. The rising airflow directing structure **210** is coupled to the fuselage by means of a plurality of structural members **19**, and fitted with a closing device **15** having a plurality of shutter panels **22** for closing the opening defined thereby, when the discharge orifices **16** are utilized.

The mechanics for accomplishing the gyration is shown in FIG. **23**, wherein the motive power for the rotors **2** is supplied by an input shaft **123** for coupling with one end of the pinion shaft **124** by means of a bevel gear arrangement. Beveled gears are utilized to distribute the power from the opposing end of pinion shaft **124** through a plurality of horizontal shafts **125**, each of the horizontal shafts **125** being drivingly coupled to a respective rotor shaft **126**, preferably by a bevel gear arrangement. Each of the horizontal drive shafts **125** are supported by appropriate bearings in the support elements **127** disposed in spaced parallel relation on the gyration plate **129**. The rotor shafts **126** are bearing supported and extend through a rotor housing **128** which is coupled to the gyration plate **129**.

The pinion shaft **124** is rotatably supported within the hollow beveled ring gear assembly **133**, which is in turn rotatably supported by the fuselage structural member **55**. Ring gear assembly **133** is supported by the structural member through the bearing members **137** and **142**, respectively coupled therebetween. Pinion shaft **124** is supported by the thrust bearings **134** and **135**, as well as bearings **139** and **140**.

The gyration plate **129** is fixedly coupled to the hollow beveled ring gear assembly **33** and supported through bearings **131**, **132**, and **138** to the structural member **55**. The bearings **131** and **138** provide a direct interface between the gyration plate **129** and the structural member **55**, whereas the bearing **132** supports the gyration plate **129** through its interface with the gyration bearing cover plate **130**, which is coupled to the structural member **55** by means of fasteners **144**. Thus, the gyration plate **129** is rotatably driven by means of the hollow beveled ring gear assembly **133**, which is driven by the drive shaft **136**, supplying power from the central motive power source, but at a lower RPM than that of drive shaft **123**.

The arrangement shown in FIGS. **6** and **8** provides a unique and new maneuvering feature which is unknown in current aircraft. Such new maneuvering feature allows for deceleration, termination of displacement, and flying backward in the same path at the same altitude. Such maneuvering may be achieved by reversing the direction of suction and discharge airflows and by simultaneously regulating the action through the elements **13**, **14** and **15** in relation to the changing speed in order to maintain the same altitude and attitude of the aircraft. This new maneuvering ability may be utilized in civilian aircraft as a final maneuvering action to avoid collision with another aircraft or edifice. Radar warning would automatically initiate evasive maneuvers and such may be controlled by a computer processor in a preprogrammed sequence.

In order to obtain and maintain a supply of compressed air below the rotors, between the plane of gyration and the closing device **14**, the particular number of blades in the rotors may be considerably larger than in previously described embodiments.

The bottom of lower rim of the suction mantle **11** may be equipped with hardened rubber pads on which the craft may rest subsequent to landing. During the landing maneuver, the ground effect will slow the craft in the same manner as is provided in a hovercraft. A landing onto a body of water may be a standard feature in aircrafts according to this inventive concept for special purposes and objectives if a needed protection against corrosion and waterproofing is provided.

Referring now to FIG. **9**, there is shown the structure of the closing device **15** for the rising airflow directing structure **210**. The rising airflow directing structure **210** is formed by a pair of cylindrical walls **20** and **21** concentrically arranged with an annular top wall **41** and annular bottom wall **40** extending therebetween. The space between the outer wall **20** and inner wall **21** is utilized to contain the closure control servos **23**, each drivingly coupled to a respective shutter panel **22**. The outer wall **20** is provided with a plurality of equally spaced through openings **234**, for receiving the down draft shutter operating servos, as will be described in following paragraphs.

Referring now to FIG. **14**, there is shown an enlarged detail of the closure control servo **23** of the closing device **15**. The shutter panel **22** is fixedly coupled to a shaft **37**, such that rotation of shaft **37** rotates the shutter blade **22** therewith. Shaft **37** includes a portion **212** having gear teeth formed therein for meshingly interfacing with the rack **214**, formed in the cylinder shaft **36**. Shaft **36** is coupled to a piston **35**, which is bi-directionally displaceable within the cylinder **34**. Cylinder **34** is a double-acting fluid operated cylinder, having fluid input/output ports **33** disposed at opposing ends thereof. Each of the shafts **37** for a respective shutter blade **22** is supported on opposing ends of the blade **22**, through apertures formed in the inner wall **21**.

Referring now to FIG. **10**, there is shown an enlarged detail of the downwash closing system **14**, wherein the rotational angle of each of the shutter blades **30** is controlled by a respective servo **25**, comprising a double-acting cylinder having a piston **26** coupled to a shaft **27**. The shaft **27** is slidingly coupled to the blade **30** by means of a plurality of splines formed on shaft **27**, which engage slotted bushings **28**, disposed on opposing ends of blade **30**. The distal end of shaft **27** is provided with a pair of helical lugs **29** for imparting a rotational moment to shaft **27**, as it is slidingly displaced by piston **26**. Thus, the blade **30** is rotated by virtue of the splined connection with shaft **27**, as shaft **27** is slidingly displaced through blade **30** and rotated by the lugs **29**. A pair of bearings **31** and **32**, disposed on opposing ends of blade **30** insure the free rotation thereof responsive to the rotation of shaft **27**.

In the closed position, shown in FIG. **11**, each of the shutter blades **30** are arranged such that the transverse axis of each blade lies in a single continuous plane, thereby closing the annular opening between the mantle **11** and the structure **210**. As shown in FIGS. **12** and **13**, rotation of the blades from the position wherein the transverse axes are coplanar to one in which they are all substantially parallel, provides an open annular path for the free flow of discharge air.

Referring now to FIGS. **15** and **16**, there is shown an alternate fuselage configuration, the fuselage **1'** having a longitudinally extended fuselage contour of the cigar-shaped type. As in the saucer-shaped fuselage, the aircraft is provided with a plurality of sets of rotor blades **2** disposed at least partially beneath the lower surface of the fuselage. On opposing sides of the aircraft fuselage **1'**, a plurality of symmetrically spaced sets of rotor blades **2** are extended from a rotor base **71**. In order to form a wall of downwash airflow about the central rising airflow path, a pair of sets of rotor blades **2'** are disposed on opposing ends of the fuselage and centered thereon. The rotor blades **2** on opposing sides of the fuselage are angled to maximize the suction generated aerodynamic lift, the principles of which having previously been described. The fuselage **1'** may be provided with horizontal thrust engines, having exhaust nozzles **73** located at the rear of the fuselage for providing longitudinally directed thrust. The fuselage **1'**, having a lifting body contour, may be provided with a plurality of windows **74** and access doors **52**, of the type normally found in commercial aircraft.

Referring now to FIG. **17**, there is shown an alternate positioning system for the saucer-shaped fuselage **1**. Each of the rotor drive pylons **218** is coupled to the fuselage **1** by means of a pivoting structure **216** for angularly displacing the thrust vector of the respective sets of rotor blades **2**. Thus, each of the pylons **218** may be rotated within an angular range of 30degrees –45 degrees for maximizing the suction generated aerodynamic lift, or any one or more pylons **218** can be rotated up to 90 degrees for providing vectored thrust to propel the aircraft **100** in a predetermined direction. Here again, as the vehicle transitions between thrust generated lift to the aerodynamic lift of the lifting body, the thrust from the downwardly directed rotors is gradually reduced as the horizontally directed rotor thrust is increased, wherein the lift created by the downwardly directed rotors is replaced by the lift of fuselage **1**.

Referring now to FIGS. **18–20**, there is shown a VTOL aircraft **100"** having a concave bottom surface for improving the flow path of the rising suction airflow which forms the high pressure region on the bottom fuselage surface. As shown, each of the rotor blade sets **2** are driven by a respective engine **4**, coupled to the fuselage **78** by means of the hollow support **212**. The pilot's cabin **7** is supported by means of a plurality of girders **75** extending between cabin **7** and the engine housings. Each of girders **75** is provided with stabilizers **76** and **77** which are in the downwash and suction airflow paths, and are utilized for rotating the craft axially about its vertical axis.

The overall profile of girders **75** are aerodynamically contoured and rotationally adjustable to minimize aerodynamic resistance. A downwash from the rotors will be pointed away from the center zone below the aircraft, which is a desirable feature in crafts for rescue missions, or other special purposes and objectives at the discretion of the user.

Since the pilot's cabin is disposed separate from the fuselage **78**, fuselage **78** may be utilized for storage of fuel **79**, in either a single large tank, or preferably in separate fuel tanks for each of the engines **4**. The singular tank, or each of multiple tanks are provided with an air cushion **80**. Here again, the directional control of the aircraft is provided by varying the ratio of thrust between opposed sets of rotor blades **2**, the relative thrust imbalance providing displacement of the vehicle in a direction of the resultant thrust vector.

Referring now to FIG. **21**, there is shown a schematic view of a power unit for use with an aircraft configuration having a sub-fuselage frame **3**, from which the vertical and horizontal thrust systems are supported. The horizontal thrust engine **6** is coupled to the sub-fuselage frame **3** by means of the hollow holding member **200**, which also supports the vertical thrust engine **99**. The fuel lines and control cabling passes through the interior cavity of the frame **3** and into an opening formed in the wall of the engine holder **200**, for respective distribution to both engines. The rotor blades **2** are driven by rotation of the hub **96**. Hub **96** includes an internal helical toothed ring gear which is meshingly engaged by a helical pinion gear **95** driven by the vertical drive shaft **94**. Vertical drive shaft **94** is supported by standoffs **97**, and drivingly coupled to engine **99** by means of the bevel gear sets **93**. As shown, the output of engine **99** is also coupled to a wheel **42** through a transmission **146** for propelling the vehicle on the ground. Hub **96** is pivotably supported by the hollow engine holder **200** through the bearing support **103**, having an inner ring **104**, which bears on an upper hub casing **101**. Hub **96** is supported on the opposing end by a thrust bearing **105**, which bears on the lower hub casing **102**.

In addition to the landing gear wheel **42**, the system may incorporate a telescopically extendable landing leg **86** having a swiveled landing pad **87** pivotedly coupled thereto. The landing leg **86** may be hydraulically operated and cushioned through the use of airsprings.

Although the invention has been described in connecting with specific forms and embodiments thereof, it will be appreciated that various modifications other than those discussed above may be resorted to without departing from the spirit or scope of the invention. For example, equivalent elements may be substituted for those specifically shown and described, certain features may be used independently of other features, and in certain cases, particular locations of elements may be reversed or interposed, all without departing from the spirit or scope of the invention as defined in the appended claims.

What is claimed is:

1. A VTOL aircraft, comprising:

a fuselage having an upper and a lower surface portion, said upper and lower surface portions together forming a predetermined surface contour defining a lifting body;

first propulsion means coupled to said lower surface of said fuselage for displacing said aircraft in a substantially vertical direction while using a suction effect of said first propulsion means for generating an aerodynamic lift for augmenting a total lifting thrust by displacing air from a central zone below said fuselage to allow additional air to be inserted by atmospheric pressure differential and to collide with said central zone portion of said lower surface of said fuselage whereby a high pressure region is formed adjacent said central lower surface portion of said fuselage, and by simultaneously displacing air from a zone above said fuselage whereby a region of a lower pressure is formed above said fuselage which in combination provides said suction generated lift said first propulsion means including a plurality of rotatably driven rotors disposed about a perimeter portion of said fuselage in spaced relation each to another, each of said rotors having an axis of rotation disposed a predetermined distance from a perimeter edge surface of said fuselage, each of said rotors being positionally located a predetermined distance from said lower surface of said fuselage; and,

control means for regulating said suction generated aerodynamic lift during vertical and horizontal flight.

2. The VTOL aircraft as recited in claim **1** where said first propulsion means includes means for rotatably driving each of said rotors.

3. The VTOL aircraft as recited in claim **2** where said rotatable drive means is disposed within said fuselage.

4. The VTOL aircraft as recited in claim **2** where said rotatable drive means includes at least three engines, each of said engines being coupled to a respective one of said rotors.

5. The VTOL aircraft as recited in claim **1** where said first propulsion means includes means for rotatably displacing each of said rotors with respect to a vertically directed central axis of said fuselage, each of rotors being maintained in said spaced relationship each to the other.

6. The VTOL aircraft as recited in claim **5** where said means for rotatably displacing each of said rotors displaces said rotors in a direction opposite to a respective rotational direction of said rotors.

7. The VTOL aircraft as recited in claim **1** further comprising second propulsion means for displacing said aircraft in a non-vertical plane.

8. The VTOL aircraft as recited in claim **7** where said second propulsion means includes at least one source of thrust coupled to said fuselage.

9. The VTOL aircraft as recited in claim **8** where said source of thrust is pivotally coupled to said fuselage for selected rotation about at least one axis.

10. The VTOL aircraft as recited in claim **7** where said second propulsion means includes means for rotatably displacing said first propulsion means with respect to said vertically directed central axis of said fuselage while maintaining said spaced relation between said first propulsion means.

11. The VTOL aircraft as recited in claim **7** further comprising a suction mantle disposed in spaced substantial concentric relationship with a perimeter portion of said fuselage for directing the air flow from said area juxtaposed to said upper surface of said fuselage toward said rotors.

12. The VTOL aircraft as recited in claim **11** where said suction mantle includes (1) an upper opening defining a first air intake, (2) a lower annular opening defining an exhaust outlet, and (3) a centrally disposed lower opening defining a second air intake.

13. The VTOL aircraft as recited in claim **12** where said second propulsion means includes (1) an alternate air intake opening formed in said suction mantle being selectively opened for forming a low pressure region in juxtaposition thereto, and (2) at least one alternate air exhaust opening formed in said suction mantle being selectively opened for directing air displaced by said first propulsion means.

14. The VTOL aircraft as recited in claim **13** where said second propulsion means further includes means for selectively restricting said first air intake disposed within said upper opening of said suction mantle.

15. The VTOL aircraft as recited in claim **14** where said second propulsion means further includes means for selectively restricting said exhaust outlet disposed within said lower annular opening of said suction mantle.

16. The VTOL aircraft as recited in claim **1** where said lower surface portion of said fuselage is substantially planar.

17. The VTOL aircraft as recited in claim **1** where said lower surface portion of said fuselage has a concave cross-sectional contour.

18. The VTOL aircraft as recited in claim **17** further comprising a pilot's cabin rigidly suspended from said fuselage.

19. The VTOL aircraft as recited in claim **1** including means for simultaneously tilting said rotors to a predetermined position for further augmenting said suction generated aerodynamic lift.

20. The VTOL aircraft as recited in claim **1** including means for displacing at least one rotor to a substantially vertical position for generating thrust for substantially horizontal flight.

21. The VTOL aircraft as recited in claim **1** including means for locating at least one engine internal to said fuselage for generating vertical thrust forces above a predetermined altitude when air density is not sufficient to support said aerodynamic lifting force.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 5,178,344

DATED : January 12, 1993

INVENTOR(S) : Vaclav Dlouhy

It is certified that error appears in the above-identified patent and that said Letters Patent **is** hereby corrected as shown below:

Column 3, Line 64; before the word "birds" delete the word "a" and insert the word --of--;

Column 5, Line 39; delete the words "systems. In" and insert therefor the words --systems, in--;

Column 5, Line 59; delete the word "an" and insert therefor the word --and--.

Signed and Sealed this

Second Day of November, 1993

Attest:

BRUCE LEHMAN

Attesting Officer *Commissioner of Patents and Trademarks*

US005203521A

United States Patent [19]

Day

[11] Patent Number: 5,203,521

[45] Date of Patent: Apr. 20, 1993

[54] ANNULAR BODY AIRCRAFT

[76] Inventor: Terence R. Day, 9 Wolfram Court, Anula, Northern Territory, Australia, 0812

[21] Appl. No.: 773,568

[22] PCT Filed: May 11, 1990

[86] PCT No.: PCT/AU90/00193

§ 371 Date: Nov. 8, 1991

§ 102(e) Date: Nov. 8, 1991

[87] PCT Pub. No.: WO90/13478

PCT Pub. Date: Nov. 15, 1990

[30] Foreign Application Priority Data

May 12, 1989 [AU] Australia PJ4143
Jun. 16, 1989 [AU] Australia PJ4760

[51] Int. Cl.[5] B64C 15/00

[52] U.S. Cl. .... 244/12.2; 244/23 C; 244/73 B

[58] Field of Search .... 244/23 C, 2.2, 52, 208, 244/73 R, 73 B, 73 C

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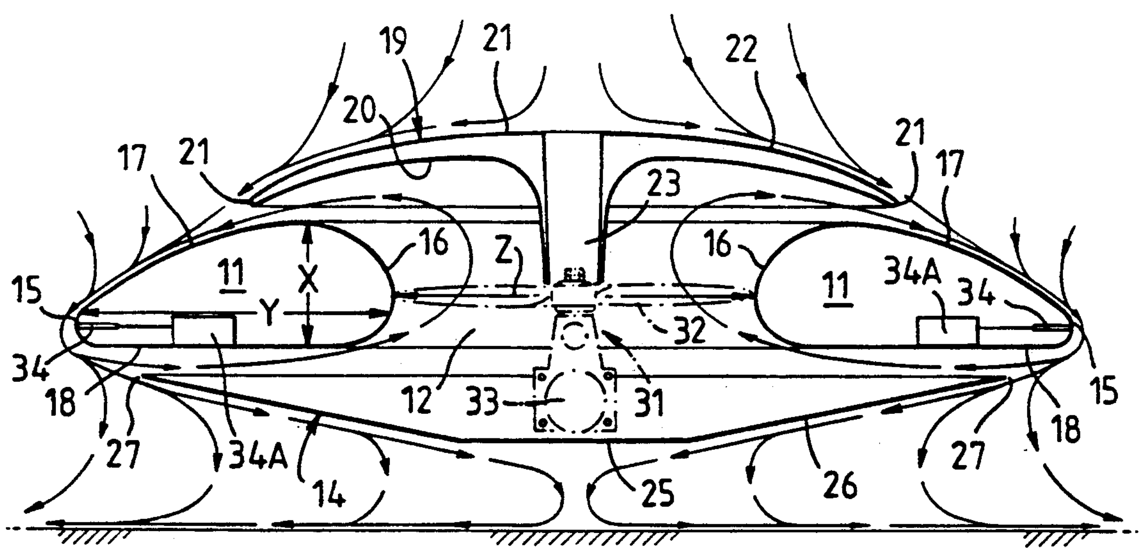
Primary Examiner—Joseph F. Peters, Jr.
Assistant Examiner—Christopher P. Ellis
Attorney, Agent, or Firm—Nixon & Vanderhye

[57] ABSTRACT

An aircraft having an annular body, defining a central passageway; an upper deflector, a lower collector and a fluid drive in the passageway. Air is accelerated by the fluid drive and circulates around the annular body. The collector divides the circulating air and directs a portion into passageway and a portion to beneath the aircraft to provide a further thrust.

14 Claims, 2 Drawing Sheets



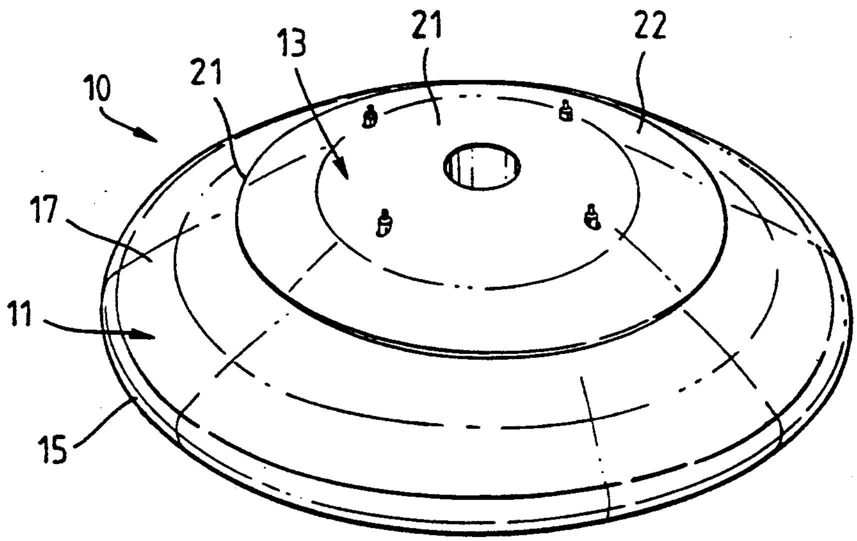


Fig. 1.

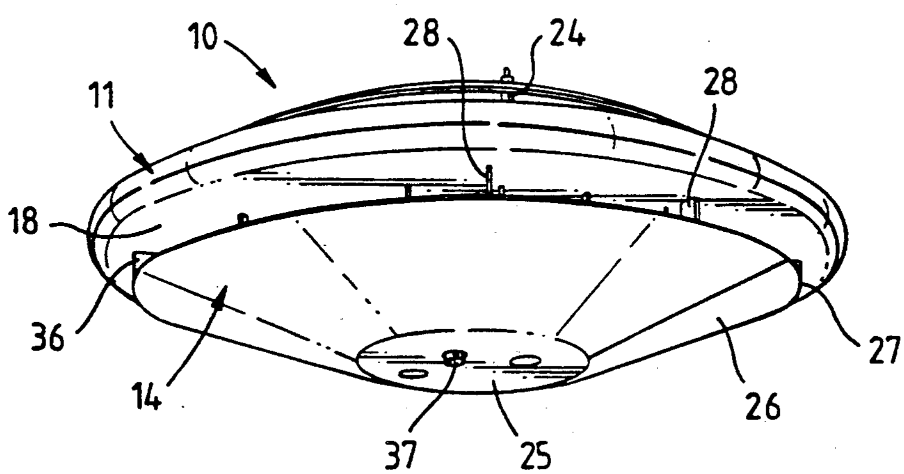


Fig.2.

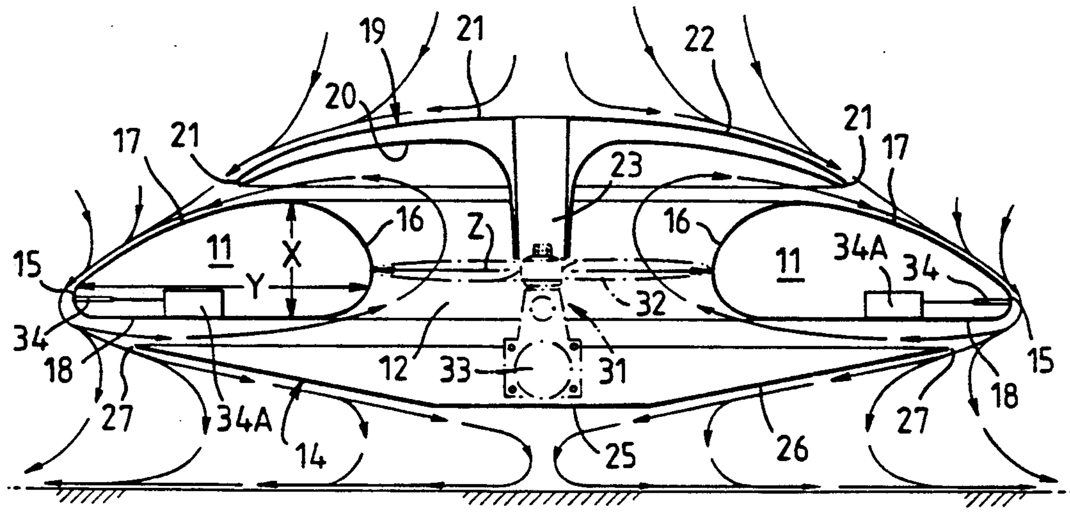

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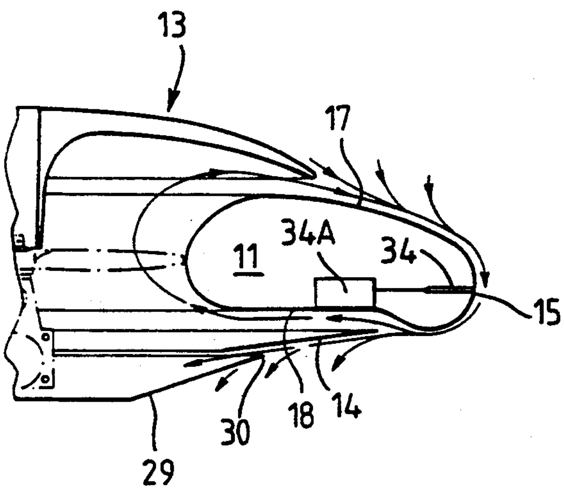
Fig.3.

Fig.4.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ANNULAR BODY AIRCRAFT

TECHNICAL FIELD

This invention relates to an aircraft having vertical lift capabilities and includes those which can hover above a ground surface. The aircraft includes an annular body.

BACKGROUND ART

Vertical lift aircraft having an annular air foil construction can be classified into two broad areas. The first area includes those which draw air from a position above the aircraft and direct the air over an upper surface of the annular airfoil. Examples of such aircraft are found in U.S. Pat. Nos. 2,927,746, 2,978,206, 3,073,551, 4,214,720 and 4,566,699.

The second type of aircraft includes those which draw air in from a position beneath the aircraft, accelerates the air by means of a propulsion system and directs the accelerated air over the upper surfaces of the airfoil. Examples of such aircraft are found in U.S. Pat. Nos. 4,674,798 and 3,397,853.

U.S. Pat. No. 4,674,708 teaches an aircraft having an annular airfoil with planar upper and lower surfaces. Air is drawn in through a base opening and is accelerated by a turbo jet engine located in a central passageway and is directed over the upper surface of the annular air foil. Due to the configuration of the air foil, air does not circulate around the upper and lower surfaces of the airfoil but instead is flung off the peripheral edge of the airfoil. This patent does not teach an airfoil configuration which allows air to circulate around the airfoil and which directs a portion of air circulating around the airfoil to below the aircraft to provide additional thrust.

U.S. Pat. No. 3,397,853 discloses an aircraft having an annular body and a central passageway. A propulsion unit is located within the central passageway. A deflector is located above the passageway to deflect accelerated air over the annular body. A cup or dish shaped member is located below the central passageway and extends sufficiently past the widest portion of the annular body to capture all the air flowing over the annular body.

The configuration of the dish shaped member does not allow a portion of the circulated air to be split off from the main stream to be diverted to beneath the aircraft to provide additional thrust. There is no teaching in this patent that the dish shaped member can be used to split circulating air flow.

DISCLOSURE OF THE INVENTION

It is an object of the invention to provide an aircraft which may be least partially overcome the abovementioned disadvantages.

In one form the invention resides in an aircraft comprising

- an annular body having a passageway, an outermost periphery, an airfoil surface and a surface configuration to facilitate circulation of fluid around said body,
- a fluid drive to accelerate fluid through said passageway,
- a deflector disposed above said passageway to direct accelerated fluid from said passageway to outwardly across the surface of said annular body, and
- a collector disposed below said passageway, said collector having a peripheral edge terminating short of said outermost periphery of said annular body, for directing a portion of fluid circulating around said annular body to said fluid drive and directing a portion of fluid circulating around said annular body to below said aircraft.

The annular body may have a cross-sectional configuration approximating that of a flattened torus. The generally flattened toroidal configuration facilitates fluid flow about the surface of the annular body and through the passageway. The torus may comprise thickened portions. The thickened portions may be disposed adjacent the inner or outer periphery of the body to enhance fluid flow around the annular body.

The annular body may be configured such that a portion of the surface of the body comprises the lowermost portion of the aircraft.

Preferably, the annular body has an upper surface which is of a generally airfoil configuration.

The annular body may be solid or may comprise one or more interior spaces or compartments. The spaces may be suitable for storage of goods, accommodation of passengers and may include a pilots cabin.

The fluid drive is preferably located within the passageway to accelerate fluid through the passageway from a lower position to an upper position. The fluid drive may comprise a propellor. The propellor may extend across the closely spaced from the wall of the passageway. The propellor may be driven by a motor. The motor may be located in the lower portion of the passageway. The motor may be supported by the collector.

Alternately, the fluid drive may comprise a jet engine, gas turbine or other type of propulsion unit.

The deflector may be rigidly mounted relative to said annular body or may be movable relative to said annular body.

The deflector may be tiltable or fixed relative to the annular body. The deflector may be spaced from the annular body by a plurality of spacers. The spacers may be annularly spaced about the annular body.

The spacing between the deflector and the annular body may be varied with smaller spacings resulting is increased volocities of fluid exiting from the deflector.

The deflector may be secured to the annular body and/or the collector by struts or fasteners. The fasteners may comprise elongate threaded bolts which may extend through the interior of the spacers.

The defender may be substantially disk-like in configuration. The deflector may have an inner surface adjacent the passageway, the inner surface being configured to deflect accelerated fluid exiting from said passageway outwardly across the upper surface of the annular body. The inner surface may include a central portion located substantially above the passageway and partially depending into the passageway and a curved surface extending from the depending portion of the periphery of the deflector. The central depending portion may comprise a hollow shaft to facilitate access to the fluid drive.

The aircraft may include a plurality of deflectors to deflect air from the passageway to the surface of the annular body. The further deflectors may be disposed adjacent the deflector or adjacent the annular body.

The collector may extend across the lower portion of the passageway and may be spaced from the lower surface of the annular body.

The collector may be rigidly mounted or tiltable relative to the annular body. The collector may be spaced from the annular body in a fixed or movable fashion. Struts may be provided to space the collector from the annular body. The struts may be spaced about the annular body.

The collector may comprise a substantially plate-like member. The plate-like member may be concave or convex relative to the passageway.

Preferably, the collector is substantially circular in configuration and has a diameter less than the diameter of the annular body such that the peripheral edge of the collector terminates short of the outermost periphery of the annular body.

The collector functions to direct a portion of the fluid circulating around the annular body towards the passageway and to direct a portion of the fluid circulating around the body to below the aircraft. The distance between the peripheral edge of the collector and the outermost periphery of the annular body can vary depending on the velocity of the fluid flow circulating around the annular body, with smaller sized collectors being suitable for higher velocity fluid flows. The spacing between the collector and the annular body can be varied depending on the volume of fluid passing into the passageway, with a larger spacing being suitable for larger volumes of circulating fluid.

The collector may include one or more slots. The one or more slots may define an annular slot. The annular slot may be positioned adjacent the peripheral edge of the collector and may function to further divert fluid to the passageway.

The collector may comprise a plurality of spaced plate-like members. The members may be of progressive smaller sizes to define a number of inlets.

The aircraft may include one or more spoilers. The spoilers may be located substantially within the annular body or adjacent the deflector or collector and may be movable to a position where they spoil the fluid flowing around the annular body. The spoilers may comprise a plate-like member which is extendible into the fluid flow. The aircraft may and preferably comprises four equally spaced spoilers.

The aircraft may include means to prevent counter spin. The means may include one or more spoilers interrupting the fluid flow around the annular body and positioning to providing a counter-thrust to the annular body to cancel the counter spin effect.

The spoilers may be located on or adjacent the deflector and/or on or adjacent the collector.

The aircraft may include suitable circuitry and componentry to allow it to be remote controlled. The componentry may be coupled to the spoilers and/or drive means to allow a remote operator to operate the aircraft.

The aircraft may be associated with landing gear or support legs to support the aircraft above the ground surface. The landing gear or support legs may be rigidly mounted or retractable within the body of the aircraft.

DESCRIPTION OF THE DRAWINGS

The invention will be more fully described with reference to the following description of one embodiment in which

FIG. 1 is a top perspective view of an aircraft according to the invention,

FIG. 2 is a bottom perspective view of an aircraft according to the invention.

FIG. 3 is a side section view of FIG. 1,

FIG. 4 is a partial side section view of an alternative body configuration.

DETAILED DESCRIPTION

The drawings are directed to an aircraft **10** having an annular body **11** which defines a central passageway **12**. A deflector **13** is positioned above the passageway **12** and a collector **14** is positioned below passageway **12**.

Annular body **11** has an outermost periphery **15**, an innermost periphery **16**, an upper surfaces **17** and a lower surface **18**.

Upper surface **17** has an airfoil configuration while lower surfaces **18** is substantially planar between outer and inner peripheries **15** and **16**.

Annular body **11** has a cross-sectional configuration having a portion of maximum thickness (X) adjacent innermost periphery **16** and which decreases towards outermost periphery **15**.

The ratio of the portion of maximum thickness (X) to the length of the annular body defined between the outmost portion **15** is about 0.12.

The ratio of the maximum width (Y) of annular body **11** to the length of the annular body defined between outermost periphery **15** is about 0.315.

The ratio between portion (X) and portion (Y) is about 0.378.

FIG. **4** describes a further configuration of annular body portion **11**. In this embodiment, the configuration of the annular body adjacent the outermost periphery **15** is enlarged to provide a gentler radius of curvature between upper and lower surfaces **17** and **18** to faciliate fluid flow around this portion.

Passageway **12** is substantially circular when viewed in plan and is partially defined by the wall of annular body **11** above and below innermost periphery **16**.

The ratio of the minimum diameter (Z) of passageway **12** to the diameter of the length of the annular body between outermost periphery **15** is about 0.35.

Passageway **12** includes upper and lower openings of wider diameter relative to the diameter of (Z), the walls of which are partially defined by the outwardly extending surfaces on annular body **11**.

Deflector **13** is positioned above the upper opening of passageway **12**. Deflector **13** is substantially circular in configuration when viewed in plan. The deflector has an outer surface **19** and an inner surface **20** which are joined along an outer periphery **21**.

The ratio of the size of the deflector **13** defined between outermost periphery **21** and the length of the annular body defined between outer periphery **15** is about 0.63.

Outer surface **19** includes a central substantially planar portion **21** and an outer curved portion **22** which extends towards annular body **11**.

Inner surface **20** includes a central portion **23** depending partially into the upper opening or outlet of passageway **12** and a substantially continuously curved surface extending from portion **23** outermost periphery **21**.

The configuration of inner surface **23** results in fluid extending from passageway **12** being deflected to pass over upper surface **17** of annular body **11**.

Central portion **12** in the embodiment comprises a hollow shaft extending between adjacent the fluid drive and outer surface **19** at a position approximately central to the outer surface. The hollow shaft allows access to the fluid drive if necessary. It should be appreciated that the hollow shaft is not essential and the central portion may also be substantially solid if access to the fluid drive is not required.

Deflector **13** is spaced from annular body **11** such that a fluid pathway is established between passageway **12** and upper surface **17** or body **11**.

Outermost periphery **21** of the deflector is spaced above upper surface **17** of annular body **11** much that the ratio between this spacing and the minimum inner diameter of passageway **12** (shown as 2) is about 0.066.

The deflector is secured to the annular body by a plurality of spacers or struts **24** (see FIG. 2) which extend about the periphery of the annular body. Some or all of struts **24** can function as counter spin spoilers which are described in more detail below.

Collector **14** is positioned below passageway **12** and below the lower opening of the passageway.

Collector **14** has a substantially circular configuration when viewed in plan and includes a central substantially planar portion **25** and an outer inclined portion **26** which is inclined towards the lower surface **18** of annular body **11**.

Outer periphery **27** of collector **14** terminates short of the outer periphery **15** of annular body **11** and is located spaced from lower surface **18**. The ratio between the length of the collector defined between outer periphery **27** and the length of the annular body defined between the periphery **15** is about 0.846.

Collector **14** is spaced from annular body **11** to establish a fluid pathway between lower surface **18** and passageway **12**. The ratio of this spacing and the minimum internal diameter of passageway **12** (shown as Z) is about 0.08.

Collector **14** is secured to annular body **11** by spacers or struts **28**. One or all of spacers or struts **28** may also function as a counter spin spoiler as described in more detail below.

FIG. **4** shows a further arrangement of the collector. In this arrangement, a further collector **29** is positioned below collector **14** to define a further fluid inlet to direct fluid into passageway **12**.

A further collector **29** is substantially circular when viewed in plan and has a maximum length which is less than the maximum length of collector **14**. In this manner, the outermost peripheral edge **30** of further collector **29** is spaced inwardly from peripheral edge **27** of collector **14**.

The ratio of the length of collector **29** to collector **14** is about 0.7.

The ratio of the spacing between peripheral edge **30** and collector **14** and lower surface **18** is about 0.33.

A fluid drive **31** is located within annular body **11** and substantially within passageway **12**. In the embodiment, fluid drive comprises a propellor **32** driven by motor **33**.

Propellor **32** is located within the passageway and adjacent the minimum internal diameter of passageway. Propellor **32** has a diameter slightly smaller than the minimum internal diameter of passageway **12** such that substantially all the fluid passing through passageway **12** is contacted by and accelerated by the propellor.

Motor **33** is supported by the central portion **25** of collector **14**.

The ratio of the maximum distance between the outer surface **19** of deflector **13** and collector **14** to the length of annular body **11** defined between outermost periphery **15** is about 0.30.

The motion of the aircraft **10** is controlled by spoilers **34**. Spoilers **34** in the embodiment are located within annular body **11** when in a retracted position and can extend therefrom to spoil the flow of fluid around body **11**. Spoilers **34** are controlled by a suitable motor such as a servo motor **34***a* which is also located within annular body **11**. Spoilers **34** include a plate like member which extends into the fluid flow. The spoilers are positioned about the annular body and advantageously four such spoilers are located equally spaced about body **11** to allow forward, rearward and sideward motion of the aircraft.

To prevent counterspin of the aircraft due to rotation of propellor **32** and engine torque in passageway **12**, a number of angled spoilers **36** are positioned within the fluid flow around annular body **11**. Angled spoilers **36** may include some or all of the spacers or struts **28** which position deflector **13** or collector **14** from annular body **11**. The angled spoilers comprise a longitudinal axis which intersects the fluid flow at an angle to provide the aircraft with the necessary amount of counterspin to cancel the effect of the motion of the propellor. It should be realized however that other propulsion units may not require counterspin spoilers however it may still be desirable to include one or more spoilers to provide a rudder and/or to control yaw of the aircraft.

In use, fluid drive **31** accelerates air within passageway **12**. The accelerated air is deflected by deflector **13** which diverts the air across the upper surface **17** of body **11**. The accelerated laminar air circulates about annular body **11** and is divided by the peripheral edge **27** of collector **14** such that part of the accelerated air flows into the lower portion of passageway **12** and part of the accelerated air flows beneath collector **14** to provide additional thrust to the aircraft. An exhaust vent **37** is located below the aircraft to exhaust combustion gases from motor **33**.

The deflector facilitates feeding the accelerated fluid smoothly onto the upper surface **17** of annular body **11** to result in even distribution of fluid about the body.

Once the accelerated fluid is travelling over surface **17**, the fluid will adhere to the surface according to well known principles. Furthermore, the accelerated fluid will give some attraction or lift to upper surface **17** due to its airfoil configuration. The accelerating fluid does not separate from the upper surface of the annular body because of its laminar nature resulting from its velocity.

In the embodiment, the deflector is of a smaller size than the annular body and thus fluid being accelerated from the deflector across surface **17** passes over a surface having a progressively increased surface area. This results in the fluid molecules exiting from the deflector causing adjacent "ambient" air to be drawn into the accelerated fluid. The combined fluids circulate about annular body **11** from upper surface **17** to lower surface **18**.

Collector **14** divides the circulating fluid flow such that the fluid flowing into passageway **12** is equal to the fluid being accelerated out of passageway **12** with the remainder of the accelerated fluid passing below collector **14** to provide further thrust to the aircraft.

The remaining portion of the accelerated fluid can form a fluid cushion beneath the aircraft to provide the aircraft with "hovercraft" capabilities, the complement the lift provided by fluid flow over the annular body.

The aircraft can be controlled by the use of spoilers as described above or alternatively, deflector **13** can be mounted for tilting movement to create more lift along one area of surface **17** relative to another area to result in tilting of the whole aircraft. Such a tiltable deflector is described in U.S. Pat. No. 3,397,853. The collector may also be mounted for tilting movement relative to the annular body to provide a similar effect.

The collector may include a concave cross-sectional configuration relative to a ground surface. This particular configuration provides better hovering characteristics to the aircraft as it traps more fluid beneath the aircraft.

A further advantage of the aircraft according to the invention is that the fluid to be accelerated through passageway **12** is substantially drawn from the fluid circulating around annular body **11** and does not include additional fluid. A consequence of this is that when hovering above a ground surface, the aircraft will not suck in ground debris or water (if hovering above water). The fluid passing beneath collector **14** provides sufficient positive pressure to prevent such contamination of passageway **12** by debris or water.

It should also be appreciated that when a gas turbine or jet engine is sused as a fluid drive, the fluid will also comprise exhaust gases of the turbine or engine. This will result in improved performance of the aircraft as a greater volume of fluid is being accelerated and passed around annular body and a greater volume of fluid is being passed below collector **14**.

It should be appreciated that various other changes and modifications may be made to the embodiment described without departing from the spirit and scope of the invention as defined in the appended claims.

I claim:

1. An annular recirculating fluid apparatus comprising:

- an annular body having a passageway, the body having an upper stationary, non-adjustable airfoil surface and being further configured to facilitate circulation of fluid around said body and through the passageway,
- a fluid drive to accelerate fluid through said passageway,
- a deflector disposed above said passageway and at least partially overlying said upper airfoil surface to direct accelerated fluid from said passageway outwardly across said upper airfoil surface of said annular body, and
- a collector disposed below said passageway, said collector having a peripheral edge terminating short of the outermost periphery of said annular body, for directing a portion of fluid circulating around and under said annular body to said fluid drive, and directing another portion of fluid circulating around and under said annular body downwardly away from said annular body.

2. The apparatus as claimed in claim **1**, wherein said annular body comprises a substantially flattened toroidal configuration.

3. The apparatus as claimed in claim **1**, wherein said fluid drive is located within said passageway.

4. The apparatus as claimed in claim **1**, wherein said fluid drive comprises a propeller extending transversely across said passageway, the outer edge of said propellor being closely spaced from the wall of the passageway, said propellor being driven by a motor.

5. The apparatus as claimed in claim **1**, wherein said deflector is disk-like in configuration and comprises an inner surface configured to deflect accelerated fluid exiting from said passageway outwardly across the upper surface of said annular body.

6. The apparatus as claimed in claim **5**, wherein said inner surface comprises a central portion located above said passageway and partially extending into said passageway and a curved surface extending from said central portion to the periphery of the deflector.

7. The apparatus as claimed in claim **1**, wherein said collector is disk-like in configuration.

8. The apparatus as claimed in claim **7**, wherein said collector is formed with a central planar portion and a surrounding inclined portion inclined towards said annular body.

9. The apparatus as claimed in claim **1** comprising a further collector disposed below said collector to divert a portion of the fluid passing below said aircraft to said passageway.

10. The apparatus as claimed in claim **1** including at least one spoiler for maneuvering the aircraft.

11. The apparatus as claimed in claim **10**, wherein said spoiler comprises a plate like member movable to a position wherein said member spoils the fluid circulating around said annular body.

12. The apparatus as claimed in claim **11**, comprising a plurality of spoilers spaced about the periphery of said annular body.

13. The apparatus as claimed in claim **1**, including means to prevent counter spin of said aircraft.

14. The apparatus as claimed in claim **13**, wherein said means includes at least one spoiler which intersects the fluid circulating about said annular body at an angle sufficient to provide a thrust to the aircraft to counter the counterspin.

* * * * *

US005213284A

United States Patent [19]

Webster

[11] Patent Number: 5,213,284

[45] Date of Patent: May 25, 1993

[54] DISC PLANFORM AIRCRAFT HAVING VERTICAL FLIGHT CAPABILITY

[76] Inventor: **Steven N. Webster**, P.O. Box 426 Sleepy Hollow, Long Creek, Mossy Head, Fla. 32434

[21] Appl. No.: **772,904**

[22] Filed: **Aug. 5, 1991**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 395,358, Aug. 17, 1989, abandoned.

[51] **Int. Cl.**[5] **B64C 29/00**

[52] **U.S. Cl.** .... **244/23 C**; 244/12.2

[58] **Field of Search** .... 244/23 C, 12.2, 23 B, 244/53 R, 60, 17.19

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2,935,275	5/1960	Grayson	244/23 C
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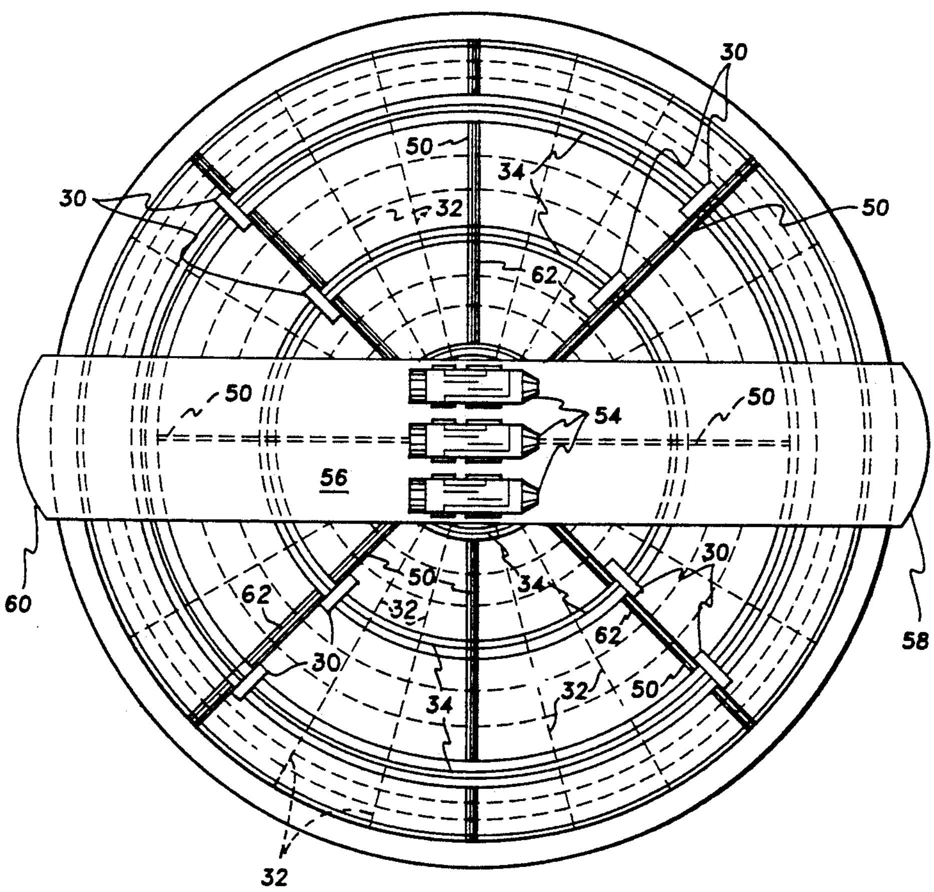
2648504	2/1978	Fed. Rep. of Germany	244/23 C

Primary Examiner—Joseph F. Peters, Jr.
Assistant Examiner—Christopher P. Ellis
Attorney, Agent, or Firm—Richard C. Litman

[57] **ABSTRACT**

An aircraft having a generally circular or disc planform configuration provides the capability of vertical flight through two concentric sets of lifting fans or blades. The two sets may each include a number of individual rings of blades, but both sets are equal in area and rotate oppositely in order to provide nearly equal volumes of airflow, and thus essentially offset any torque reaction due to the rotation of the blade sets. Several engines are provided in the preferred embodiment, with one engine providing power to the lift fan sets and other engines providing thrust for horizontal flight. Other novel features are also disclosed, such as a peripheral aerodynamic control system, power transmission system, and surface vane system. An alternate embodiment includes a peripheral passenger or cargo area, with more conventional rearwardly located aerodynamic controls for horizontal flight.

15 Claims, 5 Drawing Sheets



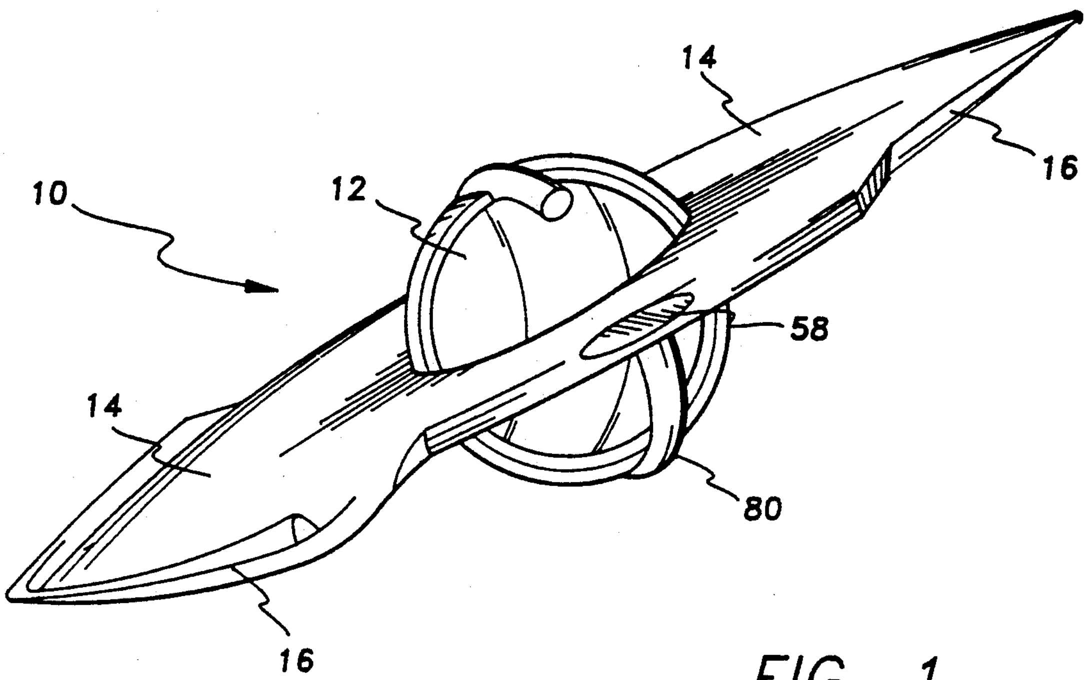


FIG. 1

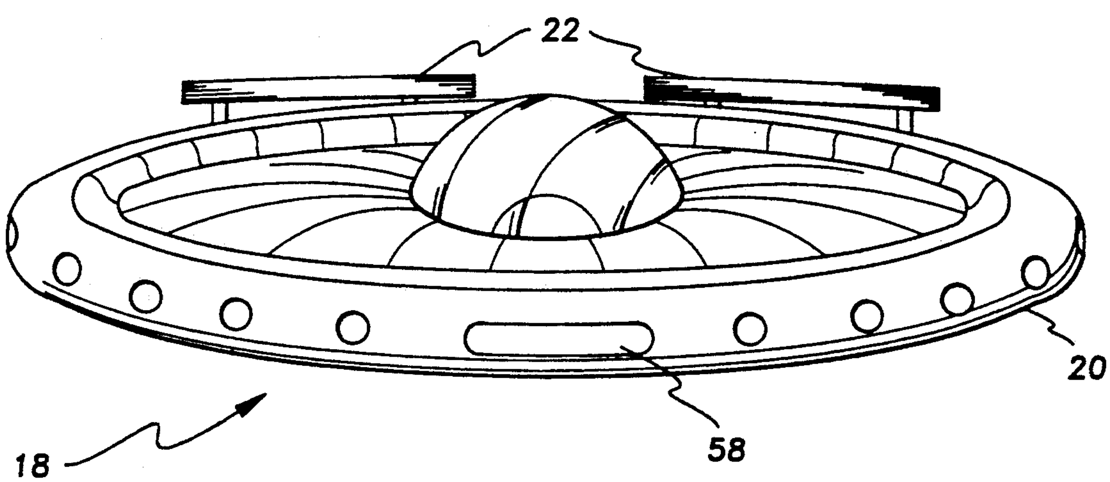


FIG. 2

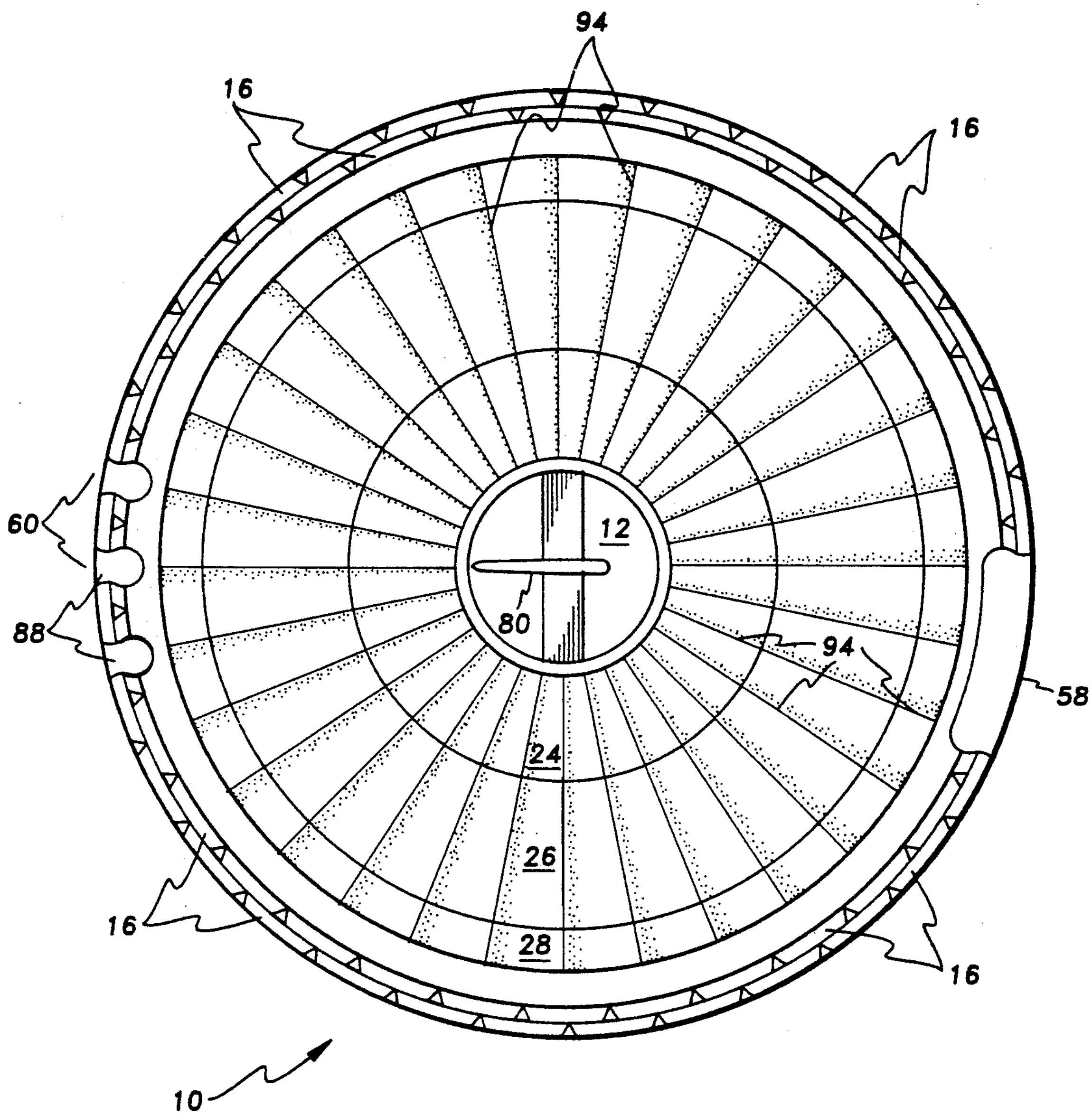


FIG. 3

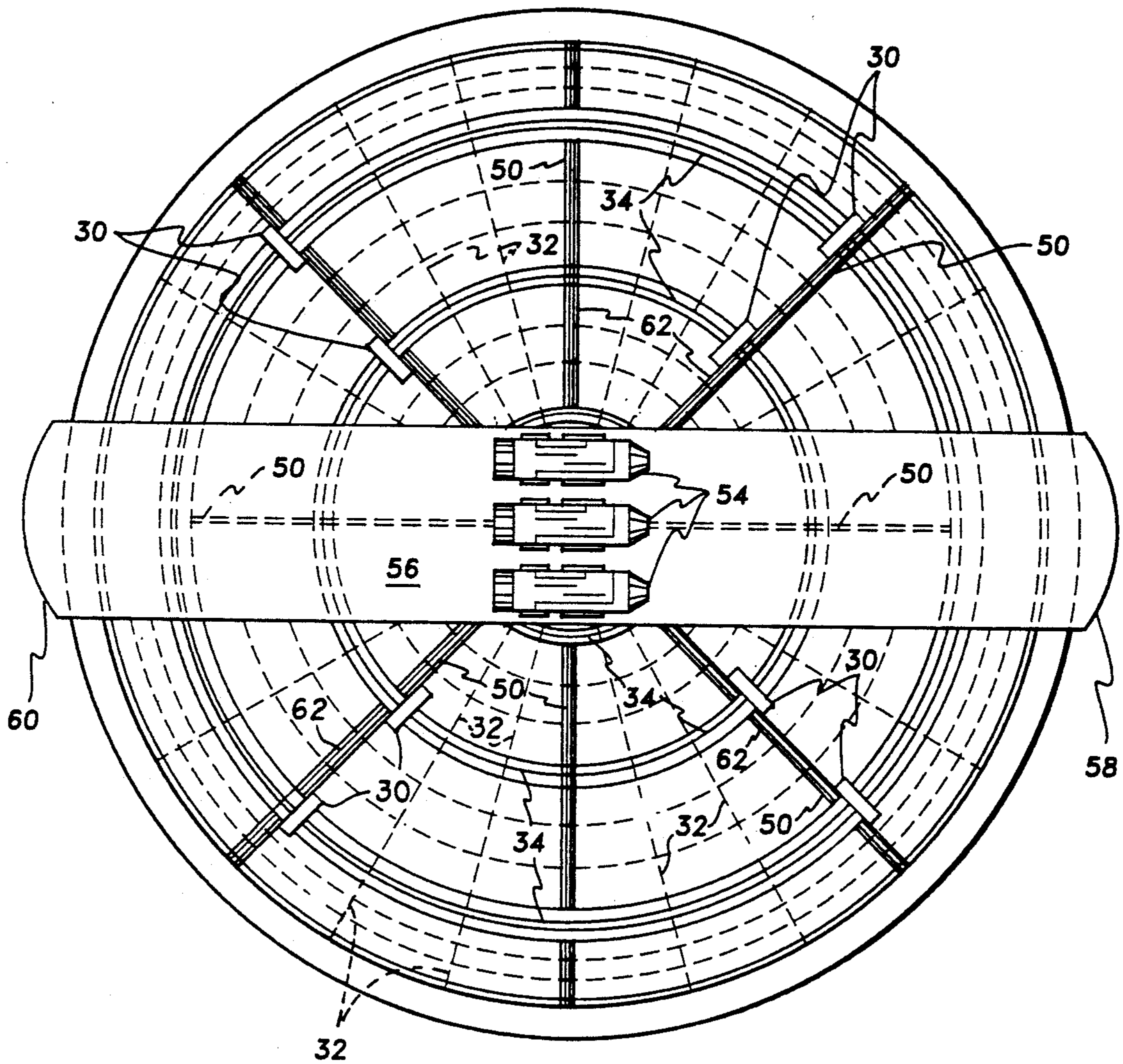


FIG. 4

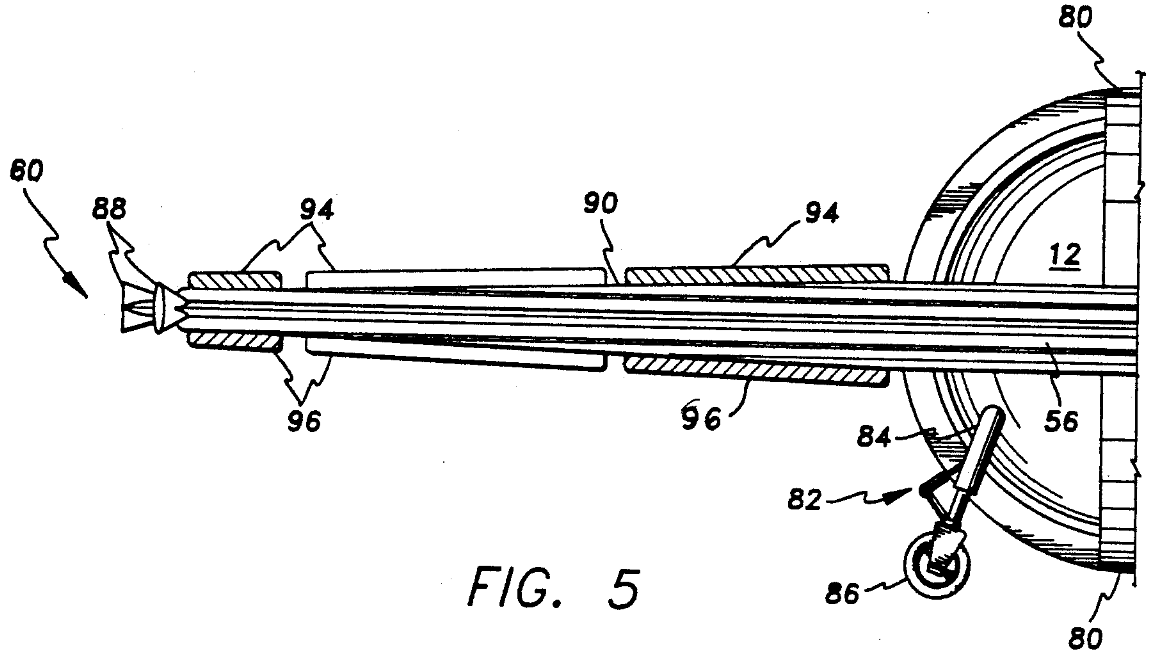

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FIG. 5

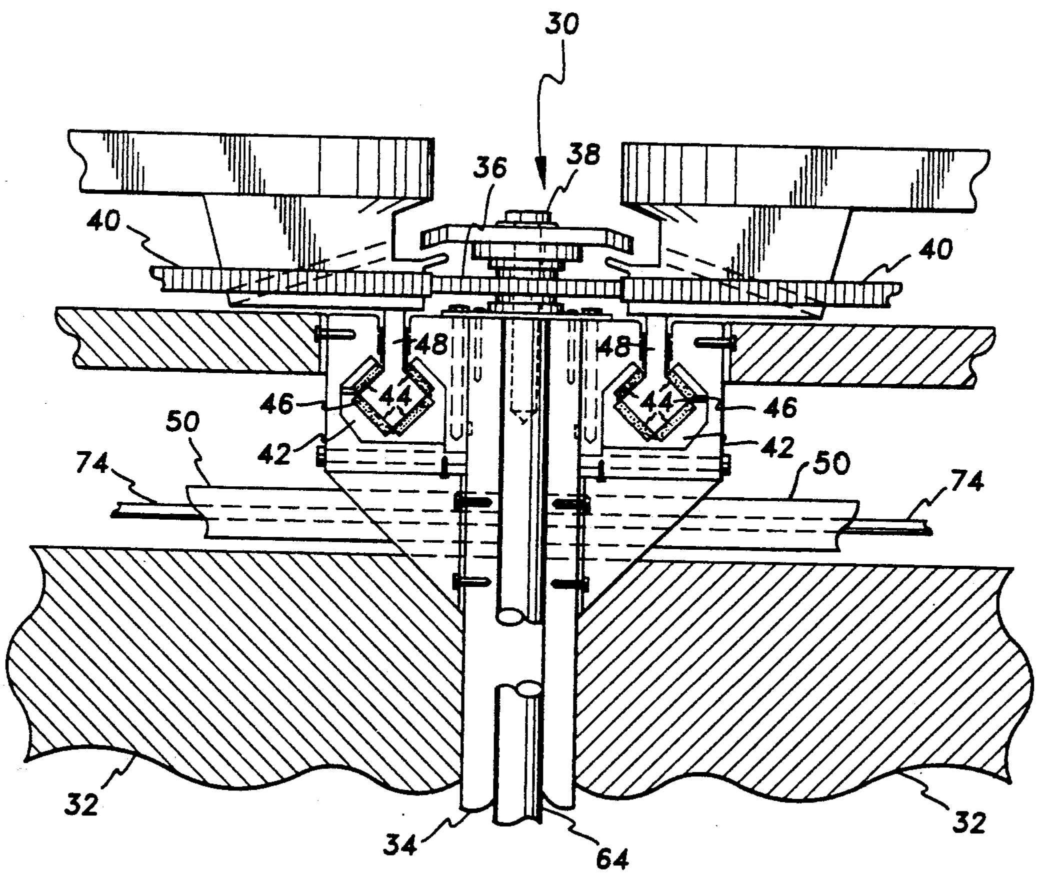
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FIG. 7

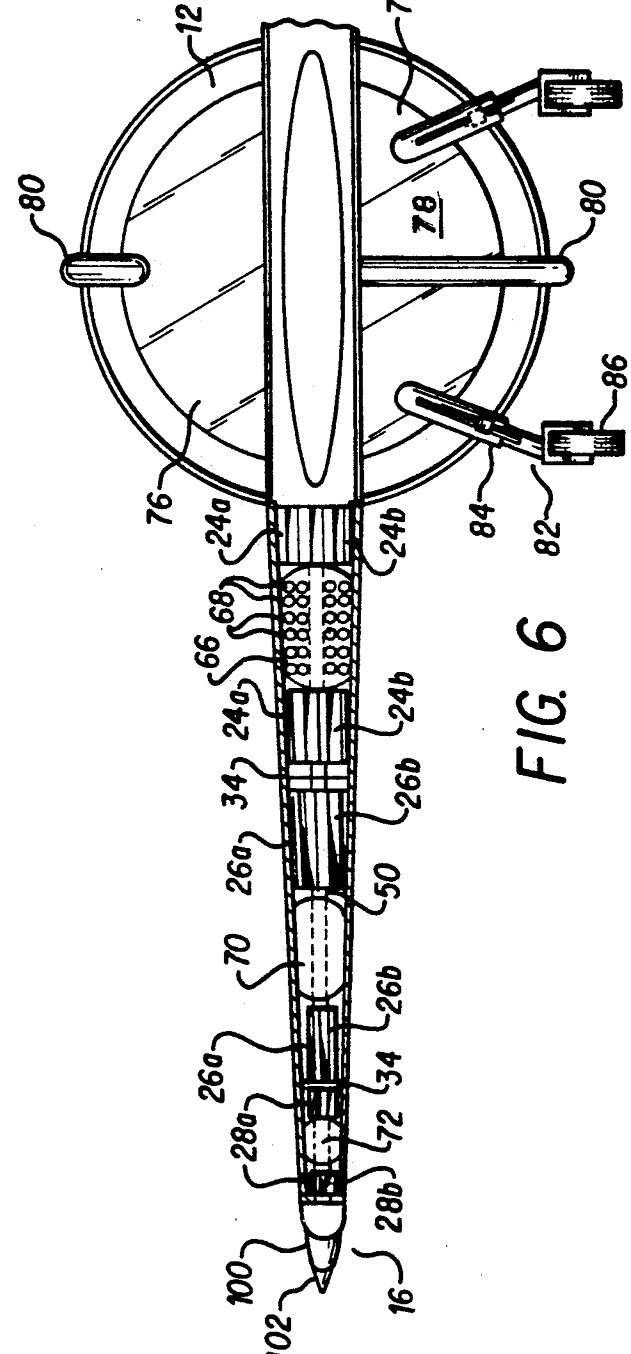
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FIG. 6

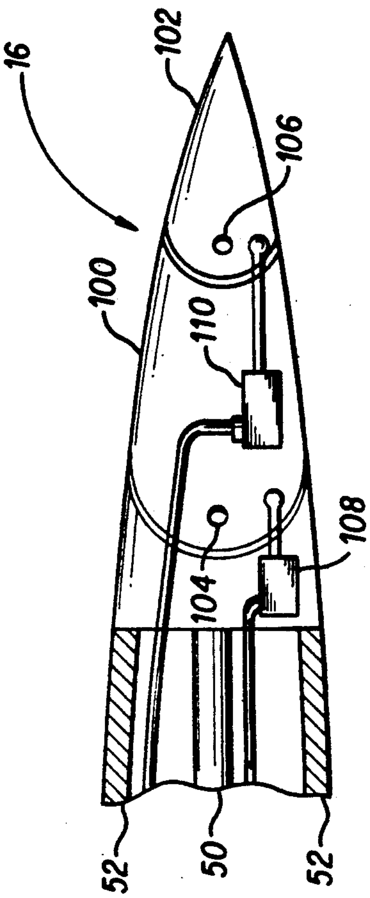
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FIG. 8

DISC PLANFORM AIRCRAFT HAVING VERTICAL FLIGHT CAPABILITY

REFERENCE TO RELATED APPLICATION

This application is a continuation in part of utility patent application Ser. No. 07/395,358 filed on Aug. 17, 1989, now abandoned.

FIELD OF THE INVENTION

This invention relates generally to aircraft, and more specifically to an aircraft type having a plurality of concentric, counterrotating lifting fans or blades and the capability of vertical takeoff and landing, as well as other novel features.

BACKGROUND OF THE INVENTION

The development of heavier than air powered aircraft (i.e., airplanes, gyroplanes and helicopters) has led to a variety of different aircraft configurations, control systems, and powerplant, propeller and/or other systems and configurations. Most of these various configurations require some horizontal distance for takeoff and landing, thus restricting their use to specific airport or at least open areas not otherwise restricted. Even in the case of helicopters, where vertical takeoffs and landings are physically possible, the relative hazard due to the rapidly spinning, large diameter rotor blades generally precludes their use in any but specially designated areas, except for specialized emergency uses such as air ambulance service and the like. Moreover, the disastrous effects which would occur if a helicopter main or tail rotor blade were to strike a fixed object while taking off or landing in a confined area, result in most helicopter operations being restricted to airports just as are operations with fixed wing aircraft.

The need arises for an aircraft which is capable of vertical takeoffs and landings, while also being capable of relatively high speed flight. The aircraft lifting rotors, fans and/or blades must be completely contained within the fixed structure of the craft, in order to permit the safe operation of the craft within confined areas. In order that the craft operate efficiently at various airspeeds ranging from zero to maximum cruise or above, both aerodynamic and thrust control systems should be implemented. Torque may be eliminated by means of counterrotating lift devices, rather than anti torque tail rotors as in helicopters, thus further enhancing the safety of the craft. Finally, the craft should employ a relatively simple powerplant system which is capable of providing both thrust for horizontal flight and a lifting force for vertical flight, by means of appropriate lift fan technology.

DESCRIPTION OF THE RELATED ART

Grayson U.S. Pat. No. 2,935,275 discloses a disc shaped aircraft which contains a general powerplant and lifting fan configuration similar to a limited extent to that of the present invention. However, it does not appear that the patent to Grayson makes provision for yaw control in the craft. Other deficiencies will be noted in comparison to the disclosure of the present invention as described further below.

J. C. M. Frost et al. U.S. Pat. Nos. 3,022,963 and 3,051,417 each disclose a disc type aircraft including a peripheral control system. The control systems rely primarily on the well known Coanda effect, which may have limited use in maneuvering a relatively large and heavy craft in all flight conditions.

P. B. Clover U.S. Pat. No. 3,243,146 discloses a vertical takeoff and landing aircraft with lifting power supplied by a single rotor or fan. Anti torque means are provided by a series of vanes within the craft which guide incoming air to the fan. The control system is completely aerodynamic (as opposed to reaction control means), but comprises generally horizontal control surfaces disposed completely within the entry air ducts of the craft. As the air mass must be contained within the respective ducts and cannot be deflected due to the duct walls, it is not seen how the control system of the Clover patent operates.

J. N. Modesti U.S. Pat. No. 3,503,573 discloses a disk shaped aircraft which is powered by rocket engines. Nearly the entire craft is spun by means of tangentially thrusting rockets, while means are provided for counterrotating the cockpit or cabin of the craft to produce a net rotational velocity which approaches zero for the cabin structure. However, no purpose for the rotation of the main portion of the craft appears to be disclosed in the Modesti patent.

J. A. Perseghetti U.S. Pat. No. 3,531,063 discloses a vertical takeoff aircraft and gyro guidance system therefor. Vertical thrust is provided by four jet engines, while the control system is by means of the gyroscopic precessional forces. Such a control system would by its nature require relatively heavy gyro assemblies, which in turn would necessitate relatively large and heavy engines to lift the weight of the craft.

U.S. Pat. Nos. 3,997,131 and 4,147,472 issued to A. Kling respectively disclose an electrically operated rotor system for aircraft and an annular shroud arrangement for rotating turbine blades.

DeSautel U.S. Pat. No. 4,214,720 discloses a disc shaped aircraft powered by sixteen jet engines arranged radially about the craft. The engines create a lifting force by directing their thrust around an annular airfoil shaped periphery. The annular periphery is also rotated, as in the patent to Modesti described above. Many of the same limitations of the Modesti patent are apparent here.

Finally, P. M. Panos U.S. Pat. No. 4,901,948 discloses a control system for a disc shaped aircraft comprising a plurality of rotatable nozzles, each of which may be rotated in its respective housing in order to direct thrust in a specific direction. This system is similar to reaction control systems known in other specialized aircraft applications, such as the Hawker Harrier aircraft series. The system bears no resemblance to the control system of the present invention.

None of the above noted patents, either singly or in combination, are seen to disclose the specific arrangement of concepts disclosed by the present invention.

SUMMARY OF THE INVENTION

By the present invention, an improved aircraft having concentric, counterrotating lifting fans and being capable of vertical flight is disclosed.

Accordingly, one of the objects of the present invention is to provide such an improved aircraft having a generally circular planform.

Another of the objects of the present invention is to provide an improved aircraft in which each of the counterrotating lifting fans or groups of counterrotating lifting fans are of equal areas.

Yet another of the objects of the present invention is to provide an improved aircraft in which the lifting fans are powered by means of turbine engines, which engines further provide thrust for horizontal flight.

Still another of the objects of the present invention is to provide an improved aircraft having an efficient and lightweight structure which combines cooperating elements which are arranged in tension and compression.

A further object of the present invention is to provide an improved aircraft having both a control system providing control at low airspeeds, and an aerodynamic control system for use at higher airspeeds.

An additional object of the present invention is to provide an improved aircraft of generally circular planform, which provides for passenger and/or cargo carriage both in a central area and further in a peripheral area of the craft.

With these and other objects in view which will more readily appear as the nature of the invention is better understood, the invention consists in the novel combination and arrangement of parts hereinafter more fully described, illustrated and claimed with reference being made to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front perspective view of the aircraft of the present invention, showing its general configuration.

FIG. **2** is a perspective view of an alternative configuration having a peripheral passenger and/or cargo compartment.

FIG. **3** is a top plan view of the craft showing the general arrangement of the lifting fans, engine intake and exhaust, central cabin area, and peripheral aerodynamic controls.

FIG. **4** is a top plan view in which the upper surface of the craft has been removed in order to more clearly show the internal structure and components.

FIG. **5** is a side view of a portion of the craft, showing additional details relating to the power system and other areas.

FIG. **6** is a front view of a portion of the craft, partially cut away, showing various internal components and systems of the lifting surface.

FIG. **7** is a view in section of the mechanism providing for the rotation of the lifting fans.

FIG. **8** is a view in section of the aerodynamic controls of the craft, showing the detail of the hinge arrangement.

Similar reference characters designate corresponding parts throughout the several figures of the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, particularly FIG. **1** of the drawings, the present invention will be seen to relate to an aircraft **10** of generally circular or disc shaped planform. The embodiment of aircraft **10** shown in FIG. **1** may be seen to generally comprise a central, generally spherical compartment **12** which is surrounded by a generally circular area or lifting surface **14** which provides means for supporting the craft **10** in flight. Aerodynamic control surfaces, generally indicated as **16**, are disposed around the periphery of surface **14**.

FIG. **2** discloses an alternate embodiment **18** of the aircraft **10** of FIG. **1**, in which the general configuration of aircraft **10** is constructed to a larger scale which enables an additional peripheral passenger or cargo compartment **20** to replace the aerodynamic control surfaces **16** of aircraft **10**. In lieu of peripheral aerodynamic control surfaces **16**, separate trailing control surfaces **22** are used near the rear of craft **18** as shown in FIG. **2**. Most of the remaining systems of the two embodiments **10** and **18** are common to the two aircraft, differing only in scale and various details as required by the structure of each aircraft **10** and **18**. These remaining systems will be discussed in detail below in a discussion of the elements of the remaining figures.

FIG. **3** discloses a plan view of the aircraft **10** shown in FIG. **1**. Before discussing in detail the arrangement shown in FIG. **3**, it is important to note that the control of torque reactions in vertical flight aircraft is of critical importance. In this respect, the aircraft **10** and **18** of FIGS. **1** and **2** respectively have some common ground with helicopters. As the rotor of a helicopter rotates and develops a lifting force, a horizontal drag force will also be developed. Assuming that the helicopter is clear of the surface, and thus is free to move or rotate about any axis, the helicopter itself will tend to rotate in a direction opposite that of the direction of rotation of the main rotor.

Various solutions have been developed to overcome this torque reaction, the most common being an anti torque rotor installed on the tail of the helicopter. Multiple main rotor systems rotating in opposite directions are also seen in larger helicopters, the torque reaction of the two counterrotating main rotors thus canceling out. In any case, some provision must be made for the cancellation of torque reaction in aircraft capable of vertical flight, which obviously involves at least some flight at airspeeds too low for conventional aerodynamic controls to be effective.

The aircraft of embodiments **10** and **18**, as shown in FIGS. **1** and **2** respectively, respond to this problem by means of a plurality of counterrotating lifting fan sets, designated as **24**, **26** and **28** in FIG. **3**. These fan sets **24**, **26** and **28** each appear as a single fan in the top view shown in FIG. **3**, but the cross sectional view of FIG. **6** discloses each fan set **24**, **26** and **28** to comprise respectively an upper fan **24***a*, **26***a*, and **28***a*, and lower fan **24***b*, **26***b* and **28***b*. While three lifting fan sets, comprised of an inner lift fan set **24**, central lift fan set **26**, and outer lift fan set **28**, are shown in FIG. **3**, it will be understood that virtually any number of fans more than one could be constructed in this manner and caused to rotate in opposite directions in order to cancel any torque reaction. The critical point is that the mass and velocity of air moved by the fan or fans rotating in one direction must be very nearly the same as the mass and velocity of air moved by the fan or fans rotating in the opposite direction. If the air mass and velocity moved by each set of counterrotating fans is essentially equal, by definition the resulting lift force will be essentially equal and therefore the resulting drag force will also be essentially equal and any torque reaction will be all but canceled.

This is basically accomplished in the present invention by making the areas of each set of counterrotating fans equal. In other words, the areas of inner fan set **24** and outer fan set **28**, which rotate in one direction, when added together are equal in area to that of central fan set **26** which rotates in a direction opposite to that of inner and outer fan sets **24** and **28**. While other factors are of course involved in the amount of lift produced by a given lift fan set **24**, **26**, or **28**, such as the blade pitch and therefore angle of attack, as well as rotational speed, these factors may be adjusted accordingly in the construction of aircraft **10** or **18**.

One means of accomplishing such adjustment is by means of the gearing used to drive lift fan sets **24** through **28**, as shown more clearly in FIG. 7. By adjusting the gear ratio as desired, rotational speed of any one of the fan sets **24** through **28** may be adjusted accordingly, thus serving to equalize the lifting force and corresponding torque developed by any one of the fan sets **24** through **28**. Alternatively, one set of fans **24**, **26** or **28** may be equipped with variable pitch blades, not shown, and adjusted by means of controls in the cabin **12** of the aircraft **10** or **18** as is well known in the helicopter art. Only one set of fans **24**, **26** or **28** need be so equipped, as when the pitch is adjusted on any one set of fan blades, the lift and therefore drag and torque may be made to be either greater than, equal to, or less than any other fan or set of fans.

The cross sectional view of FIG. **6** more clearly shows the vertical arrangement of the lifting fans **24***a* and *b*, **26***a* and *b*, and **28***a* and *b*, as well as other interior structural components described further below. In FIG. **6**, the upper fans **24***a*, **26***a*, and **28***a* and lower fans **24***b*, **26***b*, and **28***b* may be seen. It will be noted that the blades of both upper and lower inner fans **24***a* and **24***b* are angled or pitched in the same relative direction, as they are both geared together and turn in the same direction. In a like manner, upper and lower central fans **26***a* and **26***b* are both geared together and revolve in the same direction relative to one another, although that direction of rotation is opposite that of inner fan set **24** and outer fan set **28**. Similarly, upper and lower outer fans **28***a* and **28***b* are geared together in order to revolve in the same direction relative to one another and relative to inner fan set **24**, while opposite the rotational direction of central fan set **26**.

FIG. 7 discloses details of the drive mechanism **30** for fan sets **24**, **26** and **28**. It will be understood that FIG. 7 shows only the fan drive mechanism **30** for an upper set of lift fans **24***a*, **26***a*, or **28***a*, but that the drive mechanism for lower lift fans is essentially a mirror image in the vertical of the fan drive mechanism **30** shown in FIG. 7. Adjacent upper and lower drive mechanisms **30** each receive power input by means of a vertical shaft **64**, which shafts **64** receive power from cooperating power output shafts **62** further described below.

It will also be seen that FIG. 7 discloses an essentially symmetrical arrangement, as would be required for the fan drive mechanism between adjacent lifting fan sets **24** and **26** or **26** and **28**. Four fan drive mechanisms **30** are installed between upper inner lifting fan **24***a* and upper central lifting fan **26***a*, at locations 45 degrees from the longitudinal and lateral axes of aircraft **10** as shown in FIG. **4**. In a like manner, an additional four fan drive mechanisms are positioned between upper central lift fan **26***a* and upper outer lift fan **28***a*, for a total of eight fan drive mechanisms **30** to drive the upper lift fans **24***a*, **26***a* and **28***a*. A symmetrical arrangement of eight more drive mechanisms **30** are located within the lower portion of lifting surface **14** immediately below mechanisms **30** which drive upper fans **24***a*, **26***a*, and **28***a*, to drive the lower lift fans **24***b*, **26***b* and **28***b*. Thus, there are a total of sixteen lift fan drive mechanisms **30** to drive lift fan sets **24**, **26** and **28** in the aircraft configuration generally described in this specification.

Support webs **32** provide for the attachment and securing of each fan drive mechanism **30** within lifting surface **14**; many of these structural components may also be seen in FIG. **4**. Support webs **32** extend radially outward from the central vertical axis of aircraft **10**. For additional support, vertical circumferential walls **34** are located between inner and central fan sets **24** and **26** and between central and outer fan sets **26** and **28**. The joint formed at the juncture of radial support webs **32** and circumferential walls **34** at the locations of drive mechanisms **30** provide the required structural strength for the installation of those drive mechanisms **30**.

Each drive mechanism **30** is comprised of a pinion gear **36** which is secured to circumferential wall **34** by means of a bolt **38** or other suitable securing means. Pinion gear **36** in turn drives lift fan ring gears **40**, which are secured to the adjacent peripheries of related lift fans **24***a* and *b*, **26***a* and *b*, and **28***a* and *b*.

Support bearings **42** are provided at the periphery of each lift fan **24***a* and *b*, **26***a* and *b*, and **28***a* and *b*. Bearings **42** may be formed in an angular rectangular or diamond pattern, as shown, or in some other suitable form. In any case, bearings **42** must contain and provide support for lift fans **24***a* and *b*, **26***a* and *b*, and **28***a* and *b* throughout any anticipated conditions which might induce a load upon bearings **42**, hence the system of roller bearings **44** comprising each support bearing **42** which generally surround annular lift fan guides **46** in order to prevent the movement of such guides **46**, and the fans **24***a* and *b*, **26***a* and *b*, and **28***a* and *b* to which guides **46** are attached by means of annular fan guide attachments **48**, in any but a horizontal plane of rotation about the vertical axis of aircraft **10**.

Further structural details of aircraft **10** may be seen in FIGS. **4** and **6**. It is generally recognized that one of the strongest and lightest structural arrangements for a circular structure is a combination of support elements in tension and compression; this is the general arrangement used in the structure of aircraft **10**. A plurality of radial compression ribs **50** in the central horizontal plane of aircraft **10** are positioned each 45 degrees around the vertical axis of aircraft **10**. Each of these compression ribs **50** is of a generally tubular form with a hollow interior in order to provide for the containment of electrical wiring, hydraulic, fuel and other lines, etc. Additional rigidity of the structure is provided by upper and lower radial tension spokes **52**, which lie in the same vertical planes as compression ribs **50**. Each of these elements **50** and **52** is secured to the circumferential walls **34**, support webs **32** and other structure as required to form a sturdy and rigid but relatively light-weight structure.

Power for aircraft **10** is supplied by one or more turbine or other suitable engines **54**. In the preferred embodiment disclosed herein, three turboshaft engines **54** are located near the center of aircraft **10** as indicated in FIG. **4**. A surrounding housing **56** within the center of aircraft **10** contains engines **54** and extends forward to an intake **58** and rearward to an exhaust outlet **60**. While FIG. **4** discloses the general arrangement of the above power system, it is understood that structural and other components, such as central compartment **12** and some radial compression and tension ribs **50** and **52**, will also be located in the immediate area occupied by engines **54** and housing **56**. These components have generally been deleted from the engine housing **56** and intake and exhaust areas **58** and **60** in FIG. **4** for greater clarity.

At least one engine **54** is mechanically coupled to each of the drive mechanisms **30** by means of reduction gearing or a transmission, not shown, similar to that known in the art of helicopter turbine powerplants and reduction gearing or transmissions for driving the rotor blades of such helicopters. A plurality of power output shafts **62** extend from such a turboshaft transmission to drive each of the lift fan drive mechanisms **30** discussed above. Output shafts **62** are each contained within a radial compression rib **50**, and provide for transmission of power from engines **54** and other transmission means, to vertical shafts **64** and thence to each of the drive mechanisms **30**.

Radial compression ribs **50** may also contain additional wiring, conduits, etc. for the transmission of electrical, hydraulic, and other energy or fluids, as noted above. For example, FIG. **6** discloses a coolant reservoir or system **66** comprising a plurality of coils or tubes **68**, a fuel storage tank **70**, and oil storage tank **72**. It will be understood that each of these tanks or reservoirs **66**, **70** and **72** are of generally concentric annular form, passing completely around the center of craft **10** to form a series of generally ring shaped reservoirs or tanks **66**, **70** and **72**. FIG. **6** discloses these tanks **66**, **70** and **72** as a cross section through the interior of lifting surface **14**. Tubular compression ribs **50** provide space for the passage of the various fluid lines from these tanks or reservoirs **66**, **70** and **72** to the appropriate locations, such as oil line **74** to fan support bearings **42** as shown in FIG. **7**.

Engine and flight controls for these various systems are conventionally located within central compartment **12**, which provides space for a flight crew as well as some passengers and/or cargo. Central compartment **12** comprises an upper portion **76** and a lower portion **78** and is generally surrounded by a combination safety or rollover structure and aerodynamic surface **80**. The lower portion **78** of central compartment **12** provides space for the retraction mechanism and retracted storage of landing gear **82**, as well as space for additional components and/or payload. Landing gear **82** is comprised of a plurality of individual landing gear struts **84**, each of which may be equipped with conventional tires **86** or other supportive means. It will be appreciated that due to the vertical takeoff and landing capability of aircraft **10**, tires **86** or other means permitting aircraft **10** to move horizontally along a surface are not necessarily required. A simpler and lighter footpad or other suitable means, not shown, may also be installed at the lower end of each strut **84**, as desired.

Aircraft **10** may be operated by an appropriately trained flight crew by starting the engines **54** and engaging and operating the appropriate engine and flight controls. One or more of the engines **54** will drive upper and lower lifting fans **24**, **26** and **28** by means of drive mechanisms **30** and power output shafts **62**, as described above. Due to the equal areas of the counterrotating lift fans, little or no torque reaction will occur. By increasing the speed of upper and lower lift fans **24**, **26** and **28**, sufficient vertical thrust may be achieved to overcome the weight of aircraft **10** and any additional load aboard, and vertical flight will occur.

It will be evident that at very low or zero airspeed, conventional aerodynamic flight controls will not be operable. Aircraft **10** provides for controllability at such very low airspeeds by means of a cyclic pitch control system in which the pitch of at least one set of lift fan blades **24**, **26** or **28** may be varied over some portion of their rotational arc in order to increase or reduce the lifting force in some area of the lifting surface **14** and thus maintain control. It is envisioned that this cyclic pitch control be along similar lines to that already well known and used for the cyclic control of helicopter rotor blades.

The present aircraft **10** provides for a plurality of engines **54**, one or more of which may be used for the transmission of power to upper and lower lift fan blades **24**, **26** and **28** as described above. The remaining engines are provided for the purpose of forward thrust for horizontal flight, as provided by engine housing **56** and exhaust outlet **60** as shown in FIG. **4** and **5**. Exhaust outlet **60** may be equipped with thrust vectoring nozzles **88** for further control of aircraft **10**.

It will be appreciated that as the appropriate flight controls are manipulated to translate aircraft **10** from vertical to horizontal flight, that airflow over lifting surface **14** may be utilized for the production of dynamic lift. This is advantageous, as less energy is thus required by the engine or engines **54** used to provide power for lift fans **24**, **26** and **28**. However, in order to provide for such dynamic lift over surface **14**, the upper and lower surfaces **90** and **92** must be closed in order to prevent airflow from the relatively high pressure beneath lower surface **92** through lifting surface **14**, to the relatively low pressure above upper surface **90** which will naturally occur as a result of the production of dynamic lift. This is accomplished by means of upper and lower vanes **94** and **96** as shown in FIG. **5**, which may be actuated by means of pilot operable controls within the central compartment **12**. Thus, as translation is made from vertical to horizontal flight, power to lift fans **24**, **26** and **28** may be gradually reduced and upper and lower vanes **94** and **96** may be gradually closed to present a uniform, unbroken surface to such horizontal airflow as will occur in horizontal flight in order to produce dynamic lift over the airfoil shape of lifting surface **14**.

It will be appreciated that the equal areas of counterrotating lift fans **24**, **26** and **28** may not provide for precisely balanced thrust levels, and that accordingly there may be some slight net torque reaction which will tend to cause aircraft **10** to yaw or rotate about its vertical axis while hovering or operating at very low airspeeds. Upper and lower vanes **94** and **96** may be further utilized during this portion of flight by partial deflection, thus causing some sideward reaction of the air exiting the lower lift surface **92** and thereby producing such antitorque thrust as may be required. As greater airspeed is gained, such torque reactions will be reduced as power is reduced to lift fans **24**, **26** and **28** and the lift necessary to support aircraft **10** in flight is provided by aerodynamic means by lifting surface **14** as described above.

At airspeeds conductive to aerodynamic lift, it will be appreciated that aerodynamic control means will prove more desirable than the reaction control provided by the deflection of upper and lower vanes **94** and **96**. Thus, aerodynamic control is provided by means of peripheral flaps **98**. It is to be understood that as aircraft **10** is not by any means a conventional aircraft, some of the terms used in this specification do not necessarily directly relate to those used in conventional aircraft. In this instance, the term "flap" as used with conventional aircraft is generally accepted to mean an aerodynamic device located on the trailing edge of a wing, which device may be deflected downward for the purpose of increasing the lift coefficient of the wing. In the case of aircraft **10** of the present specification, the term "flap" is used to describe a peripheral aerodynamic control surface which may be deflected either upward or downward to alter the lift coefficient of lifting surface **14**. Flaps **98** may be deflected in unison, or deflected around only a portion of the periphery of lifting surface **14**, to increase or decrease the lift coefficient of that portion of lifting surface **14** to which they are applied.

Peripheral flaps **98** are preferably comprised of an inner portion **100** and an outer portion **102**, shown in greater detail in FIG. **8**. By providing a double flap arrangement some greater efficiency is achieved, although it will be apparent to those skilled in the art that alternative arrangements may be acceptable. Inner flap **100** is secured to the periphery of lifting surface **14** at inner hinge **104**, while outer flap **102** is attached to inner flap **100** by means of outer hinge **106**. Inner and outer flaps **100** and **102** may be respectively actuated by hydraulic actuators **108** and **110**, or by other suitable alternative means.

As forward speed is gained as described above, landing gear **82** may be retracted within the lower portion **78** of central compartment **12** and the aircraft **10** operated as described above and controlled and maneuvered by means of peripheral flaps **98**. When slower forward speed is desired, as in approaching for a landing, the above described procedures may be essentially reversed in order to exchange the aerodynamic lift provided by lifting surface **12**, for the lift provided by lifting fans **24**, **26** and **28**. Landing gear **82** may be extended, and aircraft **10** may be caused to descend essentially vertically and landed at any suitable location of sufficient size to contain the span of lifting surface **14**.

The embodiment disclosed in FIG. **2**, showing an aircraft **18** with an additional peripheral passenger or cargo compartment **20** may be operated in much the same manner as aircraft **10** described above, with the exception of the peripheral flight controls or flaps **98**. In lieu of peripheral flaps **98**, rearward flight controls **22** are provided when aircraft **18** has gained sufficient forward speed for their use. Flight controls **22** may be operated hydraulically as generally described above and known in the art, or by other suitable means. It will be apparent from the foregoing that aircraft **18** may be maneuvered and operated in flight in much the same manner as that described in detail for aircraft **10**, including vertical maneuvering for achieving takeoffs and landings in a limited area.

It is to be understood that the present invention is not limited to the sole embodiment described above, but encompasses any and all embodiments within the scope of the following claims.

I claim:

1. A disc planform aircraft having vertical flight capability,

said aircraft having a plurality of concentric lifting fan blade sets positioned around a central cabin area and an upper and a lower surface respectively containing upper and lower lifting fans,

said fan blade sets comprising a first set and a second set,

said first fan blade set comprises upper and lower inner lift fans and upper and lower outer lift fans and said second fan blade set comprises an upper and lower central lift fan,

said first set and said second set having equal projected horizontal areas and rotating in opposite directions to one another,

at least one engine providing power for said aircraft,

at least one of said at least one engine providing power for the operation of said fan blade sets, and

means providing power transmission from said at least one of said at least one engine to said fan blade sets.

2. The aircraft of claim **1** wherein;

each said first and said second lifting fan blade set includes a plurality of upper and lower lifting fan blades.

3. The aircraft of claim **1** wherein;

said engine include one said engine providing power for said lifting fan blade sets.

4. The aircraft of claim **3** including;

two additional engines providing power for horizontal flight.

5. The aircraft of claim **1** including;

peripheral aerodynamic control means providing for control of said aircraft in flight.

6. The aircraft of claim **5** wherein;

said peripheral aerodynamic control means comprise a plurality of first and second control surfaces,

said first control surfaces each having an inner edge and an outer edge,

each said first control surface inner edge hingedly attached to the periphery of said aircraft,

said second control surfaces each having an inner and an outer edge,

each said second control surface inner edge hingedly attached to a said first control surface outer edge.

7. The aircraft of claim **1** including;

a structure comprised of a plurality of horizontal radial members in compression in combination with a plurality of upper and lower radial members in tension.

8. The aircraft of claim **7** wherein;

said radial compression members are hollow.

9. The aircraft of claim **1** wherein;

said power transmission means comprise a plurality of radial transmission shafts from said engine providing said fan blade power to a plurality of fan drive mechanisms, and

said fan drive mechanisms providing power to said lift fan blades.

10. The aircraft of claim **9** wherein;

said lift fan blades each have a peripheral annular fan guide extending vertically therefrom,

each said fan drive mechanism including a plurality of bearing means,

said bearing means providing for the containment of said annular fan guides and associated operative forces.

11. The aircraft of claim **9** wherein;

said radial transmission shafts are contained within said radial compression members.

12. The aircraft of claim **1** including;

a peripheral cabin area providing space for the carriage of payload.

13. The aircraft of claim **12** including;

aerodynamic controls rearwardly located on said aircraft.

14. The aircraft of claim **1** wherein;

said upper and lower surfaces each include a plurality of vane means,

said vane means providing openings for the passage of air therethrough.

15. The aircraft of claim **14** wherein;

said openings of said vane means are controllably variable.

* * * * *

US005303879A

United States Patent [19]

Bucher

[11] Patent Number: 5,303,879

[45] Date of Patent: Apr. 19, 1994

[54] **AIRCRAFT WITH A DUCTED FAN IN A CIRCULAR WING**

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[73] Assignee: **Sky Disc Holding SA**, Fribourg, Switzerland

[21] Appl. No.: **9,246**

[22] Filed: **Jan. 26, 1993**

[30] **Foreign Application Priority Data**

Jan. 29, 1992 [CH] Switzerland 258/92-5

[51] **Int. Cl.**[5] **B64C 29/00**; B64C 39/06

[52] **U.S. Cl.** .... **244/23 C**; 244/12.2; 244/23 B; 244/23 D; 244/82; 244/45 A

[58] **Field of Search** .... 244/6, 7 B, 7 A, 10, 244/12.1, 12.2, 12.4, 12.5, 12.6, 23 B, 23 C, 23 D, 67, 82, 45 A

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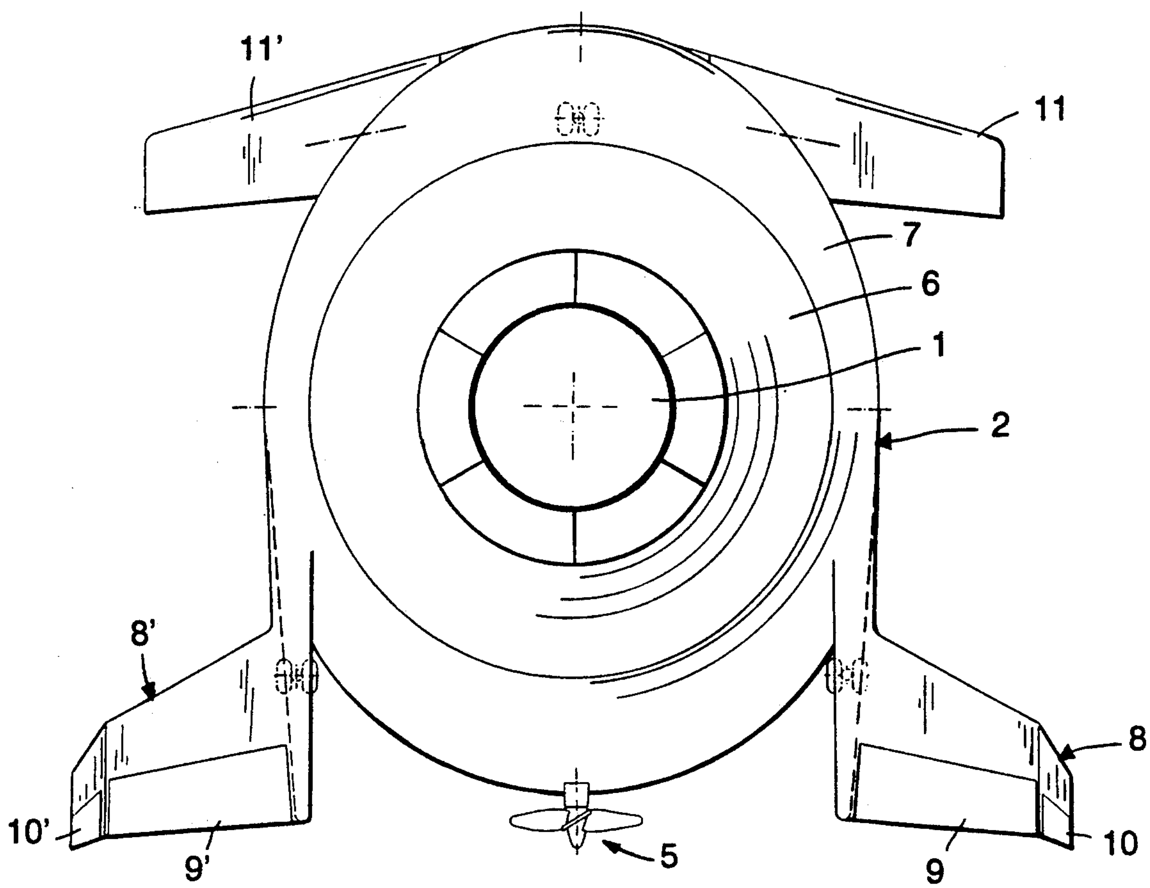
Assistant Examiner—Virna Lissi Ansley
Attorney, Agent, or Firm—Fish & Richardson

[57] **ABSTRACT**

The aircraft comprises a rotor with a vertical axis arranged in a housing for generating a lift exceeding the weight of the aircraft. The housing is essentially shaped as a circular wing. A first way of guiding air is provided for controlling the air stream generated by the rotor, by means of which the position of the aircraft can be controlled in hovering flight. From hovering flight, the aircraft can be moved into a cruise flight, where the lift of the aircraft is generated aerodynamically by the circular wing of the housing and its forward thrust by a propeller. For the transition between hovering flight and cruise flight, a second way of guiding air is provided for controlling the pitch of the aircraft. The structure for the second way of guiding air is arranged outside a zone defined by the air stream of the rotor.

21 Claims, 7 Drawing Sheets



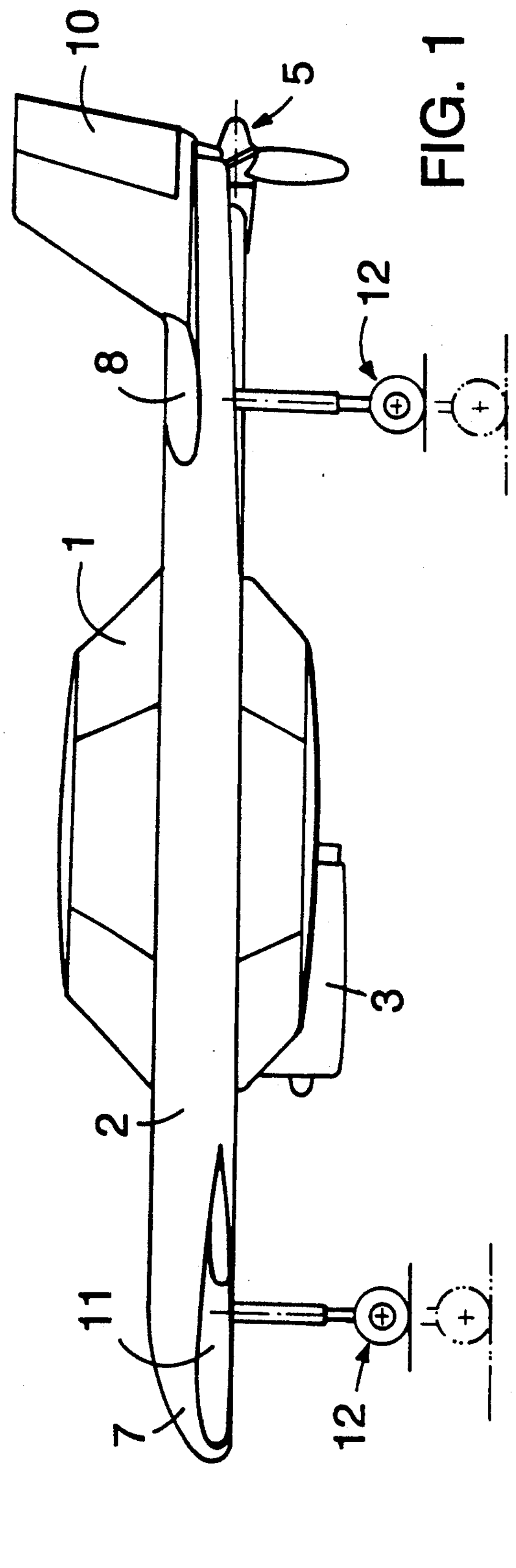


FIG. 1

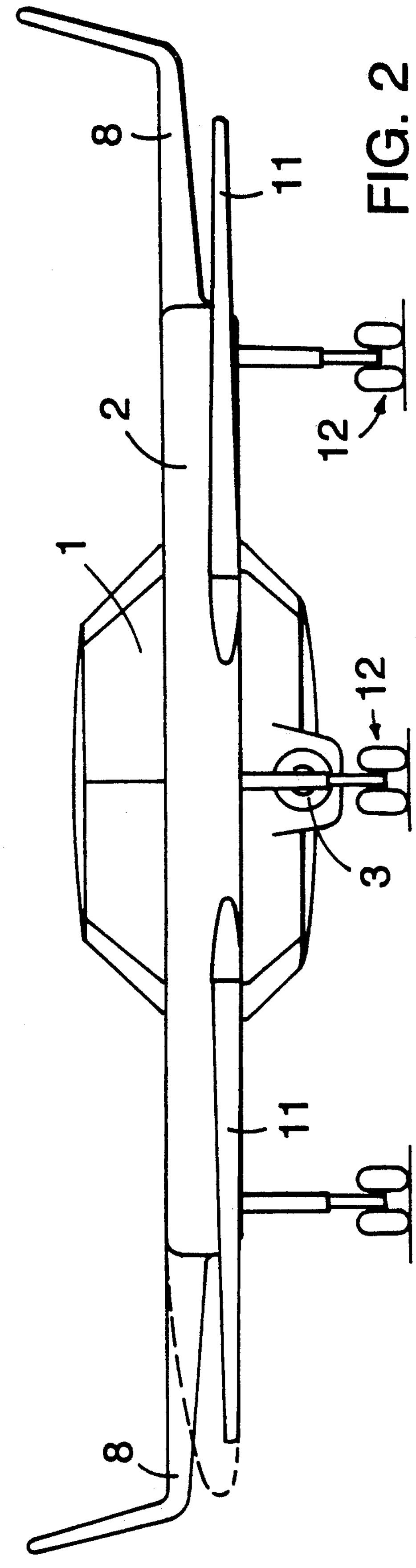


FIG. 2

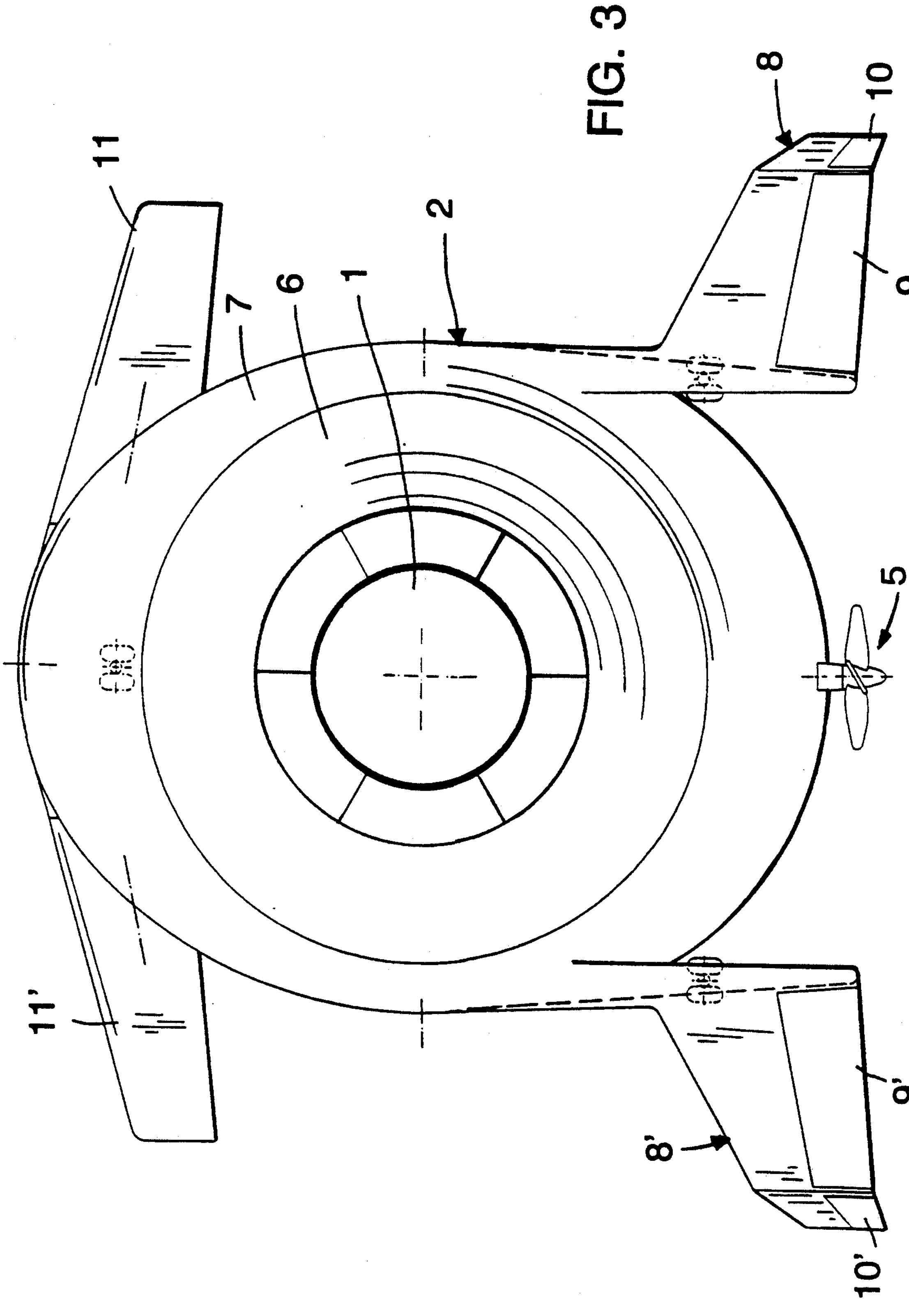


FIG. 3
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2
5
6
7
8
8'
9
9'
10
10'
11
11'

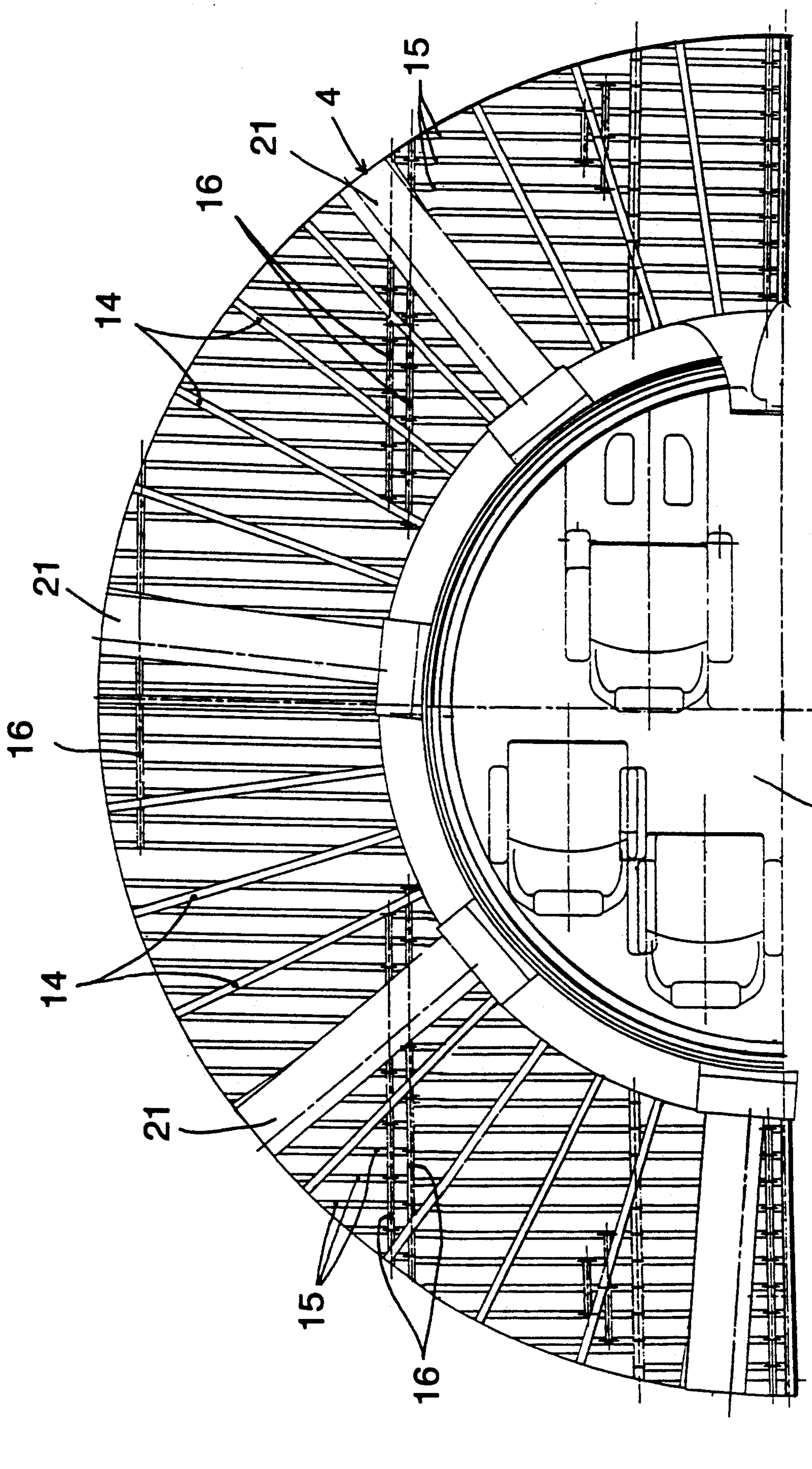

FIG. 4

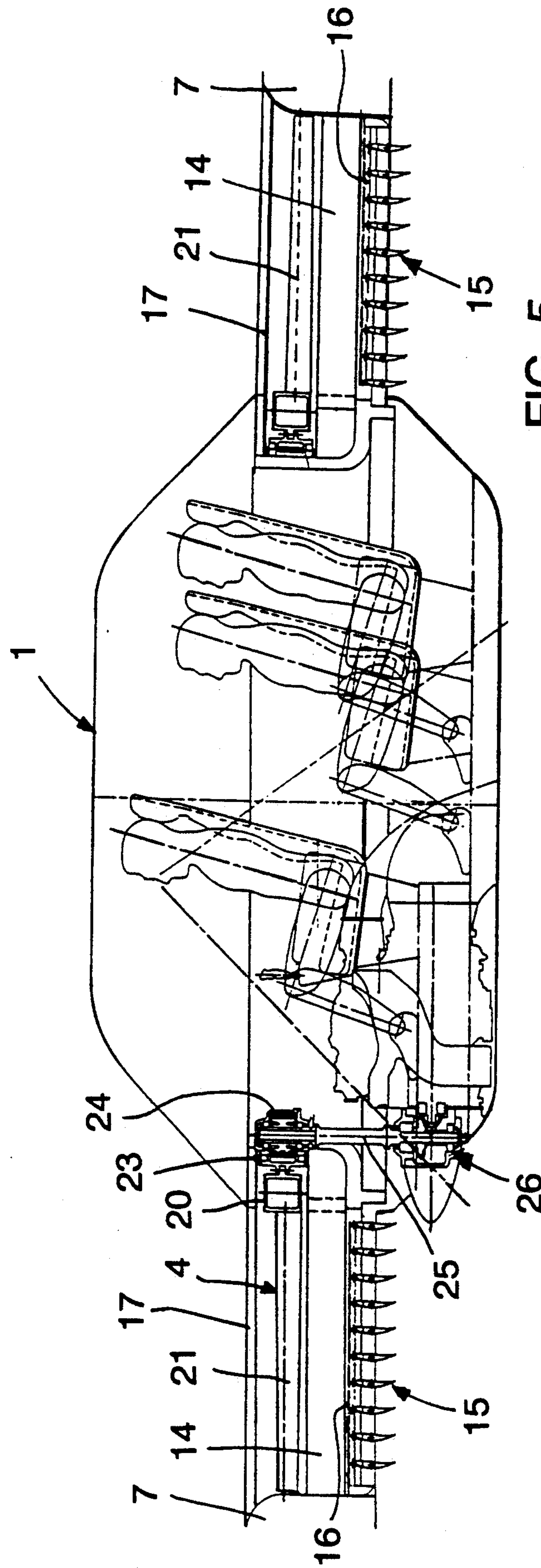

FIG. 5

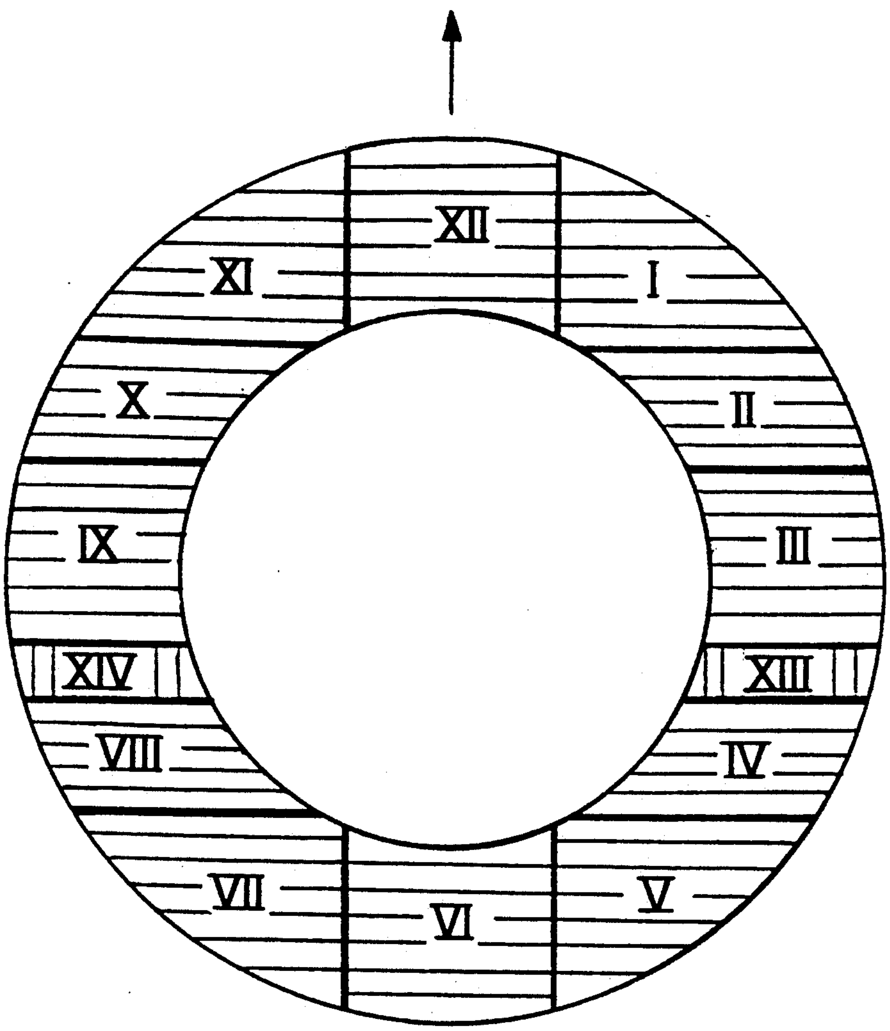

FIG. 6

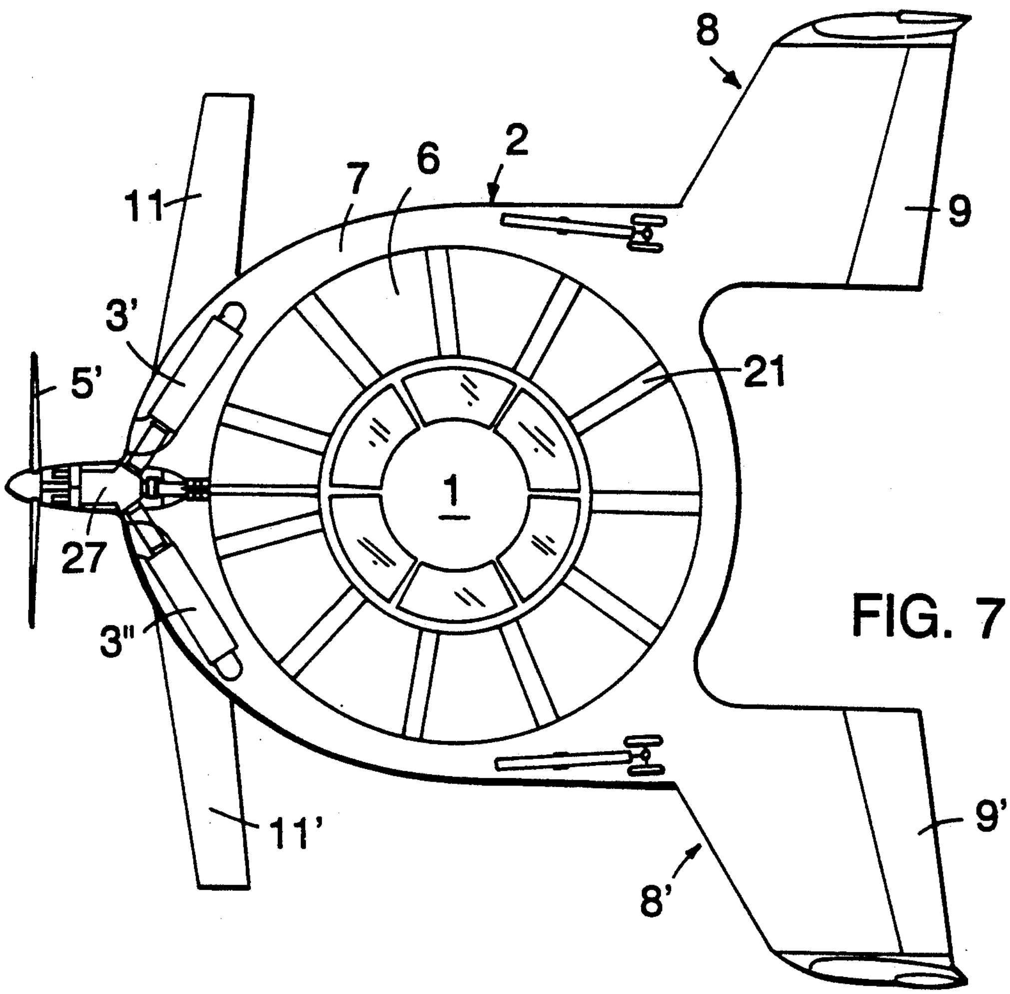

FIG. 7

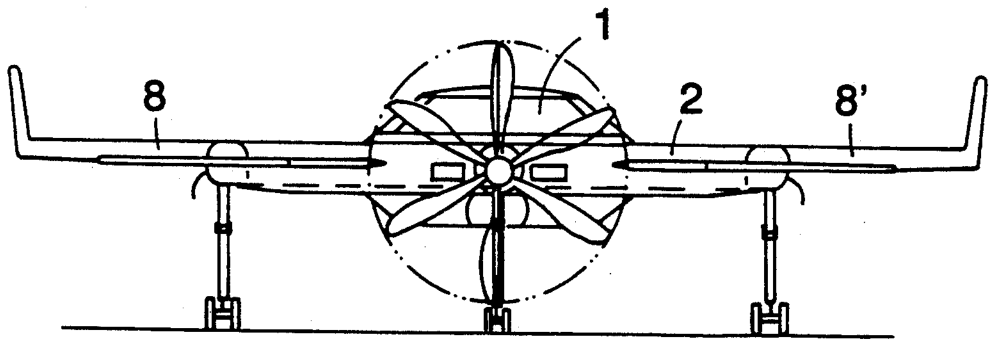

FIG. 8

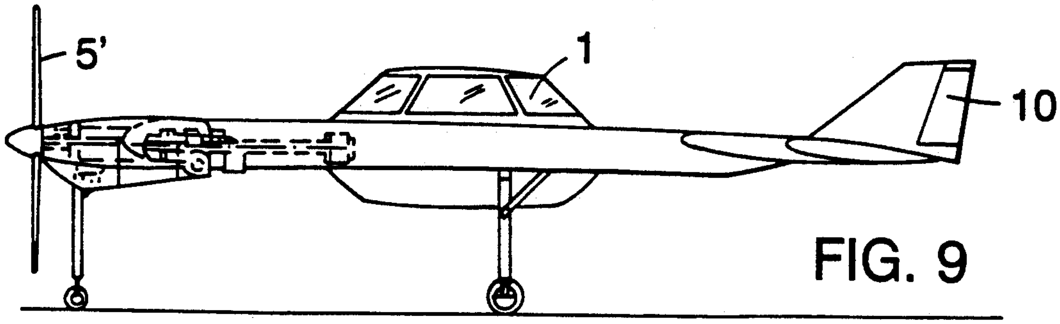

FIG. 9

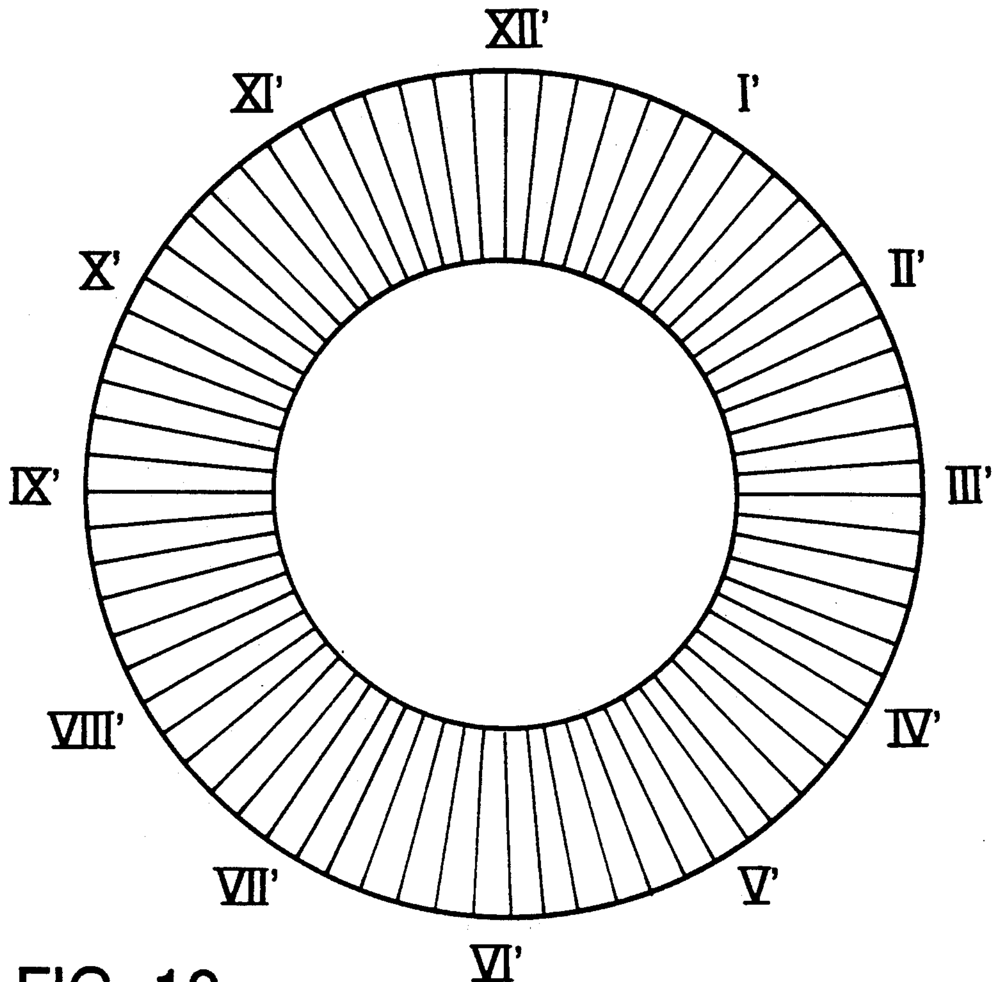

FIG. 10

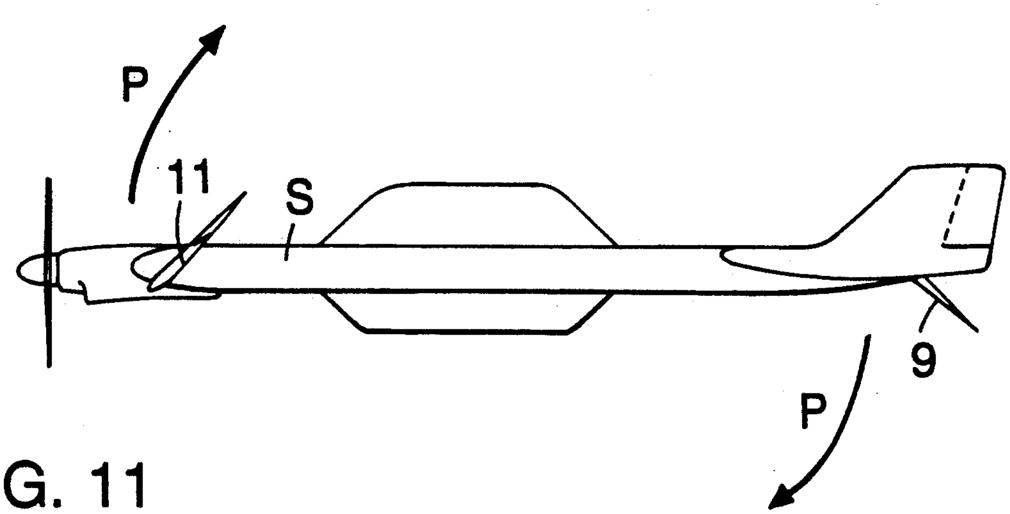

FIG. 11

AIRCRAFT WITH A DUCTED FAN IN A CIRCULAR WING

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention refers to an aircraft comprising a housing shaped as a substantially circular wing, means for generating a horizontal thrust, at least one rotor arranged in said housing, first air guiding means for controlling the air flow generated by said rotor, and second air guiding means for controlling the pitch of the aircraft.

2. Description of the Related Art

An aircraft of a similar kind has been discussed in the published European patent application EP-0393410. This aircraft comprises a vertical, ducted fan or rotor for generating a lift exceeding the weight of the aircraft in hovering flight. This rotor is arranged in a circular housing and provided with air guiding means for controlling the air flow it generates. Experiments with this type of aircraft have shown that the maximum velocity of flight in a forward direction is limited to a comparatively low value. At higher velocities an interaction between the horizontal air flow around the housing and the air flow generated by the rotor occurs, which leads to instabilities.

The air flow patterns on circular wings are not very well known and even less data is available for circular wings housing a ducted fan.

SUMMARY OF THE INVENTION

Hence, it is a general object of the present invention to provide an aircraft of this kind that also allows, besides a controlled hovering flight, a driven forward flight at high velocities, such that the aerodynamic lift generated by the circular wing can be taken advantage of.

Now, in order to implement this and still further objects of the invention, which will become more readily apparent as the description proceeds, the aircraft is manifested by the features that air guiding means are arranged outside a zone defined by the air flow generated by the rotor. Furthermore, means for generating a forward thrust are arranged on the aircraft. These air guiding means are used to control the pitch of the aircraft during forward flight at higher velocities while the rotor is still in operation.

Experiments of the applicant with circular wings containing a ducted rotor, i.e. a ducted fan, have shown that at higher horizontal velocities the interaction between the horizontal air flow and the air stream generated by the rotor causes an increase of the aerodynamic lift in a forward part of the wing and a decrease of this lift in its rear part. At low velocities this effect can be compensated by an appropriate control and deflection of the rotor air stream. However, this becomes impossible above a certain velocity.

By arranging air guiding means, e.g. winglets, outside a zone of influence of the rotor air stream, it has surprisingly been found, however, that a range of velocities exists at which the pitch of the aircraft can either be controlled by controlling the rotor air flow or by using these winglets. This transition range allows the aircraft to reach higher velocities, at which the lift can be generated aerodynamically by the circular wing alone, such that a contribution of the rotor is not required anymore.

At low velocities the lift as well as the position of the aircraft is therefore controlled by the air stream of the rotor alone. At high velocities the lift is generated aerodynamically by the circular wing and by flaps and/or winglets. At intermediate velocities, in a transition range, the rotor air stream as well as aerodynamic forces on the wings or air guiding means contribute to the lift and the control of the craft.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood and objects other than those set forth above will become apparent when consideration is given to the following detailed description thereof. Such description makes reference to the annexed drawings, wherein:

FIG. **1** shows a side view of a first embodiment of the aircraft;

FIG. **2** shows a front view of the aircraft of FIG. **1**;

FIG. **3** is a top view of the aircraft of FIG. **1**;

FIG. **4** is a top view of part of the rotor and the central cabin;

FIG. **5** is a sectional view of the part shown in FIG. **4**;

FIG. **6** is a schematic view of the sections of the vane assembly;

FIG. **7** is a top view of a second embodiment of the aircraft;

FIG. **8** is a front view of the aircraft of FIG. **7**;

FIG. **9** is a side view of the aircraft of FIG. **7**;

FIG. **10** is a second embodiment of the sections of the vane assembly, and

FIG. **11** is an illustration of the pitching forces acting on the craft in transition flight.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

A first embodiment of the invention is shown in FIGS. **1-3**, which show the housing and the arrangement of the winglets of an aircraft for six persons. A cabin **1** is arranged in the center of a rotor housing **2**. The cabin extends above and below the rotor housing. The cabin provides room for six seats, including two seats for pilots. It also houses the engine **3** (see FIG. **5** for more details). The engine **3** drives a horizontally arranged rotor **4** (cf. FIGS. **5, 6**) and a vertical propeller **5**.

An annular zone **6** of the housing provides a passage of the air stream generated by the rotor **4** in hovering flight. This zone is surrounded by a part **7** of the housing, which forms a slightly elongated circular wing with a profile suitable for generating an aerodynamic lift in a horizontal air flow. The term "circular wing" used here is to be understood to comprise other wing shapes having a span width essentially equal to their length. Two separated rear wings **8, 8'** are arranged laterally at part **7** of the housing. These wings **8, 8'** are located outside a zone defined by the air stream generated by the rotor **4**. This zone intersects the circular wing vertically in hovering flight and obliquely in forward flight. The rear wings **8, 8'** comprise elevators **9, 9'** and rudders **10, 10'**, which are used for controlling the air craft in transition flight and cruise, as will be explained below. Furthermore, front wings **11, 11'** can be provided at the head of the aircraft. The wings could also be integrated in the (enlarged) circular wing.

A retractable undercarriage **12** is mounted at the bottom side of the housing.

The mechanical setup of the rotor **4** of this embodiment and of its drive is shown in FIGS. **4** and **5**. Eight rotor blades **21** are mounted on the periphery of an annular profile **20** with a fixed angle of incidence. Depending on the rotation speed of the rotor and the arrangement of the blades, it is also possible to use a larger or a smaller number of blades. At the inner surface of the profile **20**, a roller bearing **23** with an inner gear rack is engaged by a driving pinion **24** located on a shaft **25** of a differential gear **26**. A second shaft of this differential gear **26** (not shown) drives the horizontal propeller **5**. By braking the shaft **25** driving the rotor, the rotor speed can be decreased for partially or completely transferring the energy of the engine to the propeller **5**, or vice versa. In hovering flight, the engine **3** drives only the rotor **4**. In cruising flight the rotor is stopped and the energy of the engine is fully transferred to the propeller **5**.

Below the rotor **4**, flow control means **14** in the form of blades with a small angle of incidence of a first static flow control system are arranged to absorb the rotative component of the air stream generated by the rotor. These blades **14** extend radially between the passenger cabin **1** and the outer part **7** of the housing. The blades are load bearing structural parts of the housing. In this embodiment a total of **36** of such blades are installed guaranteeing a good rigidity of the housing.

Below the blades **14**, a zone of increased pressure is generated, which pressure is discharged through an assembly of pivotal vanes **15** located below the blades **14** and the rotor **4**. This assembly of vanes **15** is used for controlling the direction and velocity of the resulting air stream. In this first embodiment, most of the vanes **15** extend in a direction perpendicular to the principal forward direction of the aircraft. As it will be explained below, the vanes are divided into groups of individually pivotal sections. In each section, the vanes are pivoted by actuating rods **16** (cf. FIG. **6**). All vanes of a section can be pivoted all simultaneously into one direction. Alternatively, pairs of adjacent vanes can be pivoted in opposite directions (cf. FIG. **6**).

On its top side the rotor is protected by a cover grating with struts **17** extending parallel to the forward direction.

As it has already been mentioned before, the aircraft of this invention has several different modes of flight. Theses modes of flight are found in overlapping ranges of velocity, which is a prerequisite for a safe operation.

A first mode of flight is the hovering mode. In this mode the lift, the movements as well as the position are controlled by adjusting the rotor air stream, i.e. by throttling or deflecting it by means of the sections of the vane assembly. FIG. **6** schematically shows a first embodiment of this vane assembly. The individual sections are denoted by Roman numbers I–XIV.

If the vanes of a section are collectively pivoted away from their vertical position, the corresponding part of the rotor air stream is deflected. This produces a reactive force with a horizontal component, which can be used as a thrust into the forward direction or for controlling the lateral position of the craft. If pairs of adjacent vanes of a section are pivoted in opposite directions, no such horizontal force is generated, but the lift of the respective section is decreased.

Using these principles the position and movement of the aircraft can be controlled during hovering flight.

The sections XII and VI with all vanes pivoted in parallel directions are used for generating a forward or backward thrust along the principal forward direction of the aircraft. Sections III and IX with vanes pivoted in opposite directions can be used for rotating the craft, while they can contribute to the forward thrust when their vanes are parallel.

The eight sections I, II, IV, V, VII, VIII, X, and XI are used for controlling the vertical movements of the aircraft with pairs of adjacent vanes pivoted in opposite directions, such that the lift of each section can be modi7 fied without generating a horizontal thrust. The sections I and XI together with V and VII can e.g. control the pitch of the aircraft. By partially closing the vanes of sections I and XI, the head of the craft dips downward because the lift of the forward part of the aircraft is decreased. A lateral tilt of the aircraft can be controlled by sections II and IV together with sections X and VIII.

Lateral movements can be controlled by pivoting the vanes of sections XIV and XIII in parallel directions.

Generally, the pivoting control movements of the vanes start from the opened, vertical position of the vanes. Adjustments for controlling the tilt and horizontal and vertical movements are thereby superimposed and carried out simultaneously. In this way, all sections are more or less open. This reduces local fluctuations of pressure over the circumference of the rotor air stream and guarantees a smooth operation of the rotor.

In this way forward speeds up to approximately 55 km/h (at SLSC, "Sea Level Standard Conditions") can be reached in hovering flight. As it has been discussed before, the increasing horizontal air flow in interaction with the rotor air stream generates a lift on the circular wing, which is much stronger in the forward part of the wing than in its rear part. From ca. 35 km/h the wings **8, 8′** and or **11, 11′** becomes increasingly effective for compensating the resulting pitch.

A transition mode is reached for velocities between ca. 55 km/h and 90 km/h. At these velocities (or even earlier) the propeller **5** is used as a propulsion unit to generate at least part of the forward thrust. In this mode, the controlling influence of the vanes **15** decreases and is increasingly replaced by the effect of the winglets, which are arranged laterally outside the rotor air stream and are therefore not affected by it. In this way, a means for controlling the pitch of the aircraft is provided that is independent from the rotor air stream and the flow around the circular wing.

From a velocity of approximately 90 km/h up to the maximum velocity of ca. 400 km/h (SLSC) the thrust is fully generated by the propeller **5** and the lift is generated aerodynamically by the circular wing **2** in the horizontal air flow (cruise mode). The vanes are closed and the rotor **4** has no effect. No air flow is passing through the circular wing. The craft is controlled in a conventional way by means of the elevators and rudders of the wings **8, 8′**.

The propeller **5** is of course not the only possible means for propagating the aircraft. The thrust could e.g. also be generated by means of a convertible turbine, which can be used to drive the rotor in hovering flight and to create an air jet in cruise mode.

As it has already been mentioned, the wings **8, 8′** and **11, 11′** can be used to compensate the pitch generated by the interaction between the rotor air stream and a horizontal air flow in forward flight, until a sufficient aerodynamic lift is generated by the circular wing alone. Then the rotor can be switched off, and the aircraft is operated in the more economic cruise mode.

In this cruise mode, the aircraft requires less motor power than in hovering or transition mode. Therefore, it may be possible to operate an overloaded aircraft in cruise mode, while hovering and transition cannot be used. In this case, conventional, propeller powered take-off and landing may still be possible.

FIGS. 7-11 show a second, preferred embodiment of the aircraft. The differences between this second embodiment and the first embodiment according to FIGS. 1-6 can best be seen from FIGS. 7 and 10.

FIG. 7 shows that the propeller 5' is located at the forward end of the aircraft. The power of two engines 3', 3'' is combined in a gear 27, which is driving the propeller 5'. The eleven rotor blades 21 are again driven over a driving shaft, which can e.g. be coupled to the gear 27 by means of a clutch or coupling. This coupling, which is preferably hydraulic or magnetic allows disconnection of the rotor from the engine in cruise mode. For controlling the thrust generated by the propeller, the angle of incidence of the propeller blades can be adjusted. This design obviates the need for a differential gear as it was used in the first embodiment.

Arranging the engines 3', 3'' at the head of the aircraft leads to a center of mass of the craft that lies in front of the aerodynamic center of the aircraft. This improves the aerodynamic stability in transition mode, as it is illustrated in FIG. 11. As it was mentioned above, the interaction of a horizontal air flow in forward flight and the rotor air stream leads to a pitch shown by the arrows P of FIG. 11. This pitch is compensated by adjusting the angles of incidence of the elevators 9, 9' and/or the forward wings 11, 11'. If the center of mass S of the aircraft lies in front of its aerodynamic center, an additional pitching moment is created that supports the action of the elevators and/or the forward wings.

The arrangement of the vanes for guiding the rotor air stream of the second embodiment of the invention is shown in FIG. 10. In contrary to the first embodiment, all vanes extend in radial direction. Again, the vanes are divided into groups of individually pivotal sections (I'-XII'). All these sections are essentially identical. This results in a modular construction of the vane assembly, which simplifies maintenance and reduces production costs. A defunct section can easily be removed and replaced by a new section.

In this embodiment, the fine control of the forward thrust in hovering flight is realized by changing the pivot angle of the vanes of sections III' and IX', while lateral displacements are controlled by sections XII' and VI'. For controlling the lift of each section, pairs of adjacent vanes can again be rotated in opposite directions, as described above.

Coarse adjustment of the forward thrust is controlled by changing the angle of incidence of the blades of the propeller 5'.

The two embodiments described above show some of the possible, preferred realizations of the invention. Further variants, however, are possible. Especially, the shape and arrangement of the wings 8, 8', 11, and 11' can be varied in many ways. Care should be taken, however, to make sure that at least part of these air guiding means are arranged outside the influence of the air stream generated by the rotor to guarantee a good control of the aircraft during transition flight.

All embodiments of the aircraft combine the advantages of a helicopter and an airplane in two separated modes of operation. The transition between these modes does not lead to instabilities and is safely controlled. As can be seen from FIGS. 1, 2, and 5, the length and width of span of the described aircraft for six passengers are comparable to those of a conventional airplane and range e.g. between 10 and 15 meters. The maximum forward speed is also comparable to conventional airplanes of this category. In cruise mode, the aircraft can therefore be compared to conventional airplanes. It has, however, the advantage of being able to be operated in hovering flight, such that maneuvers of a helicopter can be carried out as well. The described aircraft is also especially suited for medium sized passenger airplanes to be used in regular air service.

While there are shown and described present preferred embodiments of the invention, it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied and practiced within the scope of the following claims.

I claim:

1. An aircraft comprising a housing shaped as an essentially circular wing for generating an aerodynamic lift in a horizontal air flow,

means for generating a horizontal thrust in a principal forward direction,

at least one nonpivotal driven rotor with an essentially vertical axis of rotation for generating a rotor air stream, said rotor being arranged in said housing and designed for generating a lift exceeding the weight of said aircraft,

first air guiding means arranged within said rotor air stream adjustable for controlling said rotor air stream, said first air guiding means comprising radially extending vanes with pairs of adjacent vanes being adapted to be pivoted in opposite directions, said first air guiding means being capable of substantially preventing undesirable pitch of said aircraft during a portion of flight, and

second air guiding means arranged outside a zone defined by said rotor air stream, which second air guiding means are shaped for influencing the pitch of the aircraft during flight along said principal forward direction.

2. The aircraft of claim 1, wherein said second air guiding means are arranged in respect to said principal forward direction laterally outside said rotor air stream.

3. The aircraft of claim 2, wherein at least part of said second air guiding means are arranged on said housing being said rotor.

4. The aircraft of claim 2, wherein at least part of said second air guiding means are arranged on said housing in front of said rotor.

5. The aircraft of claim 3, wherein at least part of said second air guiding means are arranged on said housing in front of said rotor.

6. The aircraft of claim 1, wherein said means for generating a horizontal thrust are designed for reaching such horizontal speeds that the aerodynamic lift of the aircraft exceeds the weight of the aircraft.

7. The aircraft of claim 1, wherein said means for generating a horizontal thrust comprise said first air guiding means, which first air guiding means are adjustable for deflecting said rotor air stream horizontally thereby generating a horizontal thrust.

8. The aircraft of claim 1, wherein said means for generating a horizontal thrust comprise at least one horizontal propulsion unit, which horizontal propulsion unit is designed to generate a horizontal thrust by generating a repulsive air stream in a horizontal direction.

9. The aircraft of claim 8, wherein said horizontal drive unit comprises a driven fan with an axis of rotation parallel to said principal forward direction.

10. The aircraft of claim 1, wherein said vanes are divided into groups of individually pivotal sections.

11. The aircraft of claim 10, wherein at least one of said sections alternatingly comprises vanes pivotal into a first and into a second direction, respectively, wherein said first direction is opposite to said second direction.

12. The aircraft of claim 10, wherein all said sections are essentially of identical design.

13. The aircraft of claim 10, wherein said pivotal vanes are extending in a radial direction in respect to said axis of rotation of said rotor.

14. A method for controlling an aircraft, said aircraft comprising

a housing shaped as an essentially circular wing for generating an aerodynamic lift in a horizontal air flow,

means for generating a horizontal thrust in a principal forward direction,

at least one nonpivotal rotor with an essentially verti7 cal axis of rotation for generating a rotor air stream, said rotor being arranged in said housing and designed for generating a lift exceeding the weight of said aircraft,

first air guiding means arranged within said rotor air stream for controlling said rotor air stream, said first air guiding means comprising radially extending vanes with pairs of adjacent vanes being adapted to be pivoted in opposite directions, said first air guiding means being capable of substantially preventing undesirable pitch of said aircraft during a portion of flight, and

second air guiding means arranged outside a zone defined by said rotor air stream shaped for generating aerodynamic forces and adjustable for influencing the pitch of the aircraft during flight along said principal forward direction;

said method comprising:

a hovering mode, in which the lift of the aircraft is generated by said rotor and the position of the aircraft is controlled by said first air guiding means,

a cruise mode, in which the lift of the aircraft is generated by the aerodynamic lift of said housing and said second air guiding means, and

a transition mode, in which the lift of the aircraft is generated in part by said aerodynamic lift of said housing an in part by said rotor.

15. The aircraft of claim 10, having only one driven rotor, wherein said first air guiding means comprise flow control means arranged between said rotor and said assembly of pivotal vanes and shaped for absorbing a rotative component of said rotor air stream.

16. The aircraft of claim 15, wherein said flow control means comprise a plurality of guiding vanes extending in a radial direction in respect to said axis of rotation of said rotor.

17. The aircraft of claim 16, wherein said guiding vanes are load bearing members of said housing.

18. The method of claim 14, wherein said cruise mode said vanes are closed to form an essentially closed surface.

19. The method of claim 14, wherein in said transition mode, said second air guiding means are used to compensate forces generated by said rotor air stream and influencing the pitch of the aircraft.

20. The method of claim 14, wherein in said transition mode, said first air guiding means are adjusted to deflect said rotor air stream in a direction opposite said principal forward direction.

21. The method of claim 14, wherein said vanes are divided into groups of individually pivotal sections and wherein said hovering mode all said sections are at least partially opened for said rotor air stream.

* * * * *

US005318248A

United States Patent [19]

Zielonka

[11] **Patent Number: 5,318,248**

[45] **Date of Patent: Jun. 7, 1994**

[54] **VERTICAL LIFT AIRCRAFT**

[76] Inventor: **Richard H. Zielonka**, 61 Mark St., Chicopee, Mass. 01020

[21] Appl. No.: **874,301**

[22] Filed: **Apr. 24, 1992**

[51] **Int. Cl.**[5] **B64C 29/00**

[52] **U.S. Cl.** .... **244/12.2**; 244/60; 244/23 C; 244/17.11; 416/115; 416/170 R; 416/128; 474/167; 474/111; 464/185

[58] **Field of Search** .... 244/60, 122, 23 C, 17.11; 280/206, 207; 180/10; 440/99-100; 474/166, 167, 237, 134, 111; 416/170 R, 120, 124, 127, 128, 129, 114, 115; 464/51, 185, 30, 55; 192/74

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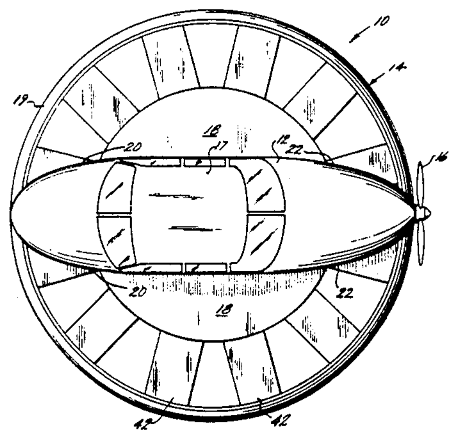
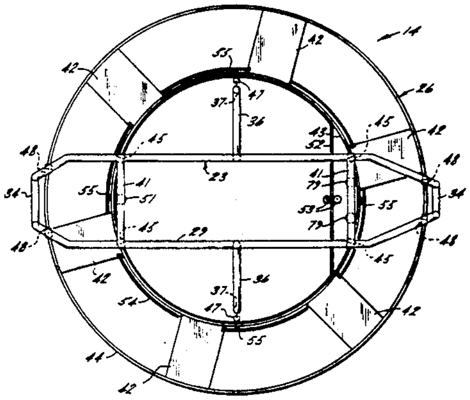
Primary Examiner—Galen L. Barefoot
Attorney, Agent, or Firm—Fishman, Dionne & Cantor

[57] **ABSTRACT**

A vertical lift aircraft comprising an aircraft body and a lifting assembly is presented. The lifting assembly comprises a frame wherein at least one airfoil assembly which includes a plurality of airfoils attached to a drive ring is secured. As the drive ring rotates, the airfoils move through the air and create lift. The pitch of the airfoils or blades can be fixed or variable. The drive ring is rotated by a band which is in frictional contact with the inner surface of the drive ring. The band is rotated by at least one pair of rollers which are in frictional contact with the band. Aircraft stability is controlled by regulating airfoil pitch which is responsive to pivoting of a control ring. Alternatively, aircraft stability is provided by regulating the flow of air or gas from a plurality of nozzles disposed about the aircraft. The body, a portion of which may be located inside the lifting assembly, includes a passenger and load carrying compartment and an engine assembly.

28 Claims, 6 Drawing Sheets





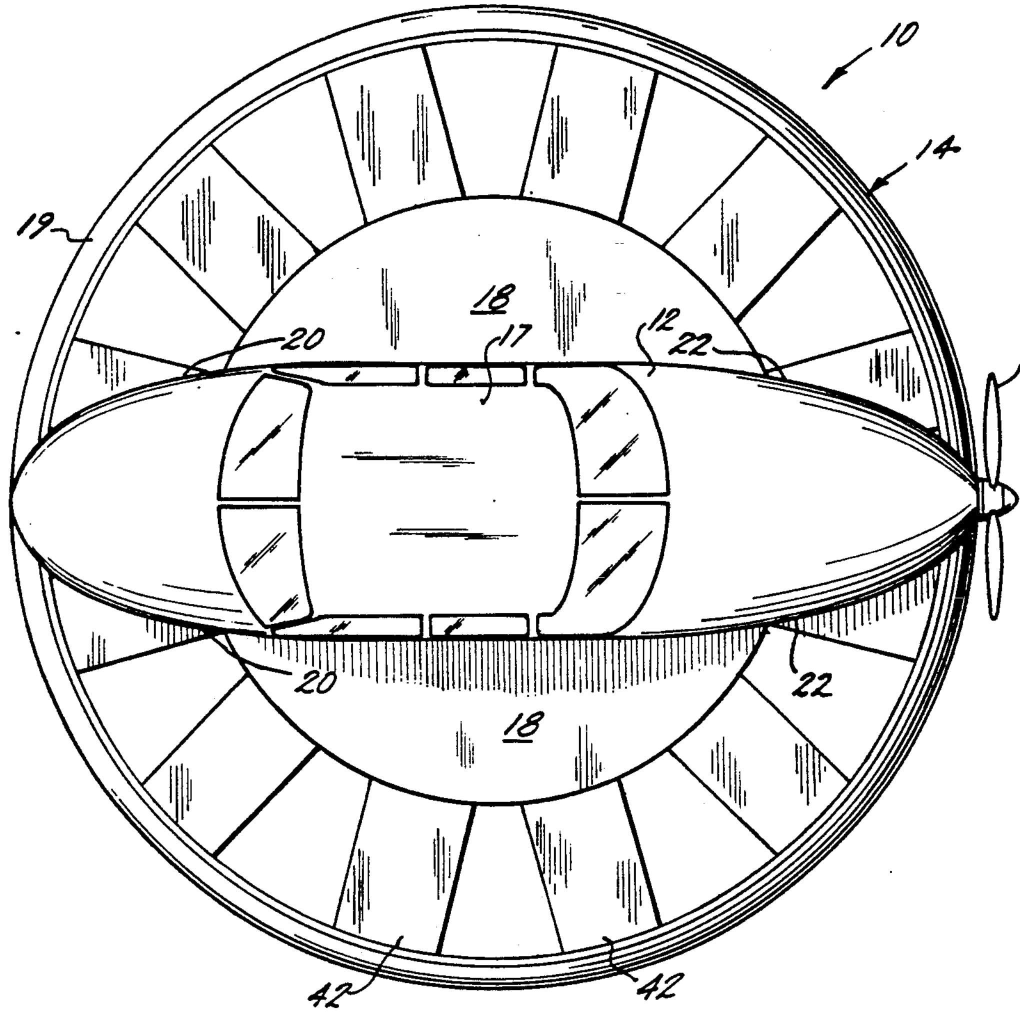


FIG. 2

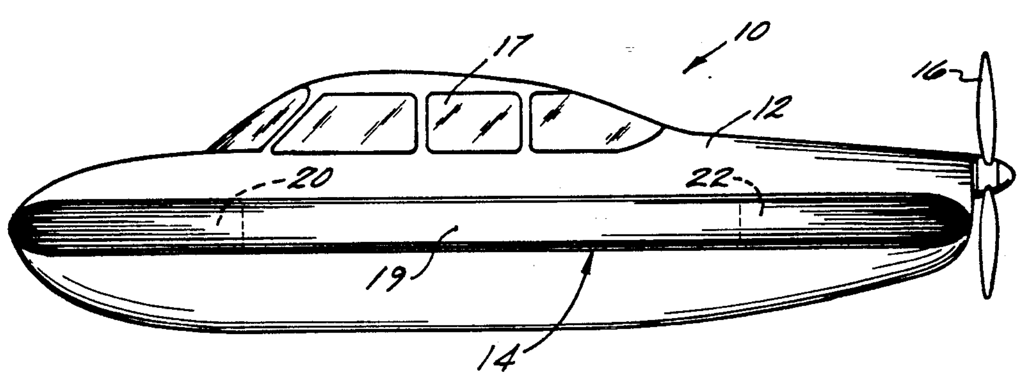


FIG. 1

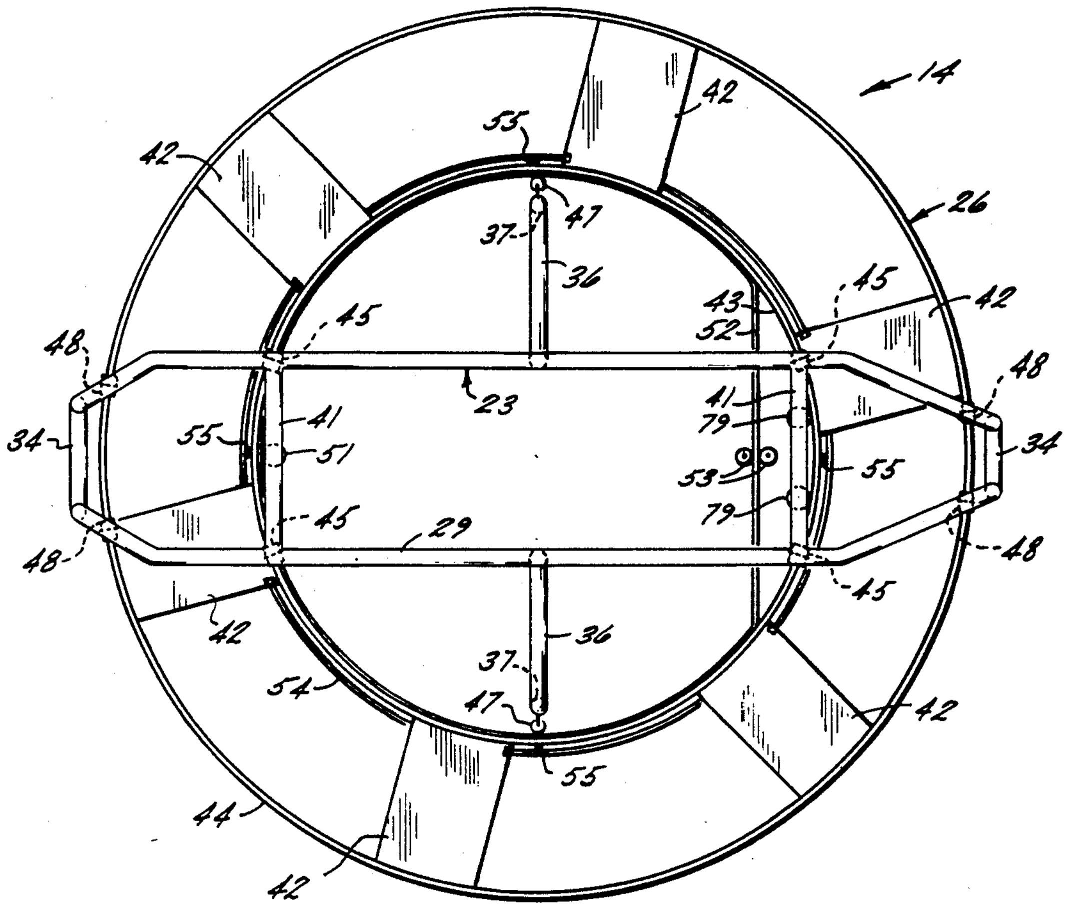

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FIG. 3

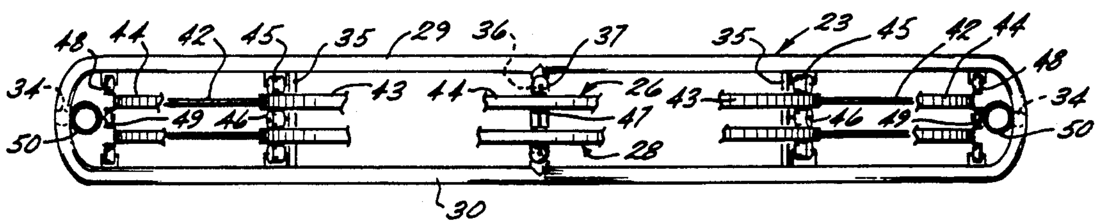
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FIG. 4

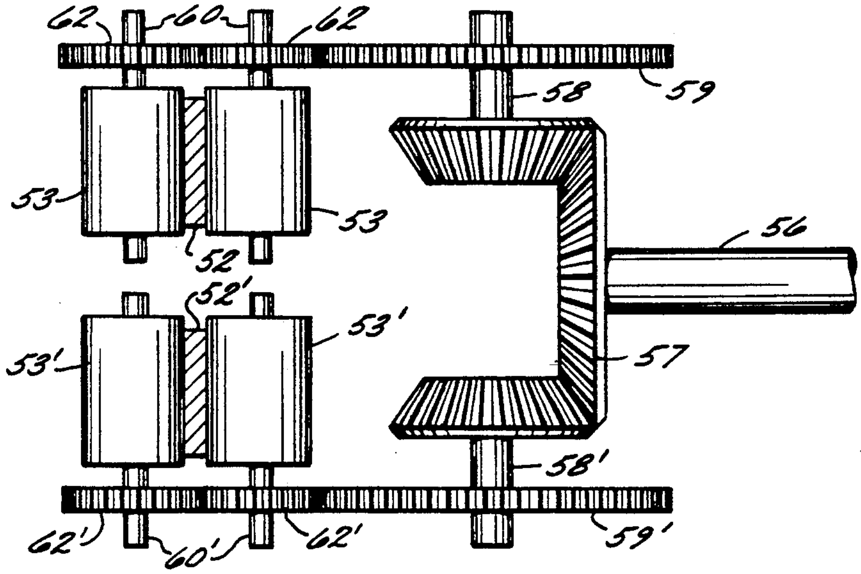

FIG. 5

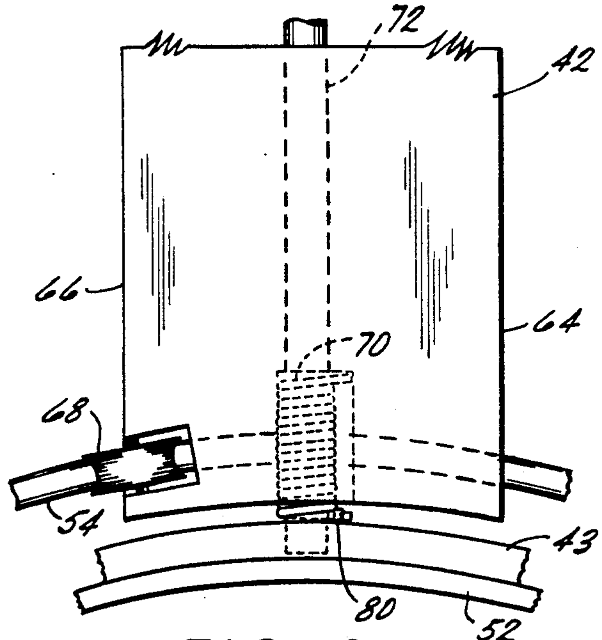

FIG. 6

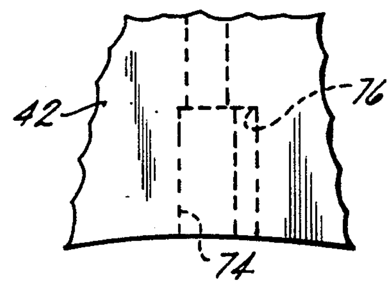

FIG. 6B

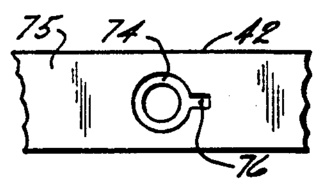

FIG. 6A

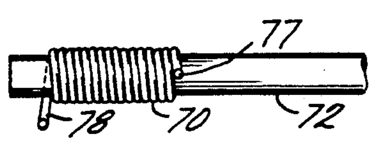

FIG. 6C

FIG. 6D

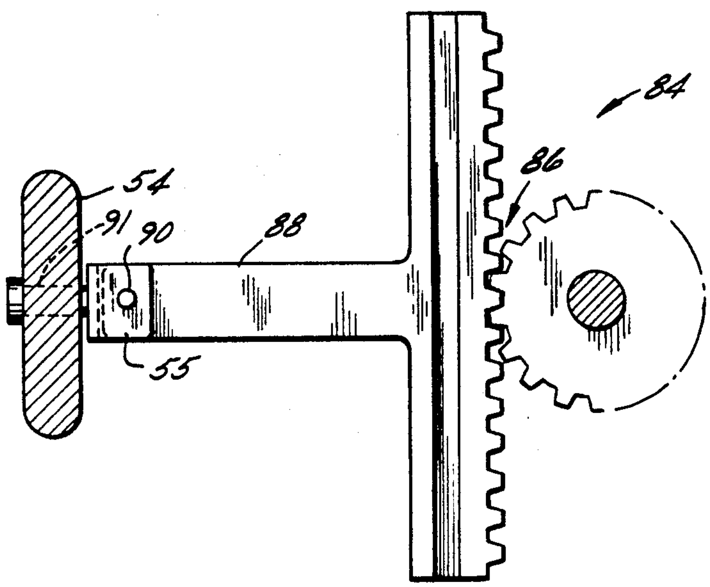

FIG. 7A

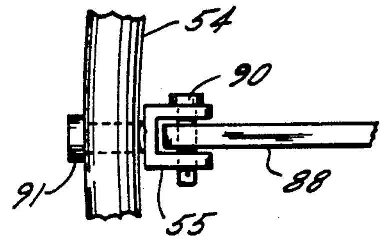

FIG. 7B

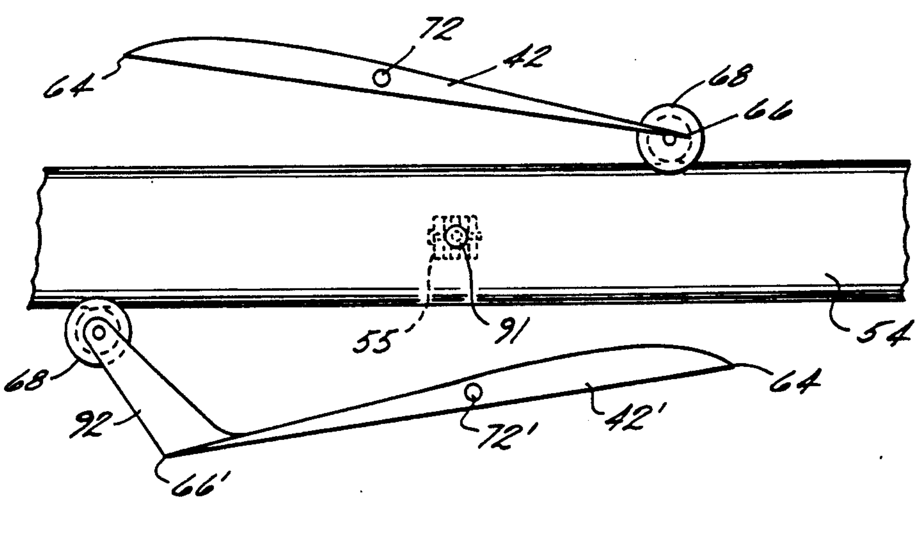

FIG. 8

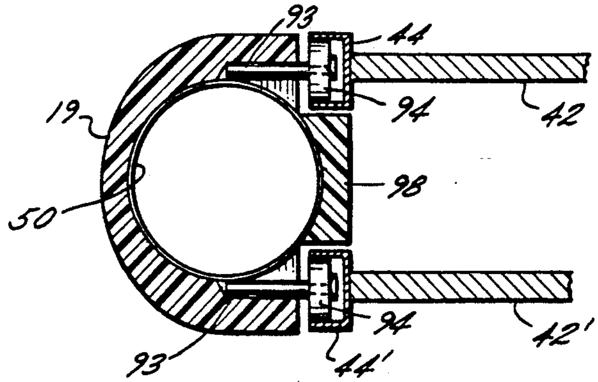
93
44
19
94
42
98
50
94
93
44'
42'

FIG. 9

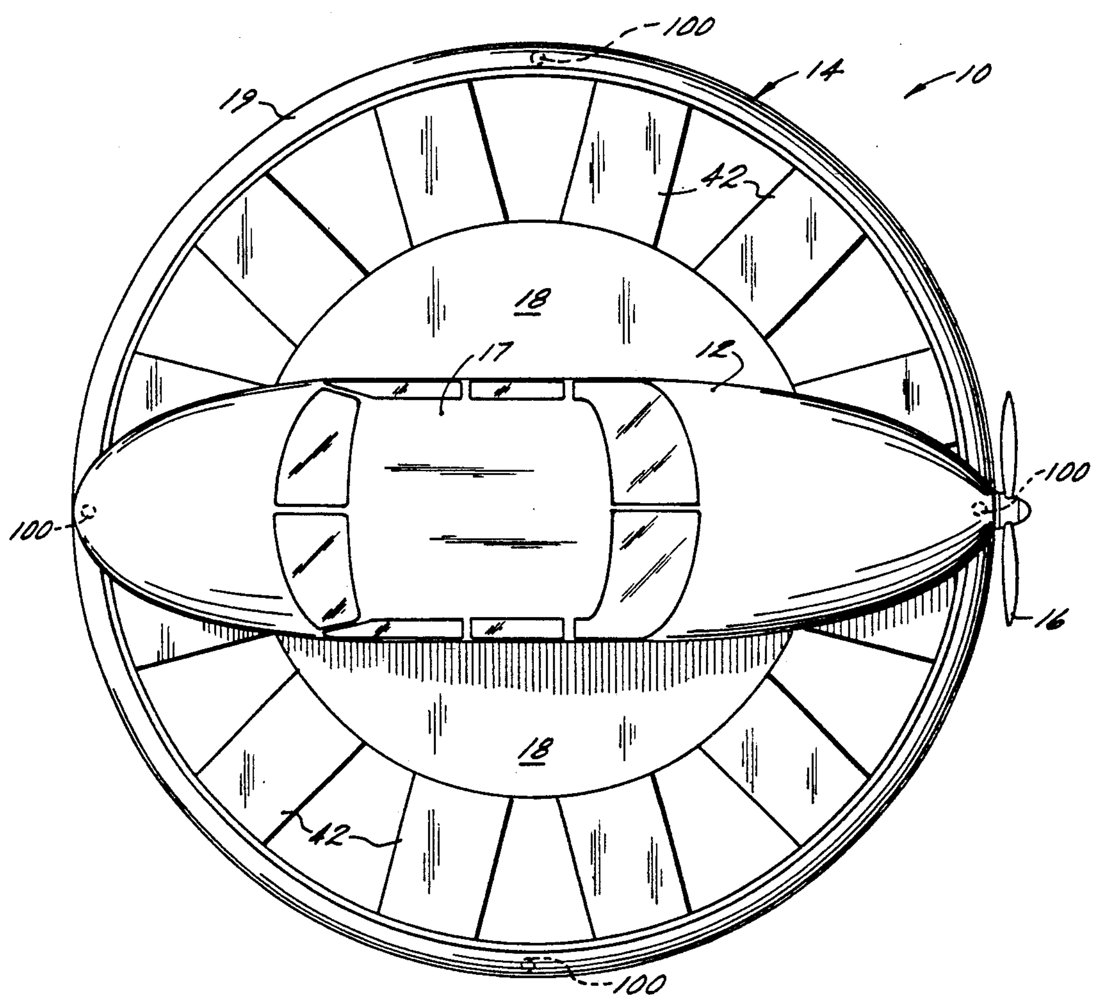
100
14
10
19
42
18
17
12
100
100
16
18
42
100

FIG. 10

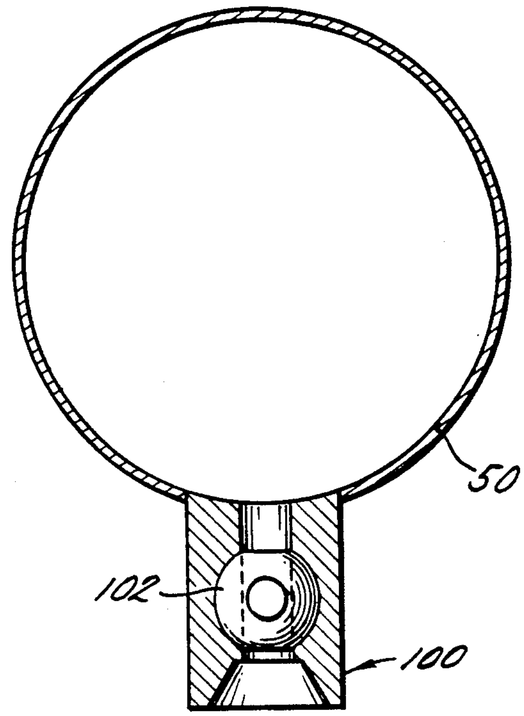

FIG. 11B

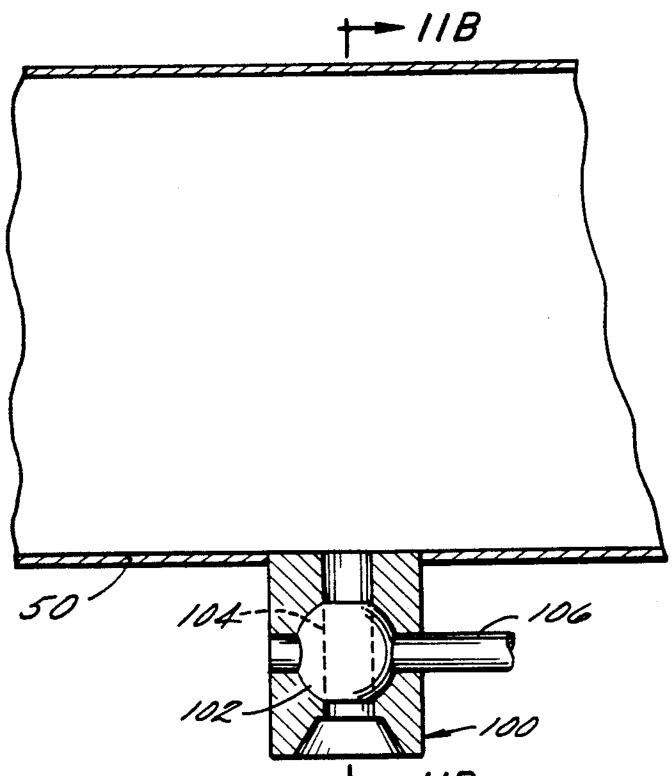

FIG. 11A

VERTICAL LIFT AIRCRAFT

BACKGROUND OF THE INVENTION

This invention relates to an aircraft and, more particularly, to a vertical lift aircraft employing a new and improved lift system.

Presently, helicopters are the most common vertical lift type aircrafts. The helicopters generally employ a single main rotor with a torque-compensating propeller on a boom at the rear of the helicopter. The body of the helicopter is located below the main rotor and is connected to the rotor system by a shaft which drives the rotor.

This conventional configuration has many deficiencies. For example, the rotor blades of the helicopter (generally between two and five) are long and heavy, and are connected to a single rotor hub; resulting in the rotor hub being heavily stressed. Damage to one of the rotor blades can create unbalances which can destroy the entire rotor system. Normal vibrations are also very difficult to damp in a conventional rotor system. The rotor blades, being free at one end, are easily damaged upon impact. The torque compensating propeller consumes a significant part of the engine power and adds a large amount of weight. The body of the helicopter being suspended below the rotor, interferes with the flow of air from the rotor, thus reducing the efficiency of the rotor. The rotor, being positioned high above the body of the helicopter, does not benefit fully from "ground effect", the lift-enhancing phenomena, which occurs when a lifting surface is operated close to the ground. The rotor of the helicopter operates at a much lower RPM than the engine which drives the rotor, necessitating the use of a heavy, RPM-reducing gear box. Other types of vertical lift aircrafts are shown in U.S. Pat. Nos. 3,437,290; 3,507,461; 3,514,053; 3,813,059 and 4,196,877. The above list is only exemplary and is not intended to be a complete list of vertical lift type aircrafts. In general, these patents address many of the deficiencies, noted above, of the helicopter type aircraft. In particular, these patents disclose the use of many airfoils located closer to the ground for providing lift as compared to the few rotor blades used on a helicopter. Further, the use of multiple sets of airfoils is disclosed in U.S. Pat. No. 3,813,059.

SUMMARY OF THE INVENTION

The above discussed and other problems and deficiencies of the prior art are overcome or alleviated by the vertical lift aircraft of the present invention. In accordance with the present invention a lifting assembly of the vertical lift aircraft comprises a frame wherein at least one airfoil assembly which includes a plurality of airfoils attached to a drive ring is secured. The outer end of each airfoil is preferably attached to an outer support ring. As the drive ring rotates, the airfoils move through the air and create lift. The pitch of the airfoils or blades can be fixed or variable. The drive ring is rotated by a band which is in frictional contact with the inner surface of the drive ring. This band is flexible and has sufficient spring characteristics to press up against the inner surface of the drive ring. The band is rotated by at least one pair of rollers. The pair of rollers comprises opposing rollers with the band sandwiched therebetween. The rollers are in frictional contact with the band, which will in turn rotate the drive ring. Any number of airfoil assemblies can be stacked or otherwise arranged to generate as much lift as is required, however two are preferred. With two airfoil assemblies, (i.e. one disposed above the other) it is preferred that they rotate in opposite directions. The passenger, engine and load carrying compartments can be located in the aircraft body within the lifting assembly.

Preferably aircraft stability or control is provided by cyclically and collectively varying the angle of attack of the airfoils (i.e., pitch). In accordance with the present invention each airfoil is disposed on and fits over a pivot shaft which extends out from the drive ring the length of the airfoil. The shaft is attached to the drive ring so that it is fixed and the airfoil is allowed to pivot or rotate about the shaft. At the drive ring, a coil spring is disposed about the shaft, with one end of the spring attached to the drive ring and the other end of the spring attached to the airfoil. When the spring and airfoil are installed, the spring is preloaded so that it tends to turn the airfoil so as to hold a roller located at the rear of the airfoil against the pitch controlling control ring. Each airfoil has a roller fixed to its trailing edge either directly or by a bracket at the drive ring end of the airfoil. The roller of each airfoil rolls along the surface of a control ring which is located adjacent to the airfoils and coaxially with the drive ring. As one end of the control ring is lifted, the rollers of each airfoil passing over the end will also be lifted, which will decrease the angle of attack of the lifted airfoils.

Control can be provided by feeding compressed gas or air to adjustable nozzles located in the front, back and on each side of the aircraft. By modulating the gas (or air) flow from each nozzle, the aircraft can be made to tilt in any direction.

The present invention employs a large number of small, light, airfoils connected to the drive ring. In the present invention, the stresses and vibrations of the airfoils or blades are distributed over a larger area, (i.e. the drive ring), as compared to a hub of the helicopter rotor (i.e. a single point). Further, damage to one airfoil will not greatly affect the balance of the airfoil assembly, unlike prior art helicopters where damage to one blade of the rotor greatly affects rotor balance. Vertical stacking of two counter-rotating airfoil assemblies eliminates the need for a torque-compensating propeller. Further, by attaching the airfoils to the drive ring instead of a hub (as in the prior art), the body of the aircraft can be placed in the same plane as the airfoil assembly. This allows the body of the aircraft to be disk-shaped, which is believed to be stronger and lighter with a lower drag coefficient than the body of the prior art helicopters. It will be appreciated that the aircraft body is located outside of the airflow path of the airfoils. This alignment of the body of the aircraft in the plane of the lifting assembly allows the rotor to be placed closer to the ground resulting in more pronounced "ground-effects" for a given ground-to-body distance.

The other types of vertical lift aircrafts discussed hereinbefore do not disclose the drive means of the present invention. More particularly, a band in frictional contact with the drive ring, the band being rotated by a roller driver system. Further the prior art also does not disclose control of airfoil pitch by pivoting a control ring which is in communication with the airfoils.

The above-discussed and other features and advantages of the present invention will be appreciated and understood by those skilled in the art from the following detailed description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings wherein like elements are numbered alike in the several FIGURES:

FIG. 1 is a side elevational view of an aircraft in accordance with the present invention;

FIG. 2 is a top view of the aircraft of FIG. 1;

FIG. 3 is a top view of the lifting assembly used in the aircraft of FIG. 1;

FIG. 4 is a side elevational view of the lifting assembly used in the aircraft of FIG. 1;

FIG. 5 is a side elevational view partly in cross section of the drive rollers and drive means used in the aircraft of FIG. 1;

FIG. 6 is a partial top view of a portion of the airfoil assembly used in the lifting assembly of FIG. 3;

FIG. 6A is a partial end view of the airfoil of FIG. 6;

FIG. 6B is a partial top view of the airfoil of FIG. 6;

FIG. 6C is a partial side elevational view of the spring and pivot shaft used in the airfoil of FIG. 6;

FIG. 6D is an end view of the spring, pivot shaft and retaining post used in the airfoil of FIG. 6;

FIG. 7A is a side elevational view of the control means for the control ring used in the lifting assembly of FIG. 3;

FIG. 7B is a partial top view of the control means for the control ring of FIG. 7A;

FIG. 8 is a partial side elevational view partly in cross section of the control ring with two air foils having rollers in contact with the control ring used in the lifting assembly of FIG. 3;

FIG. 9 is a cross sectional view of the cover and the tubular member used in the aircraft of FIG. 1;

FIG. 10 is a top view of an aircraft in accordance with an alternate embodiment of the present invention;

FIG. 11A is a side elevational view partly in cross section of a nozzle used in the alternate embodiment of FIG. 10; and

FIG. 11B is a cross sectional view taken along the line 11B—11B in FIG. 10A.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to FIGS. 1 and 2, a vertical lift aircraft in accordance with the present invention is shown generally at 10. Aircraft 10 comprises a body 12, lifting assembly 14 and a propeller 16 located a the rear of aircraft 10 for forward propulsion of aircraft 10. While propeller 16 is preferred as a means for generating forward propulsion, lifting assembly 14 can also generate forward propulsion as will be described hereinafter. Also, other means of forward propulsion may be employed (e.g., a jet engine) without departing from the spirit or scope of the present invention. Body 12 includes a passenger compartment 17 (including flight crew) located at about the center of body 12. Body 12 may be any type of body commonly used with aircrafts. A shell 18 protects the interior portions of lifting assembly 14. Lifting assembly 14 which is covered by an outer cover 19, passes through an opening 20 at the front of body 12 and through an opening 22 at the rear of body 12. This alignment of body 12 in the plane of lifting assembly 14 results in more pronounced ground effects.

Referring to FIGS. 3 and 4, lifting assembly 14 is shown without an outer cover 19. Assembly 14 comprises a frame 23 wherein upper and lower airfoil assemblies 26 and 28 are secured. Frame 23 is attached to the body 12 of aircraft 10. While one airfoil assembly may suffice, two coaxially arranged airfoil assemblies 26 and 28 are preferred. Airfoil assemblies 26 and 28 are vertically stacked and are counter-rotated. It will be noted that two counter-rotated airfoil assemblies 26 and 28 eliminates the need for a torque-compensating propeller, such is required with most prior art helicopters. Frame 23 comprises an upper support member 29 and a lower support member 30. Upper and lower support members 29 and 30 are attached at each end by end members 34 and at the interior by vertical support members 35. Upper and lower support members 29 and 30 include extending members 36 located at about the center of members 29 and 30. Extending members 36 from the upper and lower members 29 and 30 are connected by side members 37. Each upper and lower member 29 and 30 includes a pair of cross members 41. Frame 23 is secured to the body 12 of aircraft 10 by conventional methods. Further, cover 19 is secured to frame 23 at members 29, 30 and 34 by conventional means as is clearly shown in FIG. 4.

As Assembly 26 and assembly 28 are of the same type and operate in the same manner, only assembly 26 will be described herein. Assembly 26 includes a plurality of airfoils or blades 42. One end of airfoils 42 is pivotably attached to a drive ring 43 where the outer end thereof is pivotably attached to an outer support ring 44. Drive ring 43 is supported in frame 23 by rollers 45 which are attached to upper support member 29 and by rollers 46 which are attached to vertical support members 35. Drive ring 43 is also supported in frame 43 at extending members 36 by rollers 47. Support ring 44 is supported in frame 23 by rollers 48 which are attached to upper support member 29 and by rollers 49 which are attached to a tubular member 50. At a member (not shown) extending downwardly from one of cross members 41 includes a roller 51 positioned for contact with drive ring 43. A pair of other members (not shown) extend downwardly from the other one of cross members 41 with each including a roller 79 positioned for contact with drive ring 43. It should be noted that assembly 26 is not affixed to frame 23, rather the rollers 45–49, 51 and 79 are employed to allow assembly 26 to rotate freely relative to frame 23.

Outer ring 44 is preferred although it is not required for the present invention. Outer ring 44 protects airfoils 42 from impact damage and reduces the airflow around the outer edges of airfoils 42, which increases the efficiency of airfoil assembly 26. Further, although only six airfoil blades 42 are shown in FIG. 3, it is intended that any number of blades 42 may be employed. This is feasable since blades 42 are smaller and substantially lighter than the prior art helicopter rotor blades. The stresses and vibrations of airfoils 42 are distributed over the surface of drive ring 43. This is believed to be a significant improvement over the prior art, where the helicopter rotor blades are connected at the hub, a much smaller surface area.

Drive ring 43 is driven by an inner band 52. Inner band 52 has spring like characteristics which force band 52 against drive ring 43 for rotation in unison therewith. Band 52 is rotated by a pair of opposing rollers 53, thereby rotating drive ring 43 with blades 42. It should be noted that the two rollers 79 on frame 23 are employed instead of one in order to avoid any interference with rollers 53. Band 52 is preferably a continuous strip of material with a high modulus of elasticity such as high carbon spring steel or fiberglass. Generally band **52** is circular with a diameter slightly less than the inner diameter of drive ring **43**, to allow easy assembly. When band **52**, drive ring **43** and drive rollers **53** are assembled, the portion of band **52** which is gripped by drive rollers **53** is deformed towards the center of band **52**. This causes a major portion of band **52** to press up against the inside of drive ring **43**. Due to the friction between band **52** and drive ring **43**, any movement of band **52** will cause a comparable movement in ring **43**. This effect can be enhanced by coating the inside of drive ring **43** with a high coefficient of friction material. This is maybe required to avoid any slippage between drive ring **43** and inner band **52**.

The portion of band **52** that lies between drive rollers **53** and drive ring **43**, in the direction of rotation, will tend to bend as power is applied to drive rollers **53**. Band **52** must be sufficiently thick to resist this bending force.

The material or drive rollers **53** is dependent upon the material used for band **52**. If band **52** is made from high carbon spring steel, the drive rollers **53** can be made from a material of comparable hardness such as hardened steel. This combination of steel pressing against steel, will allow high pressures to be exerted. This will increase the amount of power that can be transmitted as compared to a drive roller/band combination which would not allow such high pressures. The rolling efficiency of a steel against steel combination is also very high.

The revolutions per minute (RPM) of drive rollers **53** will be much higher than the RPM of drive ring **52**, because of the difference between their diameters, thus resulting in an RPM reduction which provides a better match between a normally high RPM engine such as a gas turbine which is used in most modern helicopters, and the low RPMs which are required for a large diameter rotor system. This built-in RPM reducing capability reduces or eliminates the need for a heavy and costly gear box.

In this preferred embodiment, a control ring **54** is pivoted at a plurality of pivot arms **55**. Control ring **54** pivots to adjust the pitch of blades **42**, as is described hereinafter.

Referring now to FIG. **5**, a means for driving drive rollers **53** and **53′** is shown. Rollers **53** are associated with assembly **26** and rollers **53′** are associated with lower assembly **28**. The primed numbers herein are used to designate corresponding elements of the lower assembly **28**. A drive shaft **56** driven by an engine (not shown) is coupled to **57** to rotate, thereby rotating a shaft **58, 58′** which is coupled to gear **57**. The other end of shaft **58, 58′** is affixed to a spur gear **59, 59′**. Rollers **53, 53′** have shafts **60, 60′** extending therethrough for rotation in unison therewith. One end of shafts **60, 60′** has a gear **62, 62′** affixed thereto, each of which meshes with the other and one of which meshes with gear **59, 59′**. Band **52, 52′** is sandwiched between rollers **53, 53′**, whereby band **52, 52′** is advanced as the rollers are rotated. It will be appreciated that any autorotation of assemblies **26** and **28** is to be compensated for by a conventional clutch assembly (not shown) between the engine and drive shaft **56**.

Referring to FIGS. **6** and **6A–D**, a portion of a single airfoil **42** is shown at the end connected to drive ring **43**. Airfoil **42** comprises a pair of opposing sides forming a leading edge **64** and a trailing edge **66**. A roller **68** which communicates with control ring **54** is located on the trailing edge **66**. Airfoil **42** is biased by a preloaded spring **70** to maintain contact between roller **68** and control ring **54**. Spring **70** is disposed on a pivot shaft **72**. Spring **70** is located in an opening **74** on surface **75** of airfoil **42** which has a slot **76**. An extension **77** of spring **70** is positioned in slot **76** to prohibit rotation of spring **70**. A second extension **78** of spring **70** is retained by a post **80** extending from the outer surface of drive ring **43**. Shaft **72** is fixed and does not rotate relative to airfoil **42**. Shaft **72** also provides connection of airfoil **42** to drive ring **43** by conventional means. It will be appreciated that the pitch or angle of attack of airfoils **42** can be selected to provide forward propulsion as is well known in the art.

Referring to FIGS. **7A–B** and **8**, means for pivoting control ring **54** is shown generally at **84**. A rack and pinion assembly **86** driven by a motor (not shown) determines blade **42** pitch by raising or lowering control ring **54** at arms **55**. A shaft **88** is attached to assembly **86** at one end and is pivotably attached to control ring **54** at the other end. This pivotable attachment comprises a pivot pin **90** extending through an opening in shaft **88** and attached at each end to arms **54**. Pin **90** is fixed and does not rotate in relation to shaft **88**. Arms **55** are rotatable relative to control ring **54** by a pivot pin **91**. This pivotable attachment is employed to reduce the amount of stress at this point, that would otherwise exist with a fixed attachment. Accordingly control ring **54** is raised or lowered with shaft **88**. Each control point having arms **55** (FIG. **3**) has corresponding control means **84**. Further, it is preferred that opposing control points be operated in unison to avoid additional stresses on control ring **54**. An extension bracket **92** is required between the trailing edge **66′** of the lower airfoils **42′** and the rollers **68′** in order to ensure a proper angle of attack for airfoils **42′**, as is clearly shown in FIG. **8**.

Referring to FIG. **9**, tubular member **50** which completely encircles outer rings **44** and **44′** for protection and support is shown. Tubular member **50** is rigidly attached to frame **23** at each end. Attached to tubular member **50** are several axles **93**, at appropriate locations along the length of member **50**. Attached to the free end of axles **93** are rollers **94**. Rollers **94** fit inside U-shaped outer rings **44** and **44′**. Rollers **94** allow outer rings **44** and **44′** to rotate freely while prohibiting vertical movement of outer rings **44** and **44′**. Spacer **98** is attached to tubular member **50** along its entire length except at frame **23**. Spacer **98** reduces airflow around the outside of outer rings **44** and **44′** which increases the efficiency of the rotor system. Cover **19** is attached to member **50**. The purpose of cover **19** is to protect member **50**, axles **93**, rollers **94** and outer rings **44** and **44′**. Cover **19** is preferably aerodynamicly shaped to reduce the drag of the aircraft during flight. Cover **19** may be comprised of any light weight resilient material (e.g., formed plastic).

Referring to FIGS. **10** and **11A–B**, in an alternate embodiment of the present invention airfoils **42** may be fixedly attached to drive ring **43** at a predetermined angle of attack or pitch or pivotably attached to drive ring **43** as described hereinbefore. In this embodiment control is provided by feeding gas from a gas generator or air from an air compressor (either of which are located in body **12** of aircraft **10**) to adjustable nozzles **100** via tubular member **50**. Nozzles **100** are preferably attached at the front, back and each side of aircraft **10**. Nozzles **100** extend downwardly through cover **19**. A ball valve **102** is disposed in each nozzle **100**. Valve **102** includes an opening **104** which allows air flow from member **50** through nozzle **100** in the open position and prohibits air flow in the closed position. A shaft **106** is employed to control valve **102** by rotating ball valve **102**, thereby moving opening **104** in and out of alignment with nozzle **100**. Shaft **106** is to be controlled by conventional means. Modulation of the gas (or air) flow to each nozzle is used to control tilt of the aircraft **10**.

While preferred embodiments have been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the invention. Accordingly, it is to be understood that the present invention has been described by way of illustrations and not limitations.

What is claimed is:

1. A vertical lift aircraft comprising:

a body;

lifting means having frame means attached to said body, said lifting means including;

(a) first drive ring means for being rotated in a first direction, said first drive ring means being supported by said frame means;

(b) a first plurality of airfoil means each attached at one end to said first drive ring means for rotation in unison therewith;

(c) first band means disposed within said first drive ring means, a substantial portion of one surface of said first band means being in frictional contact with a substantial portion of one surface of said first drive ring means, said first band means having spring like characteristics for maintaining contact between said first band means and said first drive ring means, wherein said first drive ring means rotates in unison with said first band means; and

(d) first roller drive means communicating with said first band means wherein said first band means rotates in response to rotation of said first roller drive means; and

drive means for rotating said first roller drive means.

2. The aircraft of claim **1** further comprising:

propulsion means being attached to said body for providing horizontal propulsion.

3. The aircraft of claim **1** wherein said lifting means further comprises:

outer ring means attached at one end of each of said first plurality of airfoil means for rotation in unison therewith, said outer ring means supported by said frame means.

4. The aircraft of claim **3** further comprising:

a tubular member attached to said frame means; and

cover means supported by said tubular member.

5. The aircraft of claim **4** further comprising:

tilt control means having a plurality of adjustable nozzles, said nozzles attached to and in communication with said tubular member, one end of at least one of said nozzles extending through said cover means at defined locations, said tilt control means for controlling the tilt of the aircraft, said nozzles being responsive to a compressed gas in said tubular member.

6. The aircraft of claim **5** wherein said plurality of adjustable nozzles comprises four nozzles, two of said nozzles being located at laterally opposing sides of said body, two other of said nozzles being located at opposing front and rear ends of said body.

7. The aircraft of claim **5** wherein each of said nozzles further comprises:

valve means for regulating the flow of said compressed gas.

8. The aircraft of claim **1** wherein said lifting means further comprises:

pivot shaft means extending longitudinally through said first airfoil means, said pivot shaft means fixedly attached to said first drive ring means, said first airfoil means being rotatable relative to said pivot shaft means;

control ring means disposed near said first drive ring, said control ring means being pivotable at defined locations; and

roller means attached to said first airfoil means, said roller means in contact with said control ring means,

wherein said first airfoil means pivots about said pivot shaft means in response to pivoting of said control ring.

9. The aircraft of claim **8** further comprising:

spring means disposed about said pivot shaft means, said spring means restrained at one end to said airfoil means and restrained at the other end at said first drive ring means, said spring means being preloaded to assure contact between said roller means and said control ring.

10. The aircraft of claim **8** wherein said defined locations for pivoting said control means comprises four locations, two of said locations being at laterally opposing sides of said first drive ring means and two other of said four locations being at opposing front and rear ends of said first drive ring means.

11. The aircraft of claim **8** further comprising:

a tubular member attached to said frame means;

cover means supported by said tubular member; and

tilt control means having a plurality of adjustable nozzles, said nozzles attached to and in communication with said tubular member, one end of at least one of said nozzles extending through said cover means at defined locations, said tilt control means for controlling the tilt of the aircraft, said nozzles being responsive to a compressed gas in said tubular member.

12. The aircraft of claim **1** wherein said lifting means further comprises:

second drive ring means for being rotated in a second direction, said second drive ring means being supported by said frame means;

a second plurality of airfoil means each attached at one end to said second drive ring means for rotation in unison therewith;

second band means disposed within said second drive ring means, a substantial portion of one surface of said second band means being in frictional contact with a substantial portion of one surface of said second drive ring means, said second band means having spring like characteristics for maintaining contact between said second band means and said second drive ring means, wherein said second drive ring means rotates in unison with said second band means; and

second roller drive means communicating with said second band means wherein said second band means rotates in response to rotation of said second roller drive means,

wherein said drive means rotates said second roller drive means.

13. The aircraft of claim **12** wherein said first direction of rotation of said first drive means is opposite said second direction of rotation of said second drive means; and

wherein said first drive means is disposed above said second drive means.

14. The aircraft of claim 12 wherein said lifting means further comprises:

control ring means disposed near said first and second drive ring means, said control ring means being pivotable at defined locations;

first pivot shaft means extending longitudinally through said first airfoil means, said first pivot shaft means fixedly attached to said first drive ring means, said first airfoil means being rotatable relative to said first pivot shaft means;

first roller means attached to each of said first airfoil means, said first roller means in contact with said control ring means;

second pivot shaft means extending longitudinally through said second airfoil means, said second pivot shaft means fixedly attached to said second drive ring means, said second airfoil means being rotatable relative to said second pivot shaft means; and

second roller means attached to said second airfoil means, said second roller means in contact with said control ring means,

wherein said first and second airfoil means pivot about said corresponding first and second pivot shaft means in response to pivoting of said control ring.

15. The aircraft of claim 14 further comprising:

first spring means disposed about said first pivot shaft means, said first spring means restrained at one end to said first airfoil means and restrained at the other end at said first drive ring means, said first spring means being preloaded to assure contact between said first roller means and said control ring; and

second spring means disposed about said second pivot shaft means, said second spring means restrained at one end to said second airfoil means and restrained at the other end at said second drive ring means, said second spring means being preloaded to assure contact between said second roller means and said control ring.

16. The aircraft of claim 14 wherein said defined locations for pivoting said control means comprises four locations, two of said locations being at laterally opposing sides of said first and second drive ring means and two other of said four locations being at opposing front and rear ends of said first and second drive ring means.

17. The aircraft of claim 14 further comprising:

a tubular member attached to said frame means;

cover means supported by said tubular member; and

tilt control means having a plurality of adjustable nozzles, said nozzles attached to and in communication with said tubular member, one end of at least one of said nozzles extending through said cover means at defined locations, said tilt control means for controlling the tilt of the aircraft, said nozzles being responsive to a compressed gas in said tubular member.

18. The aircraft of claim 12 wherein said lifting means further comprises:

first outer ring means attached at one end of each of said first plurality of airfoil means for rotation in unison therewith, said first outer ring means supported by said frame means; and

second outer ring means attached at one end of each of said second plurality of airfoil means for rotation in unison therewith, said second outer ring means supported by said frame means.

19. The aircraft of claim 18 further comprising:

a tubular member attached to said frame means; and

cover means supported by said tubular member.

20. The aircraft of claim 19 further comprising:

tilt control means having a plurality of adjustable nozzles, said nozzles attached to and in communication with said tubular member, one end of at least one of said nozzles extending through said cover means at defined locations, said tilt control means for controlling the tilt of the aircraft, said nozzles being responsive to a compressed gas in said tubular member.

21. The aircraft of claim 20 wherein said plurality of adjustable nozzles comprises four nozzles, two of said nozzles being located at laterally opposing sides of said body, two other of said nozzles being located at front and rear ends of said body.

22. The aircraft of claim 20 wherein each of said nozzles further comprises:

valve means for regulating the flow of said compressed gas.

23. A vertical lift aircraft comprising:

a body; and

lifting means having frame means attached to said body, said lifting means including;

(a) first drive ring means for being rotated in a first direction, said first drive ring means being supported by said frame means;

(b) a first plurality of airfoil means each attached at one end to said first drive ring means for rotation in unison therewith;

(c) first pivot shaft means extending longitudinally through said first airfoil means, said first pivot shaft means fixedly attached to said first drive ring means, said first airfoil means being rotatable relative to said first pivot shaft means;

(d) control ring means disposed near said first drive ring, said control ring means being pivotable at defined locations; and

(e) first roller means attached to said first airfoil means, said first roller means in contact with said control ring means,

wherein said first airfoil means pivots about said first pivot shaft means in response to pivoting of said control ring.

24. The aircraft to claim 23 further comprising:

propulsion means attached to said body for providing horizontal propulsion.

25. The aircraft of claim 23 further comprising:

spring means disposed about said first pivot shaft means, said spring means restrained at one end to said first airfoil means and restrained at the other end at said first drive ring means, said spring means being preloaded to assure contact between said first roller means and said control ring.

26. The aircraft of claim 23 wherein said defined locations for pivoting said control means comprises four locations, two of said locations being at laterally opposing sides of said first drive ring means and two other of said four locations being at opposing front and rear ends of said first drive ring means.

27. The aircraft of claim 23 further comprising:

second drive ring means for being rotated in a second direction;

a second plurality of airfoil means each attached at one end to said second drive ring means for rotation in unison therewith;

second pivot shaft means extending longitudinally through said second airfoil means, said second pivot shaft means fixedly attached to said second drive ring means, said second airfoil means being rotatable relative to said second pivot shaft means; and

second roller means attached to said second airfoil means, said second roller means in contact with said control ring means,

wherein said second airfoil means pivots about said second pivot shaft means in response to pivoting of said control ring.

28. The aircraft of claim 27 further comprising: first spring means disposed about said first pivot shaft means, said first spring means restrained at one end to said first airfoil means and restrained at the other end at said first drive ring means, said first spring means being preloaded to assure contact between said first roller means and said control ring; and

second spring means disposed about said second pivot shaft means, said second spring means restrained at one end to said second airfoil means and restrained at the other end at said second drive ring means, said second spring means being preloaded to assure contact between said second roller means and said control ring.

* * * * *

US005344100A

United States Patent [19]

Jaikaran

[11] **Patent Number: 5,344,100**

[45] **Date of Patent: Sep. 6, 1994**

[54] **VERTICAL LIFT AIRCRAFT**

[76] Inventor: **Allan Jaikaran**, 136 Crest Camp, Fyzabad, Trinidad and Tobago

[21] Appl. No.: **18,101**

[22] Filed: **Feb. 17, 1993**

[51] **Int. Cl.**[5] **B64C 39/06**

[52] **U.S. Cl.** .... **244/12.2**; 244/23 C

[58] **Field of Search** .... 244/12, 23 A, 23 B, 244/23 D, 56; 384/616, 613, 620, 585

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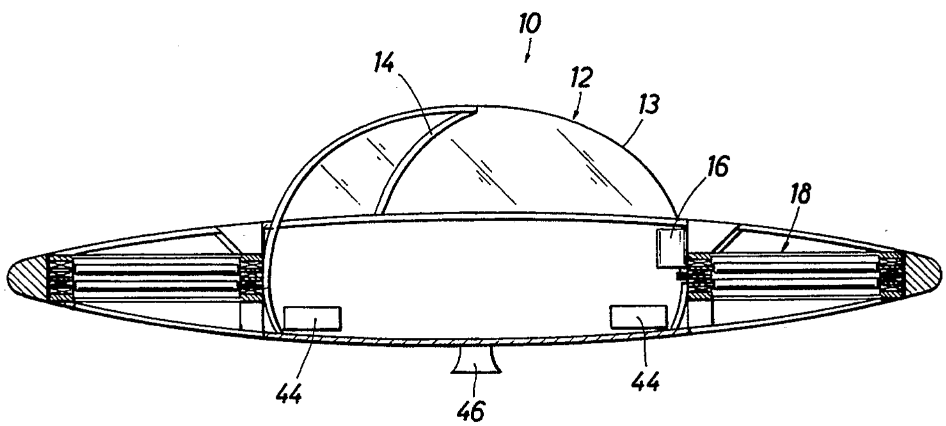
Primary Examiner—Galen L. Barefoot

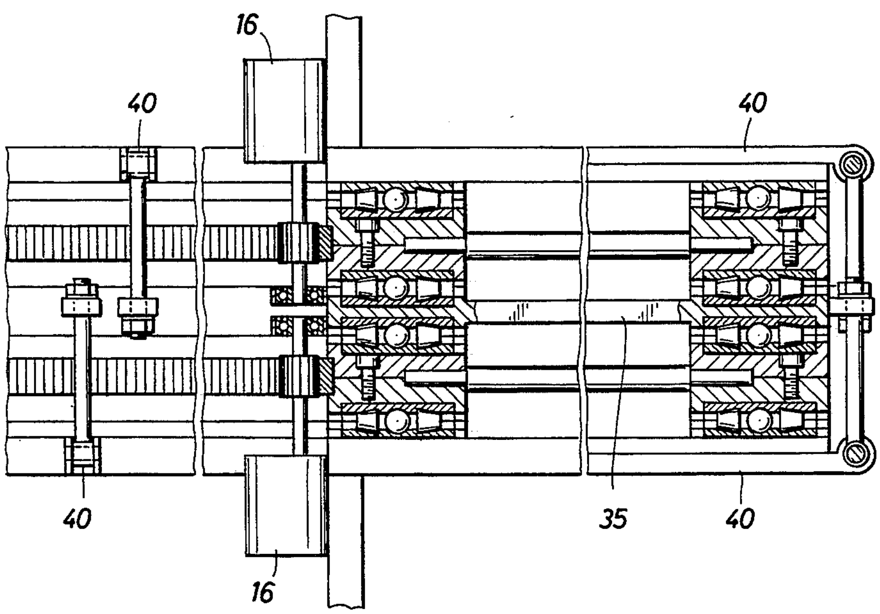
Attorney, Agent, or Firm—Gunn & Kuffner

[57] **ABSTRACT**

A vertical lift aircraft includes a central cabin and a set of concentric, circular, counter-rotating power blade assemblies. Gas turbine engines located in the central cabin provide power for rotating the power blade assemblies to cause lift and motion of the aircraft. The turbine engine exhaust gases are directed through a rotatable exhaust nozzle for aiding in the thrust and momentum of the aircraft. The gas turbine engines drive electric power generators which provide the necessary power for operation of the aircraft.

6 Claims, 5 Drawing Sheets





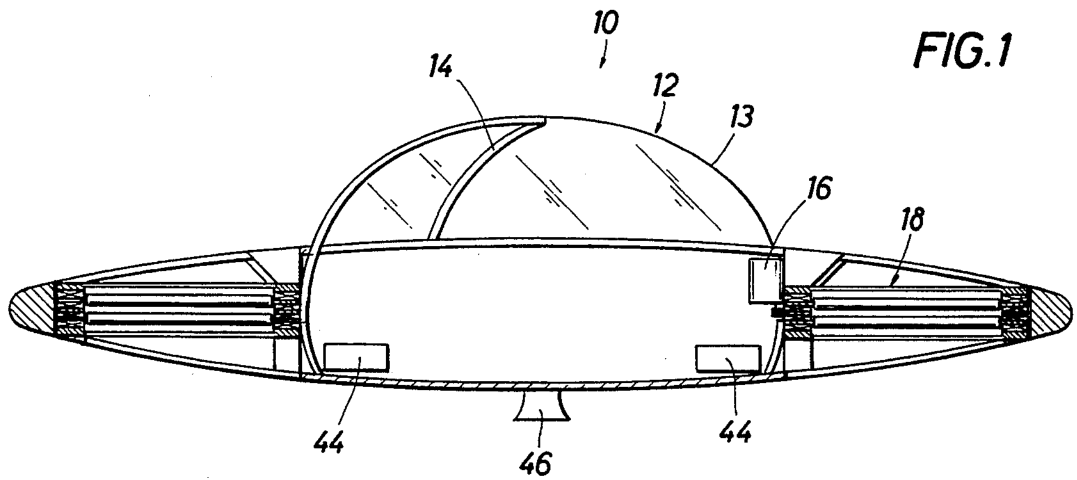


FIG. 1

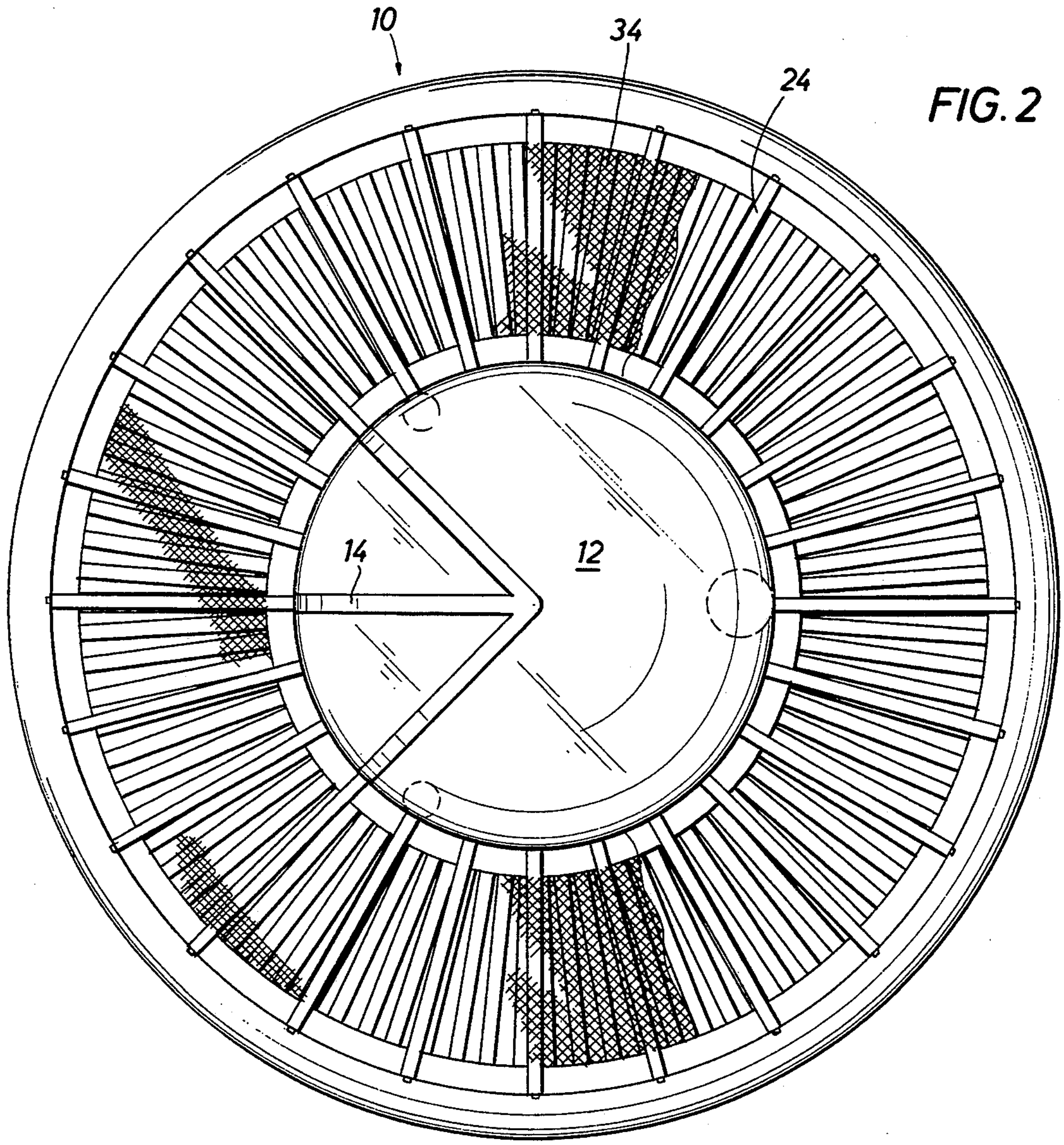


FIG. 2

FIG. 3

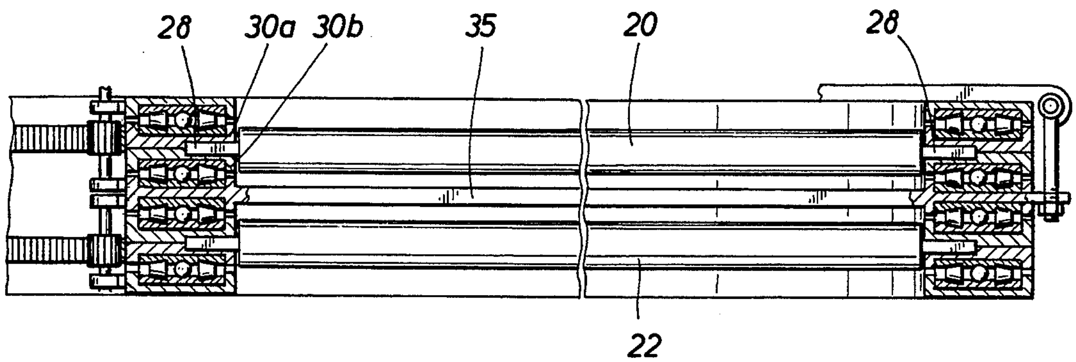
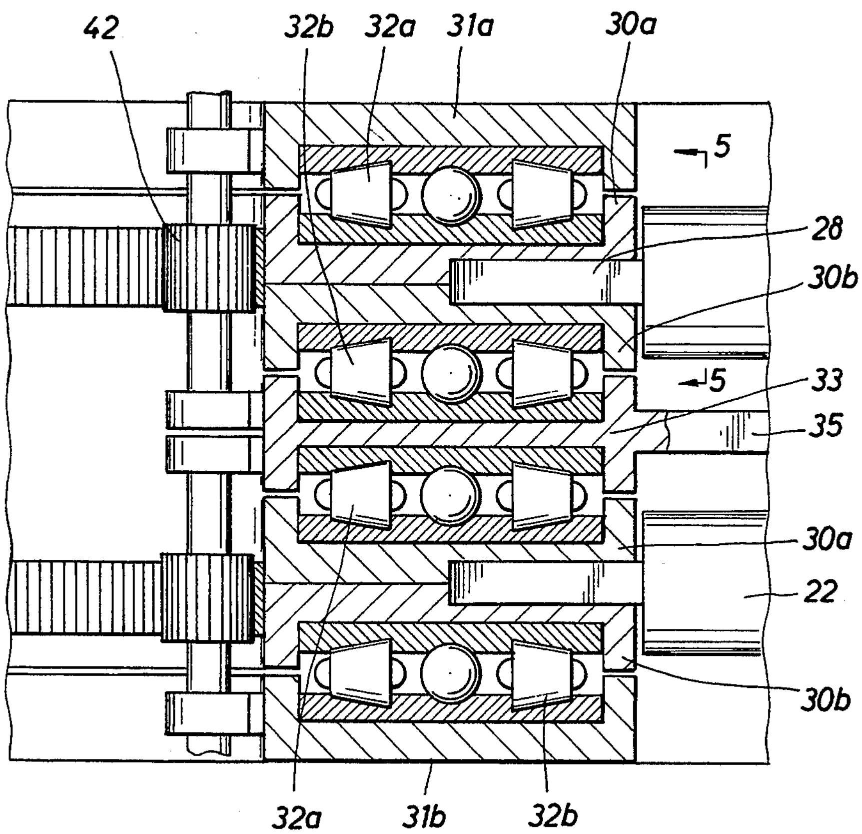

28
30a
30b
35
20
28
22

FIG. 4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32b
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32a
31b
32b

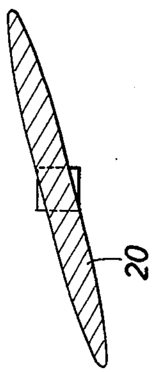


FIG.5

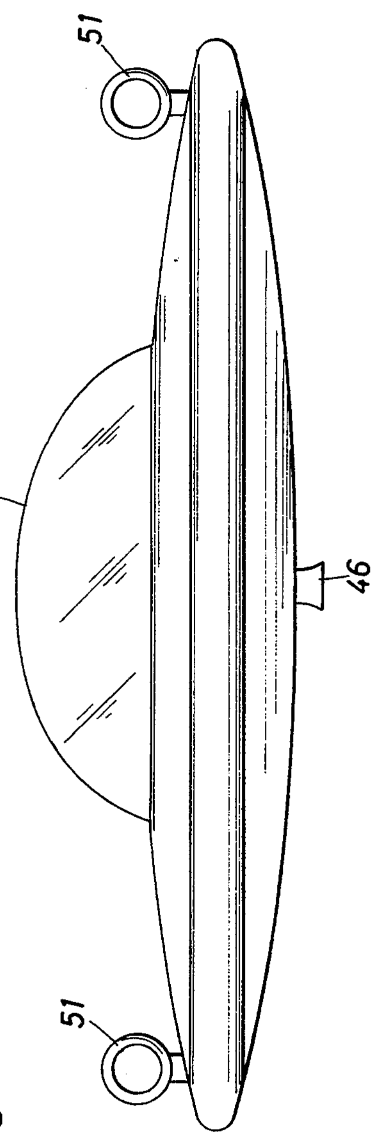


FIG.6

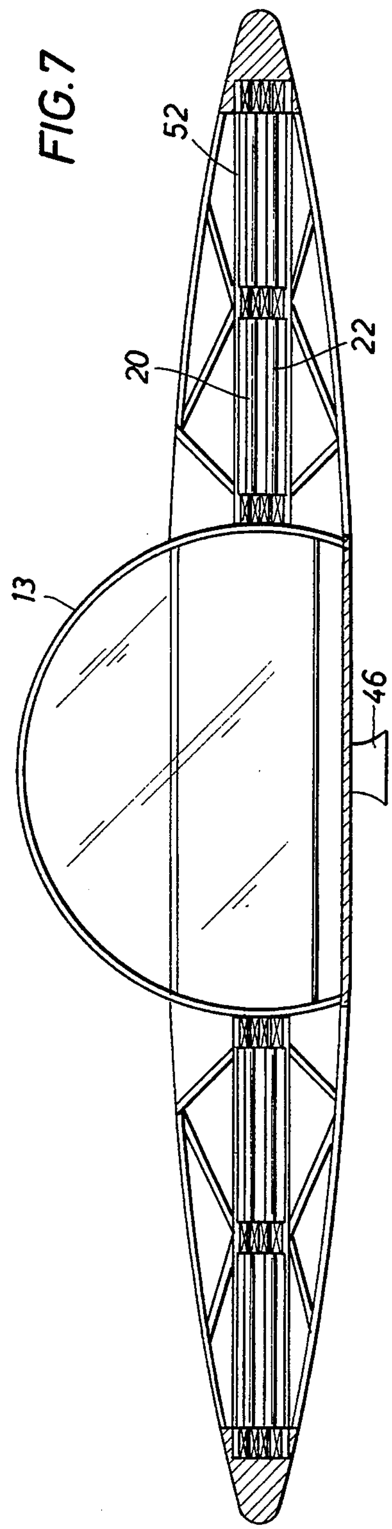


FIG.7

FIG. 8

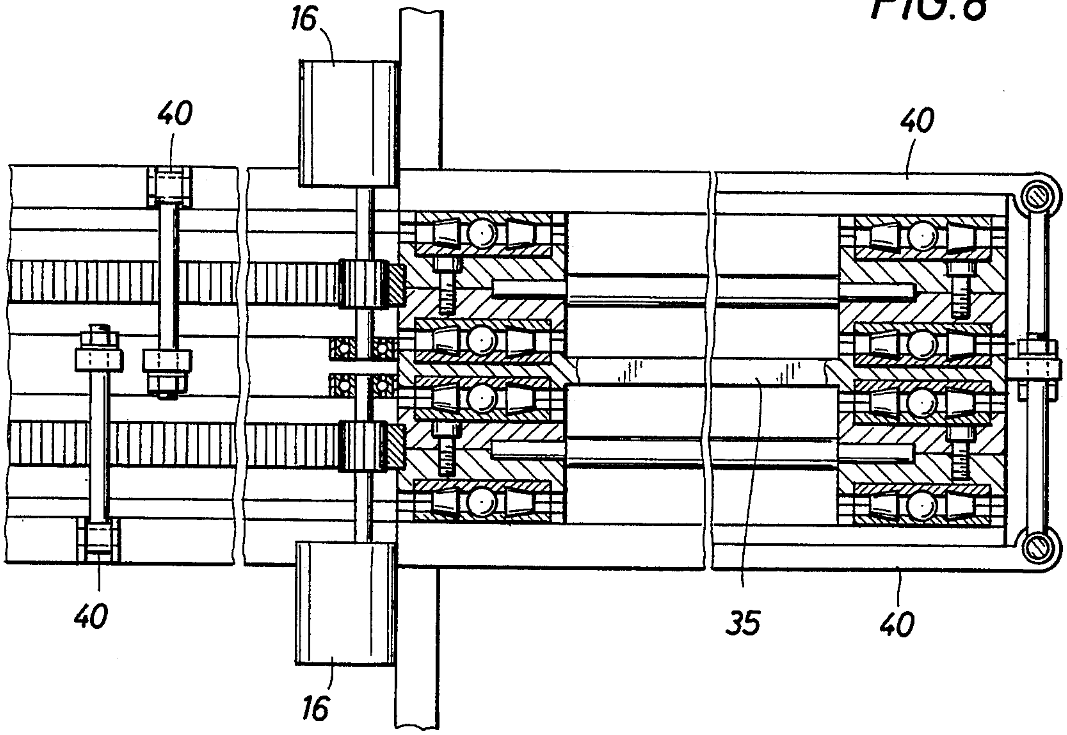


FIG. 9

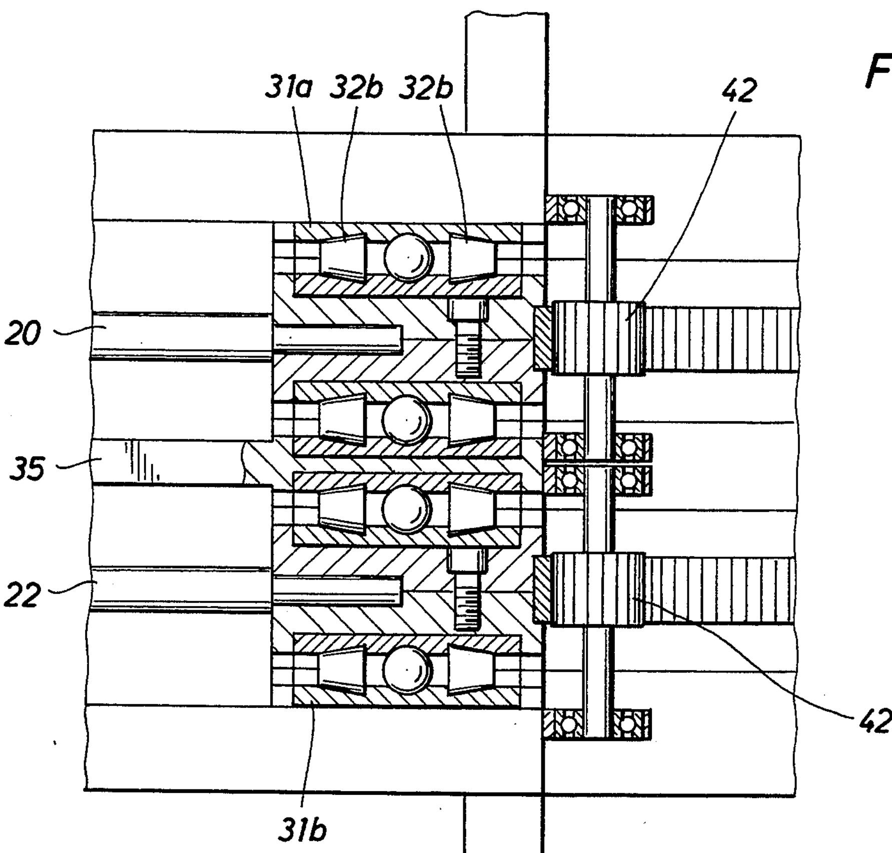


FIG. 10

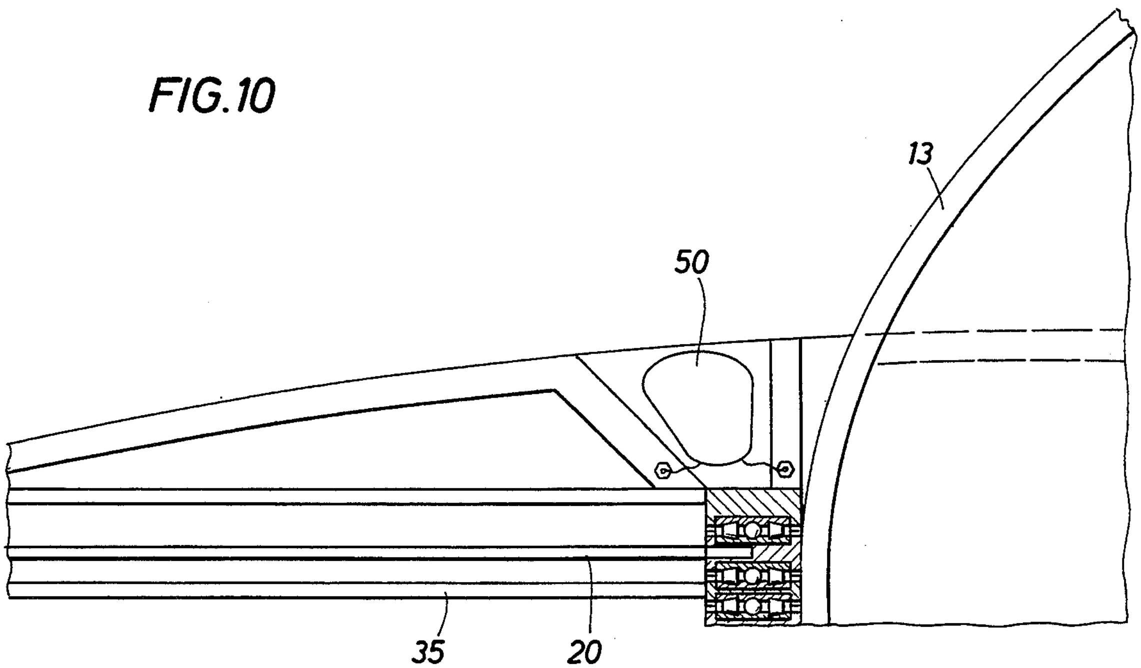
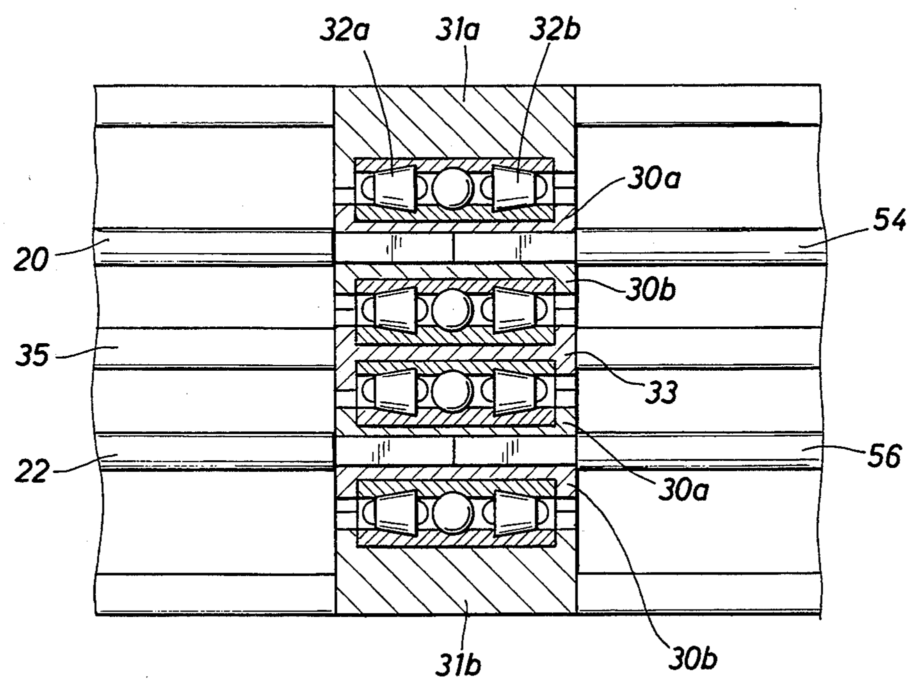


FIG. 11



VERTICAL LIFT AIRCRAFT

BACKGROUND OF THE DISCLOSURE

This application is directed to vertical take-off and landing aircraft designed to replace motor vehicles as the basic method of passenger transportation. More particularly, this application relates to a vertical take-off and landing aircraft having a circular body and a shape which, in cross section, is substantially equivalent to one or more air foils.

Because of their design, helicopters are inherently limited in the number of blades which the rotating mechanism can carry. As the rotation of each blade increases from rest, a pressure differential is created between upper and lower surfaces of the blade whereby lift is achieved. These generally horizontal rotating blades are referred to as the power blades. The most efficient area of power blades during lift is that area adjacent to the outer periphery or tip of the blades. The amount of lift generated by the rotating blade is essentially proportional to the area of the blade per unit length of the distance the blade travels. This proportionality changes from the tip of the blade to the axis of rotation, at which point the lift per unit area is almost nil. The lift created by a rotating helicopter blade is proportional to the inclination of the blade or angle of attack of the blade in relation to the air. The relationship of lift per unit length is proportional to the distance from the axis of rotation at whatever angle of attack the blades are set.

The force of the rotating blades needed to lift the helicopter also produces an undesirable gyroscopic effect. Without some means of correction, the gyroscopic effect of the blades would spin the body of the helicopter out of control. In helicopters, the gyroscopic effect caused by rotation of the power blades is typically canceled (i.e., balanced) by the use of a tail rotor.

SUMMARY OF THE INVENTION

In the present invention, unlike in a helicopter, the power blades are of a uniform cross section, generally in the shape of an air foil. In this way, the aircraft of the present invention utilizes the maximum benefit of lift from the outer extremity of each blade, where the lift per unit length of blade is greatest.

In the aircraft of the present invention, there is a plurality of power blades, affixed in such a way that each has a fixed angle of attack with the air. These blades are each rigidly affixed between two circular blade holders which rotate on circumferential bearings at the top and at the bottom. Because the blades are supported at both ends they experience much lower stress loads than that of a typical helicopter blade.

The aircraft of the present invention, will include a central cabin and a set of concentric, circular, counter-rotating power blade assemblies. It will also include twin gas turbine engines located in the central cabin, each adequate to provide power to cause rotation of the power blade assemblies and consequently to cause lift and motion. The high volume and high pressure exhaust gases generated by the gas turbine engine are directed through a mechanism capable of rotating through 180 degrees. This mechanism permits the aircraft to travel forward, in a reverse direction or to hover. The exhaust gases, via a turbo-expander, aid the aircraft to move in all directions and to hover. The turbo-expander is used to convert high velocity energy of the exhaust gases to low velocity, high pressure exhaust gases. This aids in thrust and momentum of the aircraft. The gas turbine engines drive electric power generators which provide all the necessary power for the utilities required and which also drive two independently operated electric motors. The electric motors drive the two power blade assemblies. The operation of the two electric motors are computer controlled to adjust to and to provide positive and negative gyroscopic effects that may be required to maintain aircraft stability from external weather conditions or from internal transference of weights or movement of people. The electric power provided is used to drive the on board computer, to provide air conditioning and to provide lights in accordance with the aircraft's requirement, including search lights for nighttime use of the aircraft. The aircraft will also be fitted with radar for safety and a global positioning system (GPS) for determining aircraft position anywhere on the world by using satellite positioning.

The power blade assemblies of the invention each consist of a plurality of rotor blades disposed circumferentially and extending generally radially outward from the center of the disc-shaped body. The rotor blades are of a uniform cross section, substantially that of an air foil in order to reduce drag. Furthermore, the blades are oriented at an angle which is fixed in relation to the flow of air through the assemblies and to the direction of rotation of each assembly such that the air flows in a single direction, thereby maximizing vertical lift. Since the blades are supported at both ends and have the same fixed angle of attack to the air, stresses caused by deflection and other such stresses, will be much lower than on a typical helicopter blade. As a consequence, aircraft control will be easier to achieve.

The power blade assemblies are secured between two circular rotating bands, a first band which is generally disposed around the periphery of the disc-shaped body, and a second band, which is generally disposed inward of the periphery and surrounding the aircraft cabin. The blades in each power blade assembly are substantially of the same physical size, shape and weight, and there are the same number of blades in each assembly. The assemblies are oriented one above the other and caused to rotate counter to each other. Because the two assemblies will have equal mass, circumference and drag, the counter rotation of the second assembly creates a gyroscopic effect which cancels the gyroscopic effect of the first assembly.

It may be desirable to protect the blade assemblies from external objects by means of a mesh screen, or the like, which is installed over the area of the blades.

It is important that all static and dynamic forces, which tend to cause the rotating blade assemblies to be out of balance, be removed before installation. It is also important that the bearing pressures on the two sets of power blade assemblies be the same. To accomplish this, it is preferred to have adjustable clamps installed on structural flaming surrounding each set of blade assemblies in association with means to control such adjustment.

DESCRIPTION OF THE DRAWINGS

So that the manner in which the above recited features, advantages and objects of the present invention are attained and can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to the embodiments thereof which are illustrated in the appended drawings.

It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

FIG. 1 shows a side view of an aircraft embodying the invention of this application, with the power blade assembly and its support shown in vertical cross section;

FIG. 2 illustrates a plan view of the aircraft of the invention with portions of the protective mesh removed and structural frame numbers shown;

FIG. 3 is an illustration in greater detail of the cross section shown in FIG. 1, with attention directed to the roller bearings and support structure of the rotating bands which support the power blade assemblies, including the outer clamp and bearing pressure adjuster;

FIG. 4 is an additional view of the support structure illustrated in FIG. 3, with additional detail directed to the drive mechanism;

FIG. 5 is an illustration of a cross section of a single rotor blade;

FIG. 6 is an illustration of an additional embodiment of the invention, wherein the aircraft is fitted with small gas turbines to provide additional forward thrust;

FIG. 7 illustrates an embodiment of an aircraft of the invention showing an additional set of power assemblies located concentrically to the first set in order to provide additional lifting power;

FIG. 8 is a partially broken away view of the invention with attention directed to details of the drive mechanism of the invention;

FIG. 9 is a partially broken away view of the invention with attention directed to details of the idle gears on the drive mechanism of the invention;

FIG. 10 is a partially broken away view of the aircraft of the invention illustrating an embodiment of the invention including a parachute release assembly; and

FIG. 11 is a partially broken away view of the invention with attention directed to details of the roller bearing and support structure between the inner and outer power blade assemblies.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With particular reference to the embodiments illustrated in the attached drawings, the details of the invention will be more readily discernible. It will be observed that the embodiments of the invention set forth are intended to contain all necessary elements for the device to climb, hover and fly.

With reference first to FIGS. **1** and **2**, it will be seen first that the profile of the vehicle of the invention, generally identified by the reference numeral **10**, has an aerodynamic shape and thus, in and of itself, is intended to be capable of generating lift. The vehicle **10** will be seen to be generally in the shape of a disc. The cross section, shown partially in FIG. **1**, is generally in the shape of an aero-foil. The aircraft control mechanisms, power supply and passenger unit will be primarily located in cabin generally identified by the reference number **12**, the upper half of which is shown in the drawing as a dome shaped portion **13**, which is supported by structural frame members **14**. The cabin **12** of the aircraft **10** may also contain two or more electric motors **16** for providing an electric power source used to drive the power blades of the counter-rotating turbine assemblies.

Directly surrounding the central cabin **12** and generally disposed around the periphery thereof are two sets of counter-rotating turbine blade assemblies **18** positioned one above the other. The turbine blade assemblies **18** comprise two sets of power blades **20** and **22** assembled so as to rotate in opposite directions. In the drawings, twenty sets of structural frame members **24** are shown above the top set of power blades **20** and twenty sets of structural frame members **24** below the lower set of power blades **22**. It will be appreciated that the number and size of the structural frame members **24** will depend upon the diameter of the aircraft **10** requiring support and the deflection, if any, on the circumferential bearings which will be described.

In the power blade assemblies **18**, as best shown in FIG. **3**, there is a plurality of blades **20** and **22** mounted on a shaft **28** which, in turn, is supported between two sets of movable rotatable bands **30*a*** and **30*b***.

The detail of the power blade assemblies is more particularly shown in FIGS. **3** and **4** of the drawings. As shown therein, the power blades **20** and **22** are rigidly affixed between the two circular bands **30*a*** and **30*b*** which rotate on circumferential bearings **32*a*** and **32*b*** above and below the rotatable bands. The circumferential bearings allow the bands **30*a*** and **30*b*** with the power blades **20** and **22** affixed thereon to rotate on the periphery or circumference of the aircraft **10**. In all instances it is recommended that the angle of attack at which the blades **20** and **22** are fixed remains the same so that the air generated by the rotating turbine blades **20** and **22** is in a single direction.

In each of FIG. **3** and FIG. **4**, it will be seen that the second set of blade assemblies **18** is of the same physical size, weight and shape, with the same number of power blades **22**, and placed below the first set of power blades **20**. The blades are oriented in each set of power blades **20** and **22** in such a way that the angle of attack is the same. This requires that the blades **20** and **22** to be placed in opposite directions with respect to the positive x-axis. This is so that the rotation of the circular bands **30*a*** and **30*b*** is opposite and the gyroscopic effect of each set of power blades **20** and **22** is canceled out.

In reference to FIG. **2**, there is shown portions of a wire mesh covering **34** that is placed over the top of the rotating blade assemblies in order to protect the blades **20** and **22** from external objects.

In order to assure that the compressive pressures on the two sets of bearings **32*a*** and **32*b*** are essentially the same, adjustable clamps **40** are installed on each set of structural framing about the blade assemblies **18**. Disposed in positions balanced in relationship to the motors **16**, and around the periphery of the blade assemblies **18**, there are located idle gears **42** which are needed to keep the blade assemblies in place during rotation.

It is important that all static and dynamic forces be balanced and/or offset in the operation of the counter-rotating sets of blade assemblies. It is particularly important that the compressive pressures on the roller bearings **32*a*** and **32*b*** on which the blade supporting bands **30*a*** and **30*b*** rotate be controllably adjustable. A detail of a preferred adjustable clamp **40** is presented in the drawings, FIGS. **3** and **8**.

The structural framing includes a circular rib, similar to a flat ring **31*a*** and **31*b***. Both the number of structural frames and the circular ribs **31*a*** and **31*b*** used are such that the outer set of bearings **32*a*** and **32*b*** (the circumferential or peripheral set of bearings) have a constant bearing pressure. The structural framing is fabricated out of high strength low weight materials to provide adequate strength for support and containment of the bearings as well as to reduce the weight of the present invention. A central stationary, circular band **33** provides support for and a bearing surface for the innermost set of bearings **32***a* and **32***b*. Additional stability is provided by a set of centre tie members **35** extending between the inner and circumferential bearing assemblies **18**. The centre tie member **35** are welded integrally formed with, or otherwise fixed to the stationary circular band **33**.

Lift off of the aircraft **10** of the present invention is achieved by rotating the two sets of turbine blades **20** and **22**. The blades are powered by individually controlled electrical motors **16** affixed to each set of power blade assemblies **18**. The motors **16** are adequately sized and powered to accomplish the necessary lift. Power to the motors **16** is provided from two generators affixed to two gas turbine engines **44**, each of which is adequate to power the aircraft. The generators are adequately sized and powered to supply power to the individual motors **16** and additional power for the auxiliary devices such as lighting (both interior and external for night travel), air conditioning, cabin pressurization and computer and control facilities. It is preferred to provide an individual power drive for each blade assembly **18**, as best shown in FIG. **8**, so as to use normal gyroscopic effect for turning the aircraft through the adjustment of the speed of one set of power blades in relation to the other set of power blades while in flight.

Idle gears **42** or others means are necessary to hold each assembly in place as it rotates. At least three points of contact, spaced evenly, are preferred to prevent the blade assemblies **18** from shifting from side to side. All blade assemblies **18**, whether side by side or one above the other, must be held stationary in this fashion.

The aircraft presented in this application utilizes exhaust gases from the power sources to provide proper flight attitude by lifting the rear of the aircraft **10** in relation to the front, so that the power blades are able not only to provide lift, but also to provide forward speed. It is contemplated that the fuel supply, engine and power transfer mechanism, control mechanisms, seating and storage facilities are all suitably located in the cabin. The high volume and high pressure exhaust gases of the gas turbine is directed through an exhaust nozzle **46** capable of rotating through 180 degrees and via a turbo-expander to cause a change in aircraft attitude for providing forward motion, the ability to hover by rotating the exhaust nozzle **46** by 90 degrees or to go in a reverse direction by first going through the hovering sequence and then rotating the exhaust nozzle **46** through a total of 180 degrees from the horizontal, i.e., from forward motion, to stop and to reverse motion. The turbo-expander (not shown in the drawings) is used to convert high velocity energy of the exhaust gases to low velocity, high pressure exhaust gases. This aids in thrust and momentum of the aircraft **10**.

Additional safety features, including a releasable parachute assembly **50**, may be provided preferably above the support framing for the internal rotating bands **30***a* and **30***b*, as illustrated in FIG. **10**. By the very nature of the design of the bottom of the aircraft **10**, if the engine fails, the aircraft would slow down and start to fall, but would not fall precipitously. When parachutes are added, the slow downward drift of the aircraft **10** would be facilitated even more. At least four parachutes assemblies **50** substantially equally positioned about the periphery of the cabin **12** are preferred to provide a stabilized downward drift of the aircraft **10**.

The present design of the aircraft **10** also provides added protection in the form of flotation cells, placed around the base of the aircraft, preferably underneath the internal rotating bands **30***a* and **30***b*. These cells would prevent the aircraft **10** from sinking should it stall and fall into water.

For additional speed, the aircraft **10** may be fitted with small gas turbines **51** on small air foils located on the periphery of the aircraft **10** to provide additional forward thrust, should this be required. The small gas turbines **51** mounted on small air foils must be mounted so as to allow the gas turbines to be rotated through a few degrees to the vertical to ensure that the forward thrust is maintained through the changes in attitude of the aircraft **10** while in flight. The air foils provide additional stability to the aircraft **10**. The stability of the aircraft **10** may be increased even further by using small rudders and/or flaps on the air foils.

In the instance where additional lifting power is required, a second set of counter-rotating blade assemblies **52** may be fitted on both the upper and lower set of blade assemblies **18**, as shown in FIG. 7. The outer set of power blades **54** and **56** are powered by the inner set of power blades **20** and **22** via the central circular blade bands **30***a* and **30***b*. The inner and outer set of power blades are connected end to end, as best shown in FIG. **11**.

The instant invention has been shown and described herein in what is considered to be the most practical and preferred embodiment. It is recognized, however, that departures may be made therefrom within the scope of the invention contemplated. Those skilled in this art will recognize that obvious modifications may be made to the specific embodiment described without departing from the spirit and scope of this disclosure.

WHAT IS CLAIMED:

1. An aircraft capable of vertical take-off and landing comprising:

(a) a substantially disc-shaped body having a cross-section generally in the shape of an airfoil;

(b) a central cabin located in the center of the body;

(c) a pair of concentric, circular power blade assemblies disposed within said body, wherein the power blade assemblies are positioned one above the other, and wherein each power blade assembly comprises;

(i) a first circular band generally disposed around the periphery of the disc-shaped body and a second circular band generally disposed inward of the periphery and surrounding the central cabin;

(ii) a plurality of rotor blades extending generally radially outward from the center of the disc-shaped body and fixedly secured between the first and second bands, wherein the rotor blades are oriented at a fixed angle in relation to the flow of air through the power blade assembly and to the direction of rotation of the power blade assembly such that the air flows in a single direction;

(iii) a plurality of roller bearings securely positioned above and below each circular band; and

(iv) controllable means to adjust the bearing pressure compressing each set of bearings; and

(d) means located in said cabin to cause the pair of power blade assemblies to rotate in opposite directions.

2. The airshaft of claim **1** wherein the means for rotating said bands comprises individually controlled electric motors operatively connected to said power blade assemblies.

3. The aircraft of claim **1** wherein said controllable means for adjusting the bearing pressure for each set of bearings comprises a circumferentially mounted adjustable clamp.

4. The aircraft of claim **1** including gas exhaust means for changing the flight attitude of the aircraft by expelling the exhaust gases through a rotatable exhaust nozzle, wherein said exhaust nozzle is rotatable through 180 degrees enabling the aircraft to move forward, stop, and to reverse direction.

5. The aircraft of claim **1** including at least one releasable parachute assembly mounted on said disc-shaped body of the aircraft.

6. The aircraft of claim **1** including gas turbine means located on the periphery of said disc-shaped body for providing additional forward thrust and stability to the aircraft.

* * * * *

US005351911A

United States Patent [19]

Neumayr

[11] **Patent Number: 5,351,911**

[45] **Date of Patent: Oct. 4, 1994**

[54] **VERTICAL TAKEOFF AND LANDING (VTOL) FLYING DISC**

[76] Inventor: **George A. Neumayr**, 2536 10th Ave. North, Apt. 302S, Lake Worth, Fla. 33461-3124

[21] Appl. No.: **1,319**

[22] Filed: **Jan. 6, 1993**

[51] **Int. Cl.**[5] **B64C 29/00**; B64B 1/20

[52] **U.S. Cl.** .... **244/23 C**; 244/12.2; 244/5; 244/23 D

[58] **Field of Search** .... 244/5, 12.2, 12.4, 23 C, 244/23 D, 25, 67

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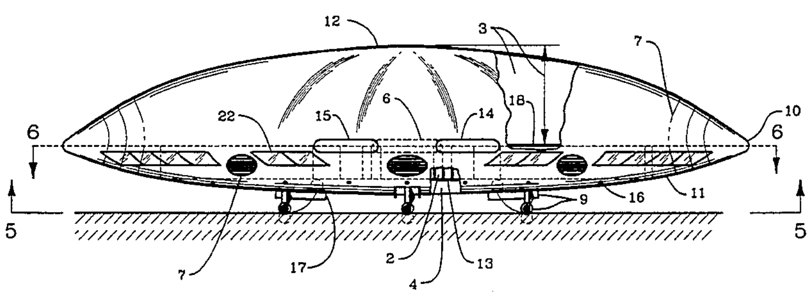
Primary Examiner—Michael S. Huppert
Assistant Examiner—Virna Lissi Ansley
Attorney, Agent, or Firm—Malin, Haley, DiMaggio & Crosby

[57] **ABSTRACT**

A flying disc capable of vertical takeoff, hovering, or powered horizontal flight. The aircraft configuration comprises a circular disc-like airfoil-shaped wing structure having a convex upper surface and a concave lower surface with a leading edge and a trailing edge. At least one thrust-producing unit is attached at each of the leading and trailing edges, respectively. A plurality of other thrust-producing units are mounted symmetrically about the circular wing structure. Each thrust-producing unit has attached thereto a thrust deflector assembly for angularly adjusting the thrust produced by the thrust-producing unit, thereby allowing the aircraft to fly both vertically and horizontally. A substantial volume of helium gas is stored encompassing the inner upper hull of the aircraft, thereby giving the flying disc greater lift capacity. The outer skin of the upper surface consists essentially of a plurality of solar panels for delivering power to a multiplicity of devices.

12 Claims, 17 Drawing Sheets



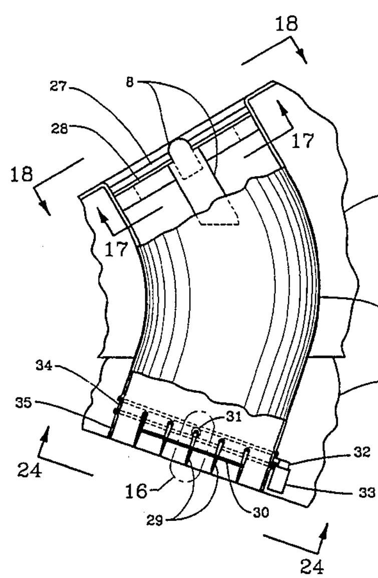


FIG. 1

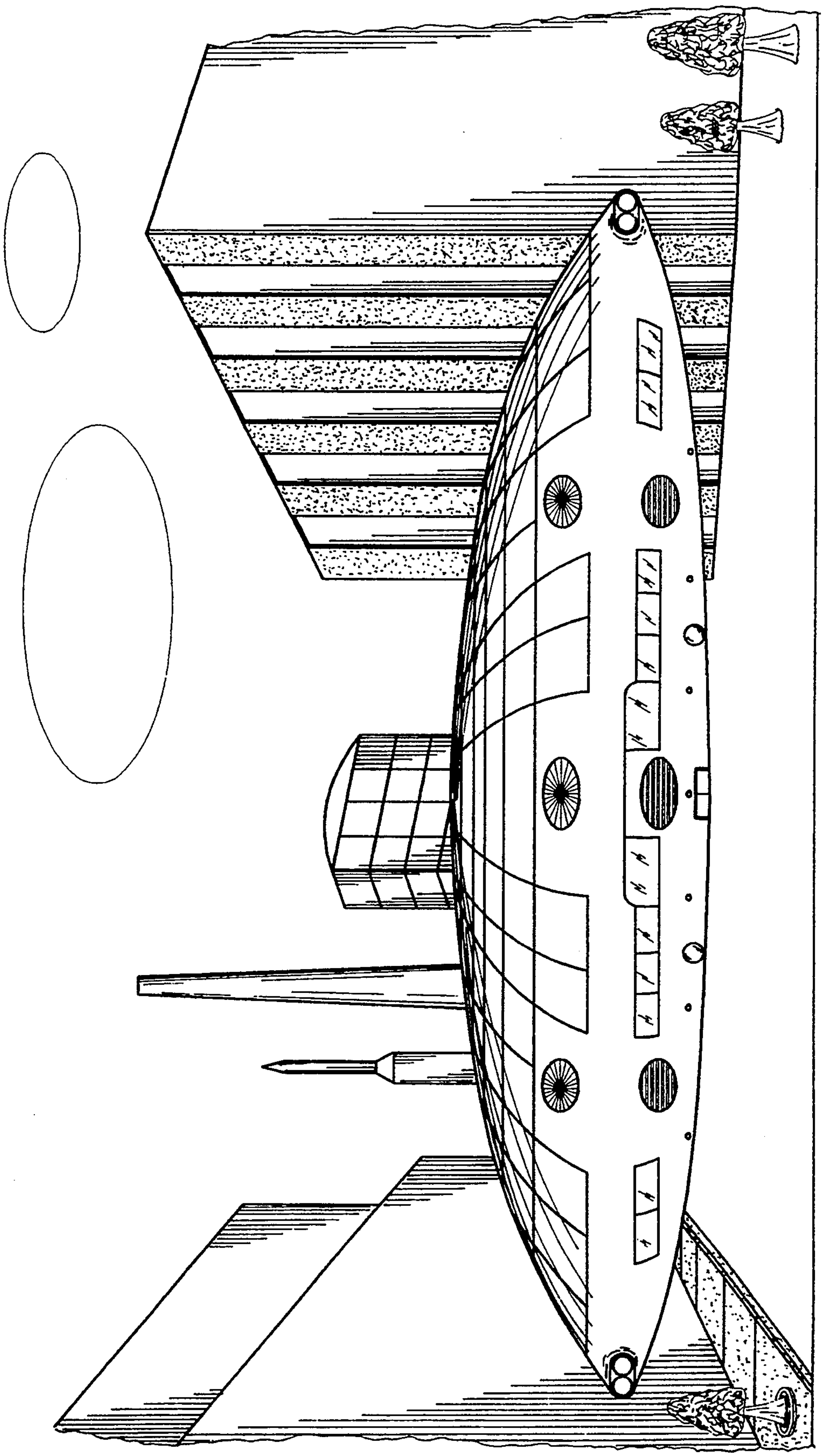
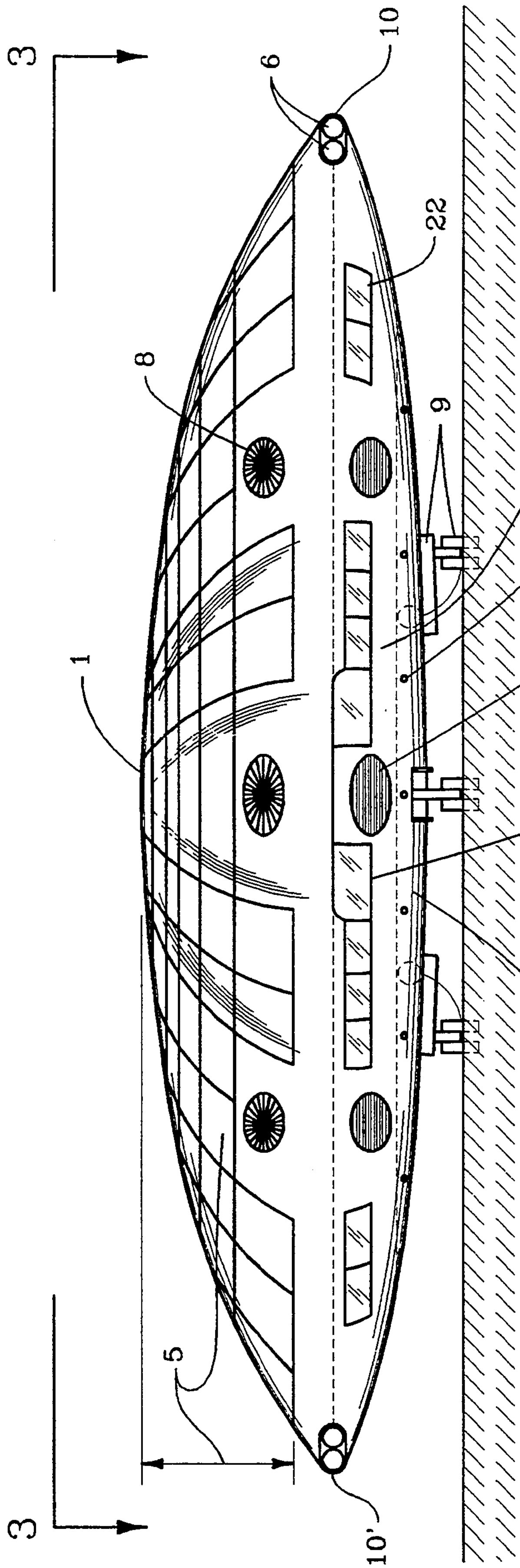


FIG. 2



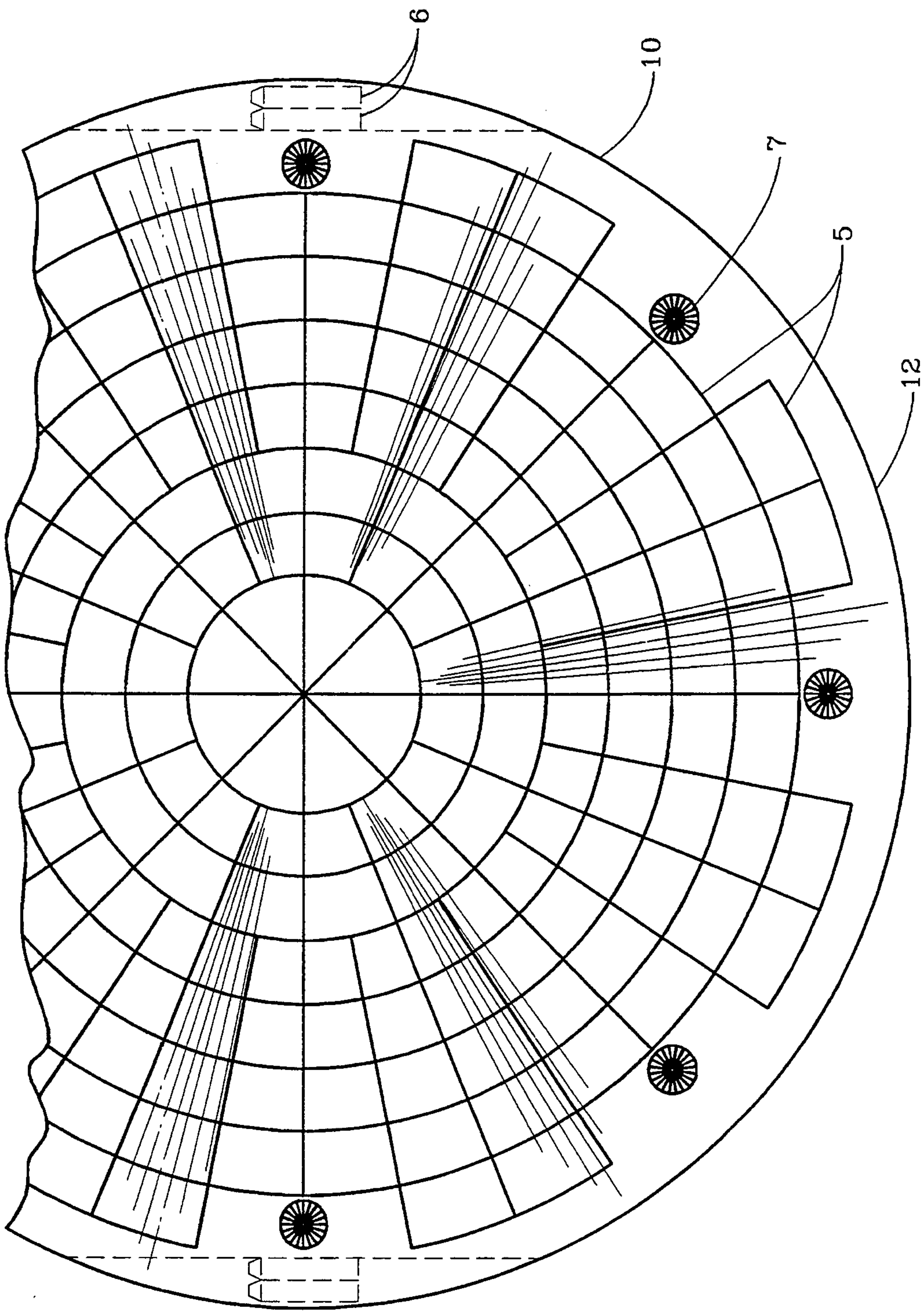
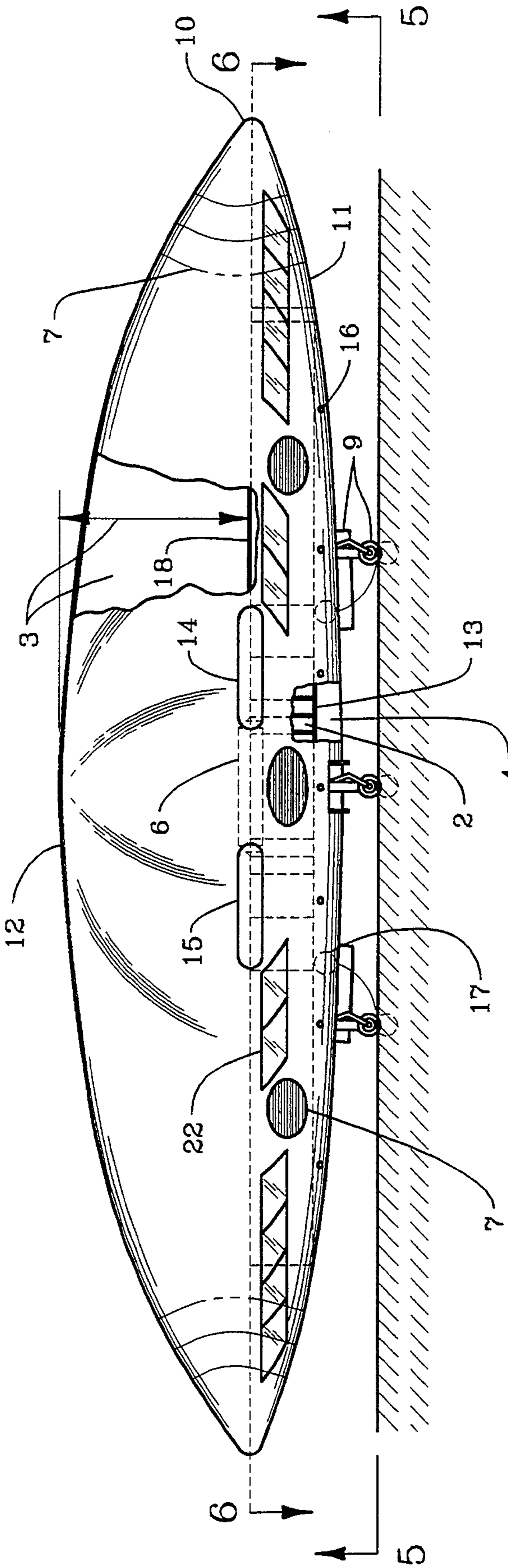


FIG. 3

FIG. 4



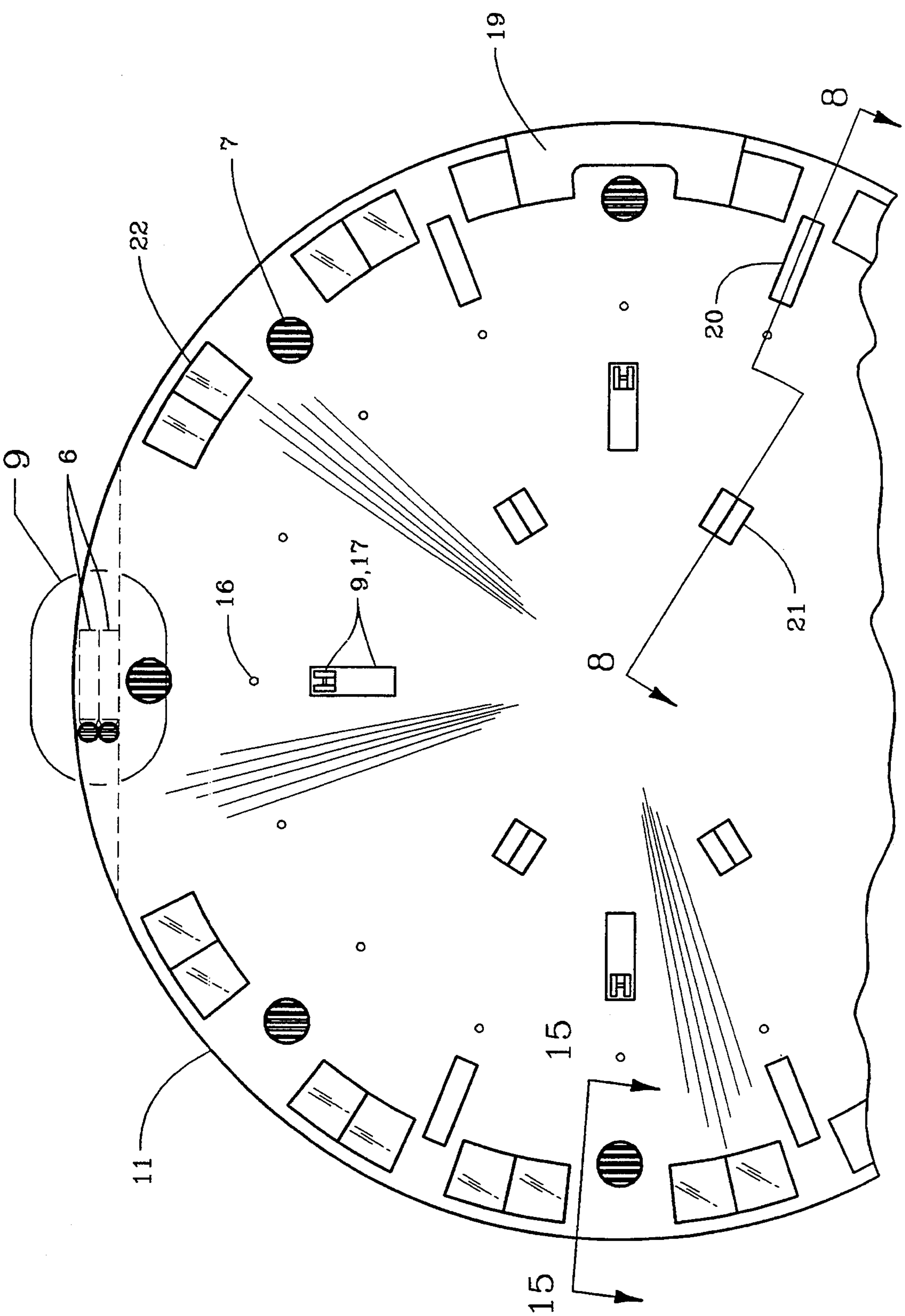


FIG. 5

FIG. 6

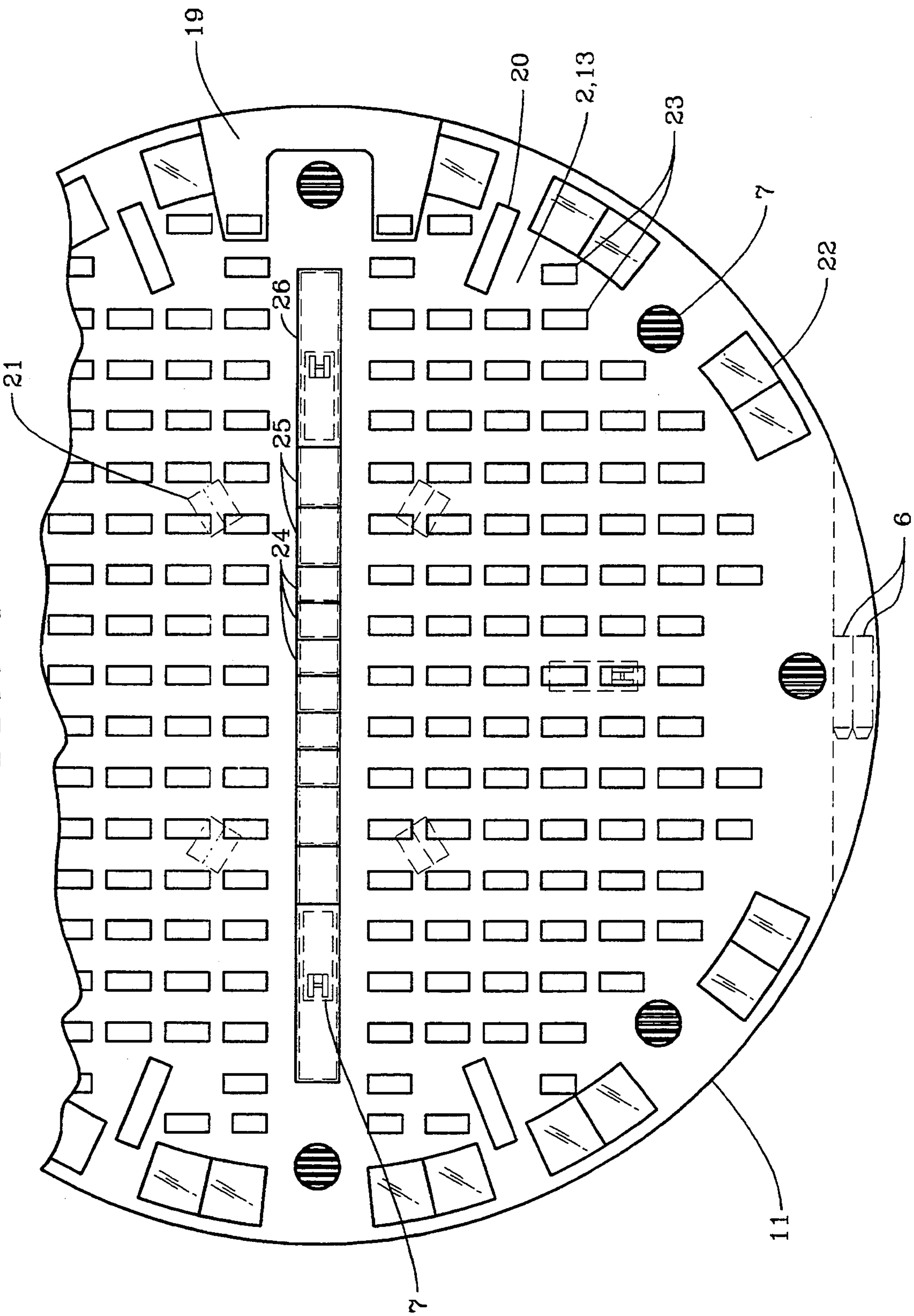


FIG. 8

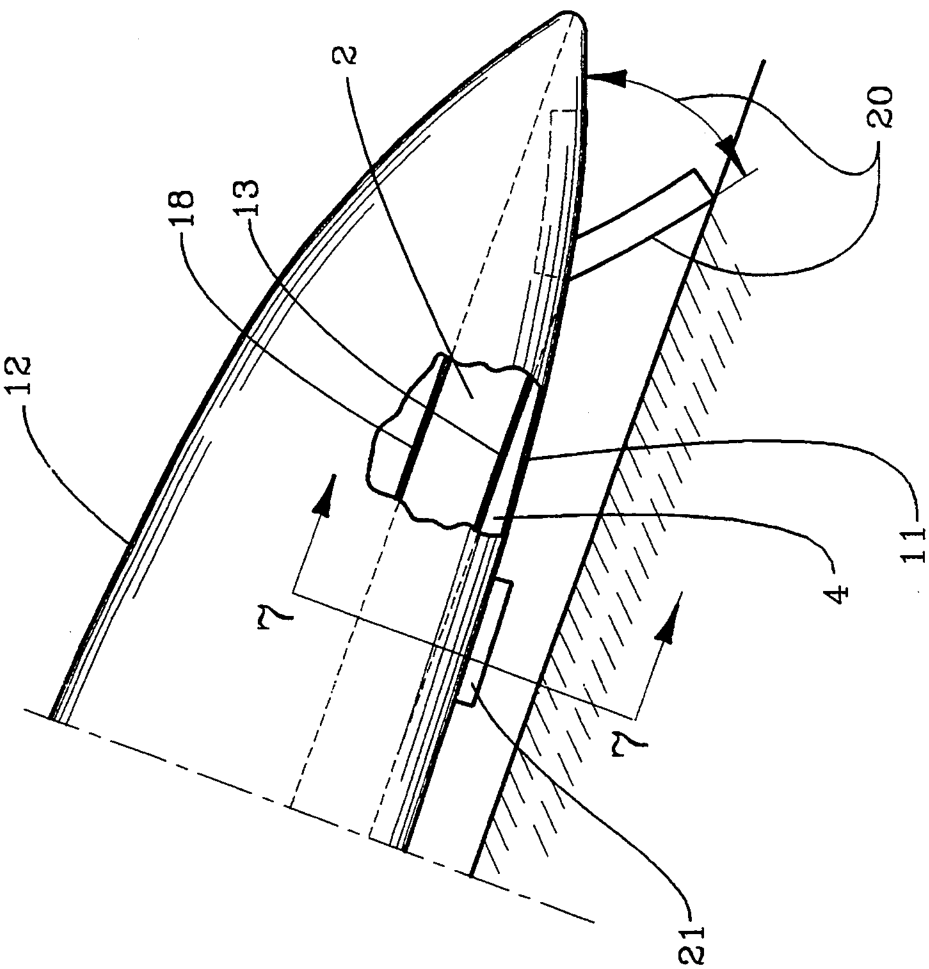
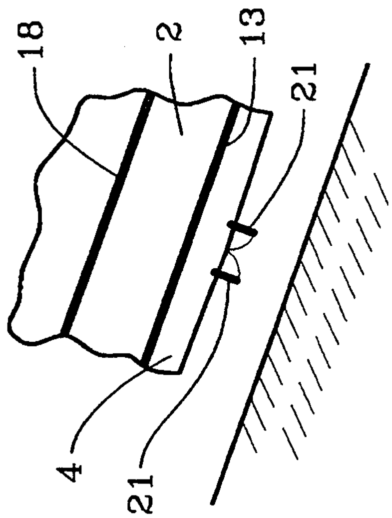


FIG. 7



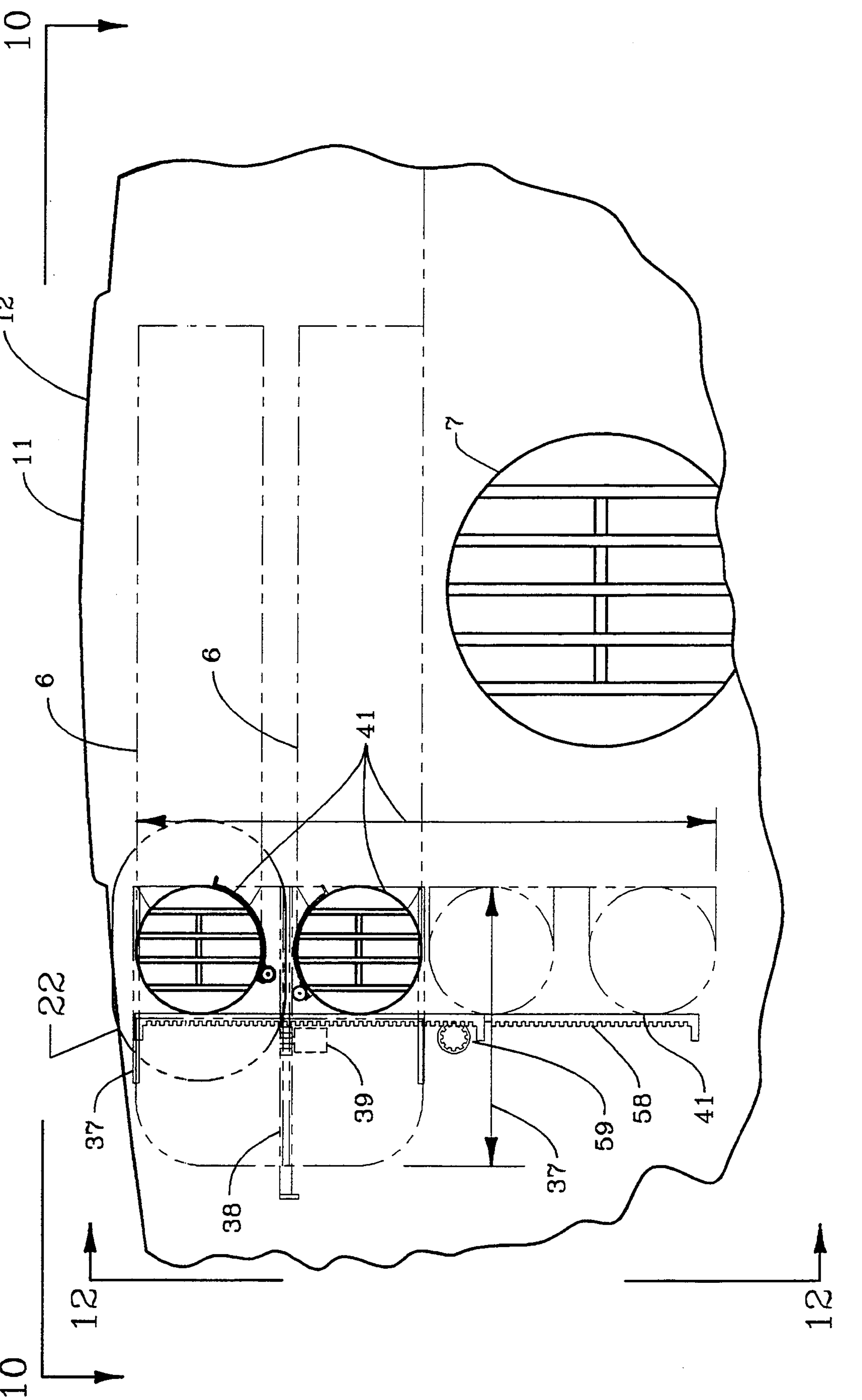


FIG. 9

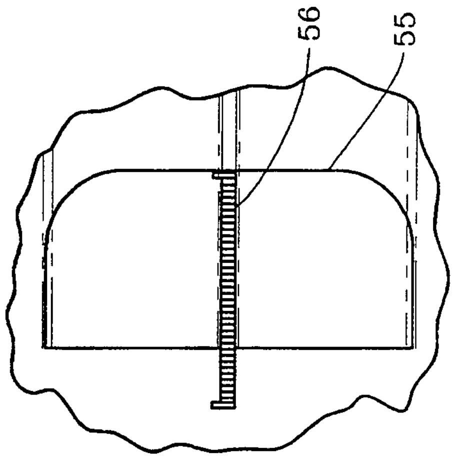


FIG. 11

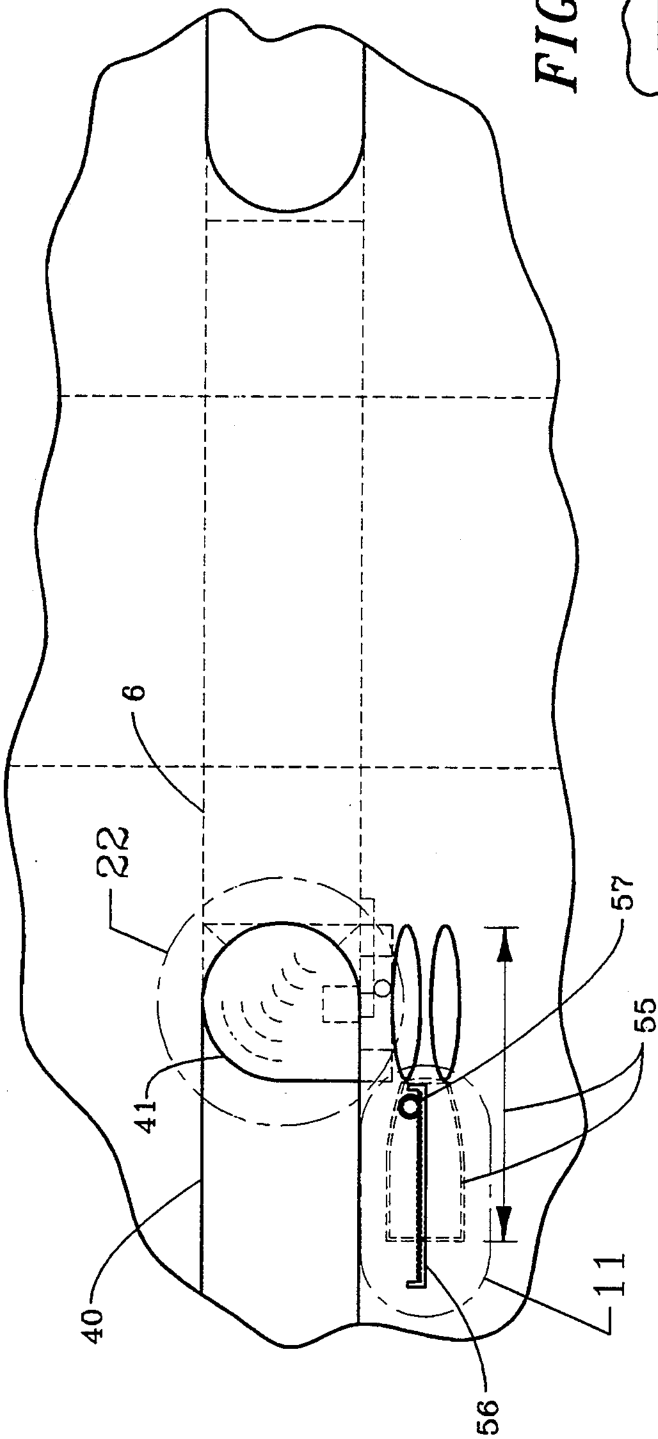


FIG. 10

FIG. 12

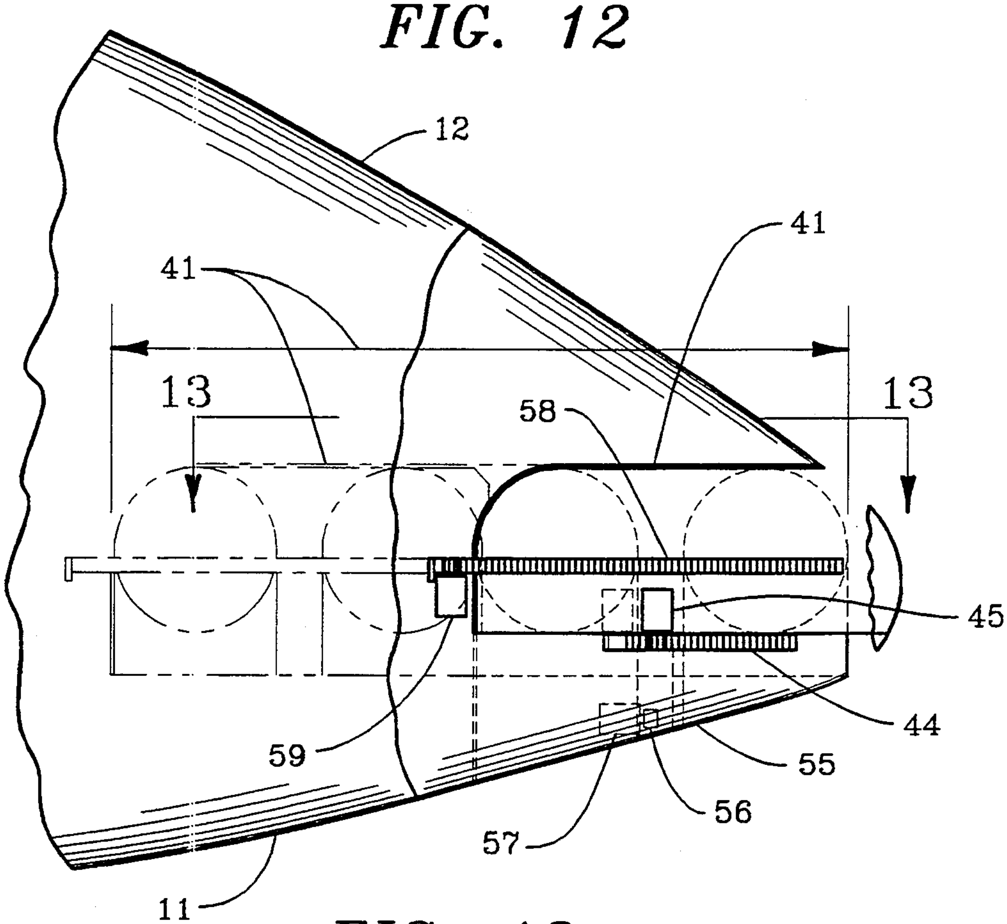


FIG. 13

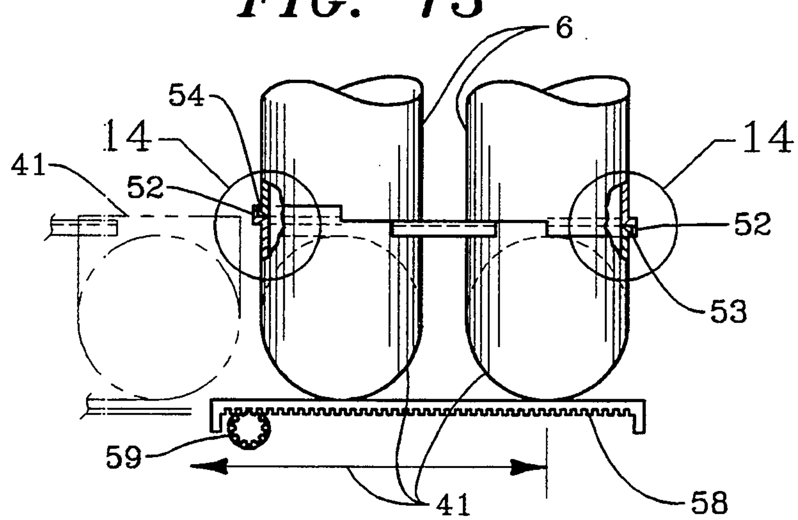


FIG. 14

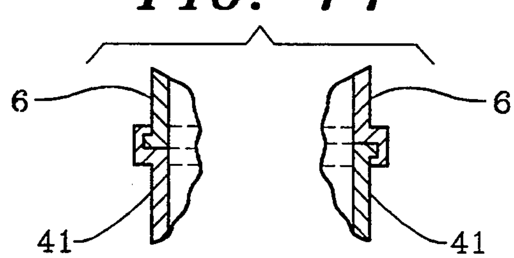


FIG. 15

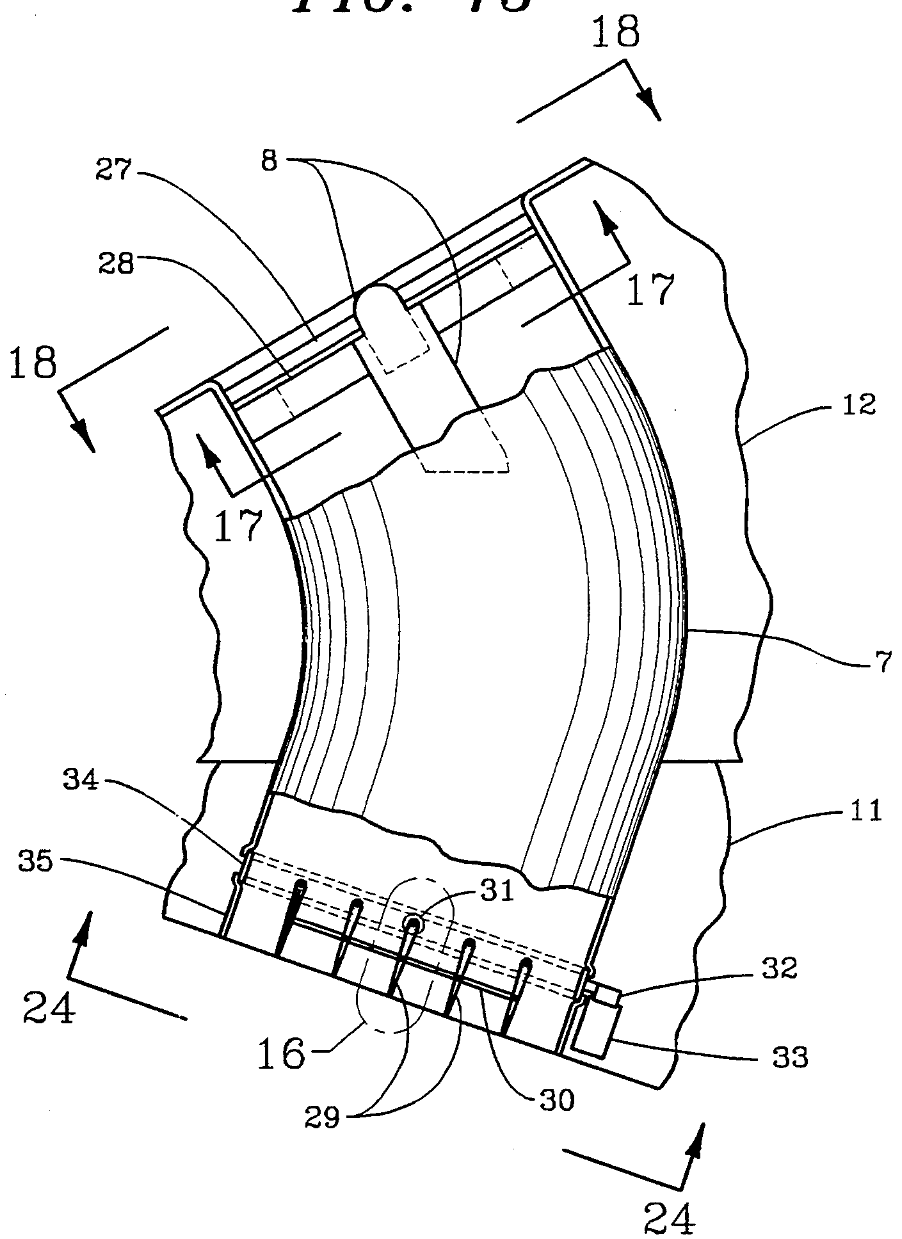


FIG. 16

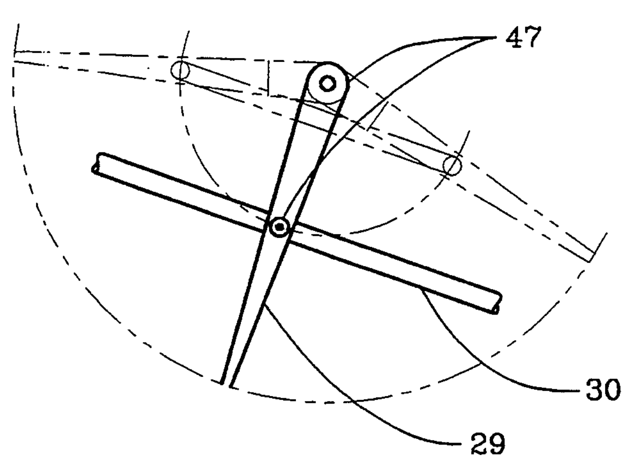


FIG. 17

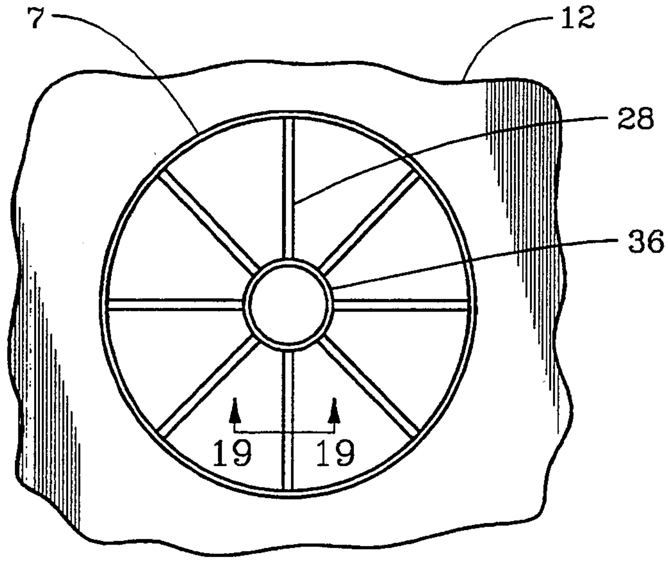


FIG. 18

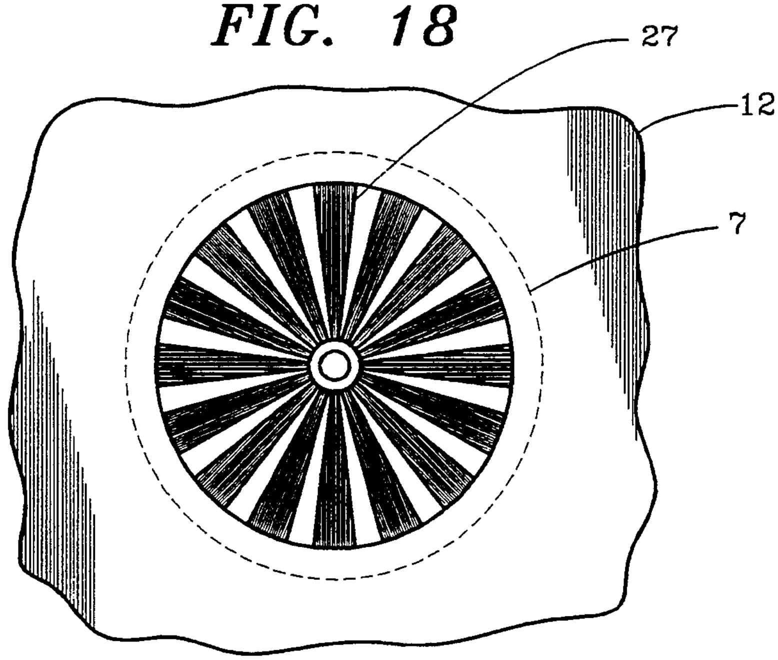
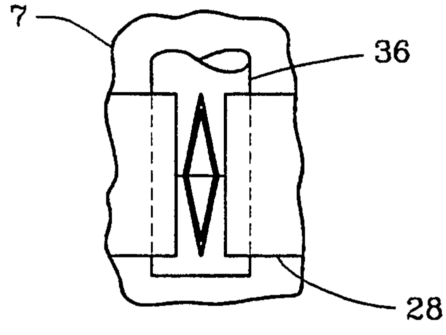


FIG. 19



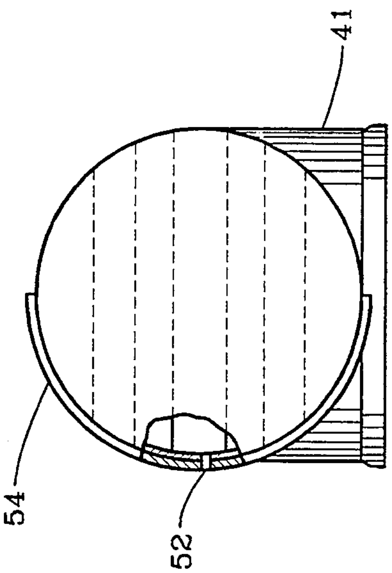


FIG. 21

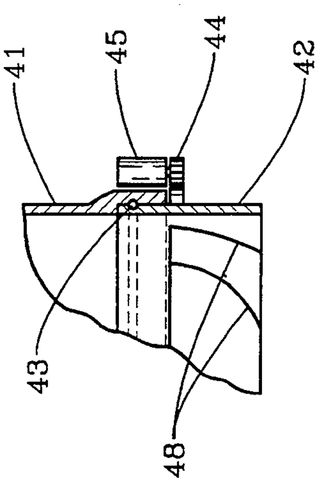


FIG. 23

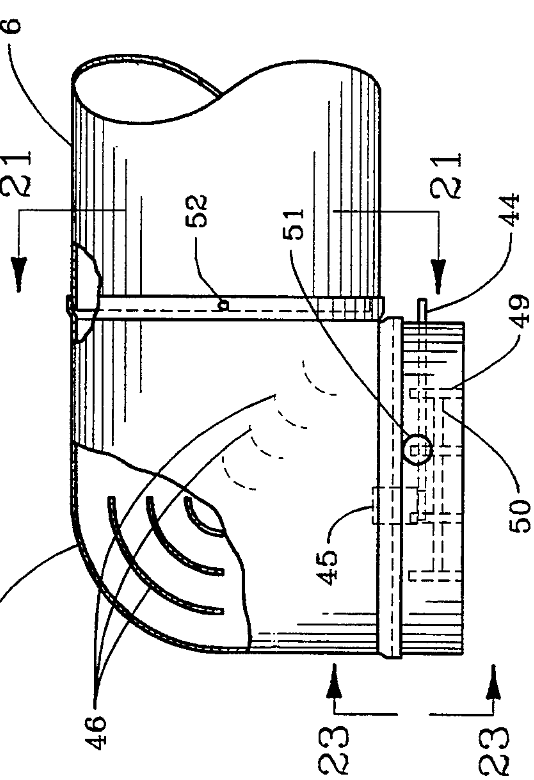


FIG. 20

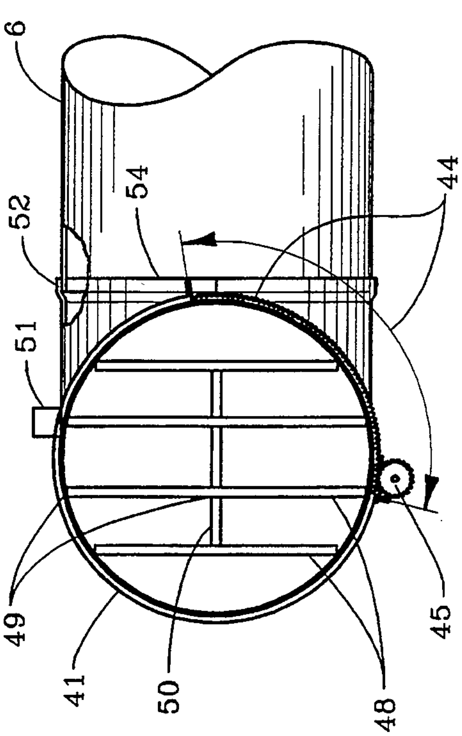


FIG. 22

FIG. 25

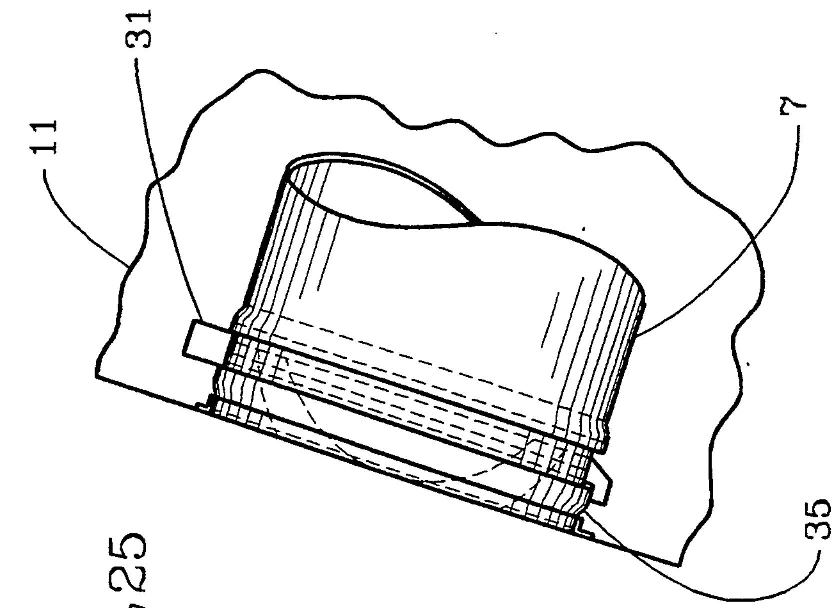


FIG. 24

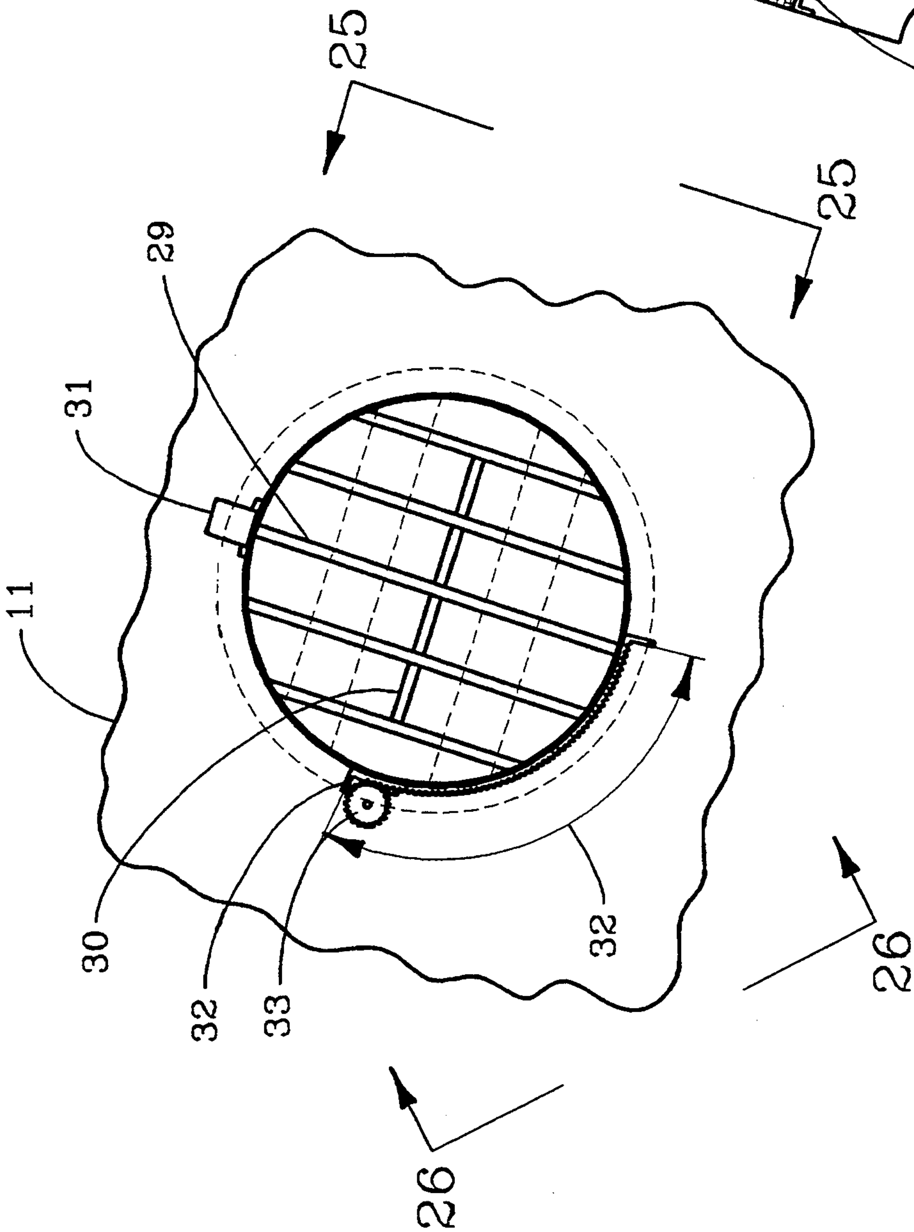


FIG. 26

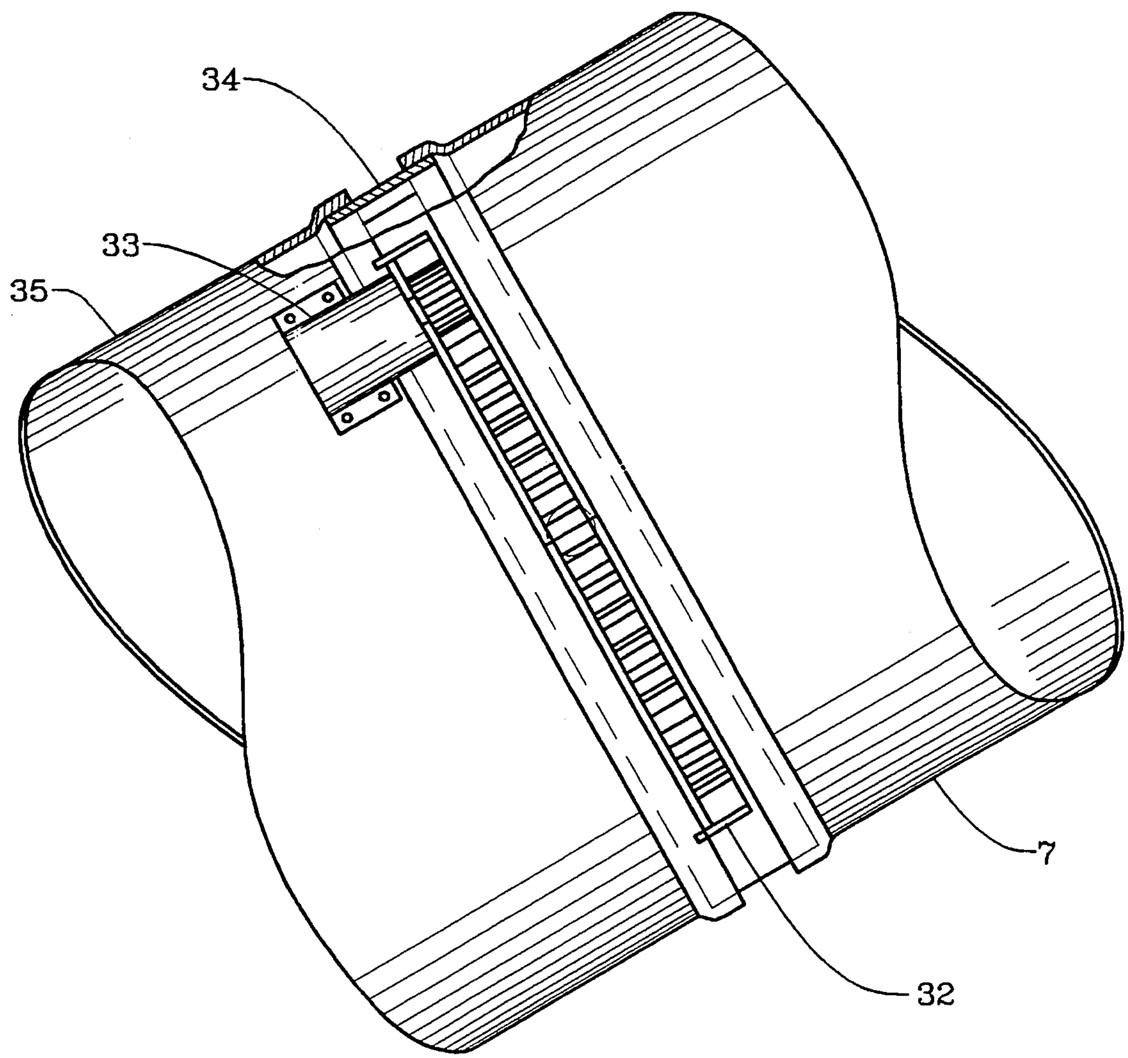


FIG. 27

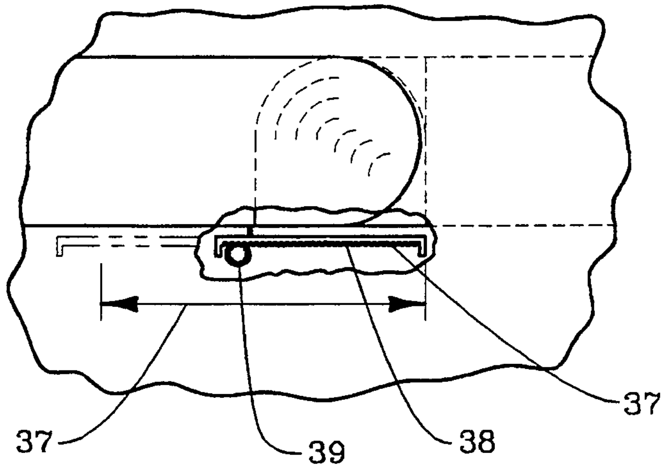


FIG. 28

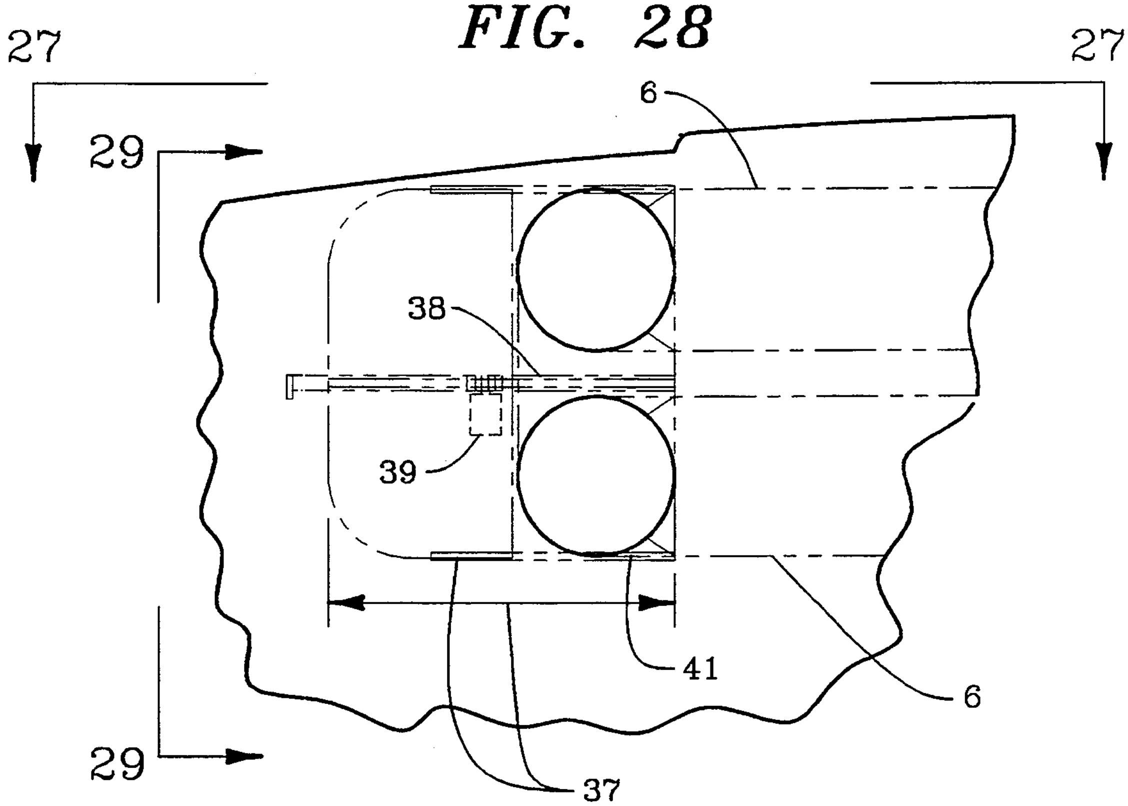


FIG. 29

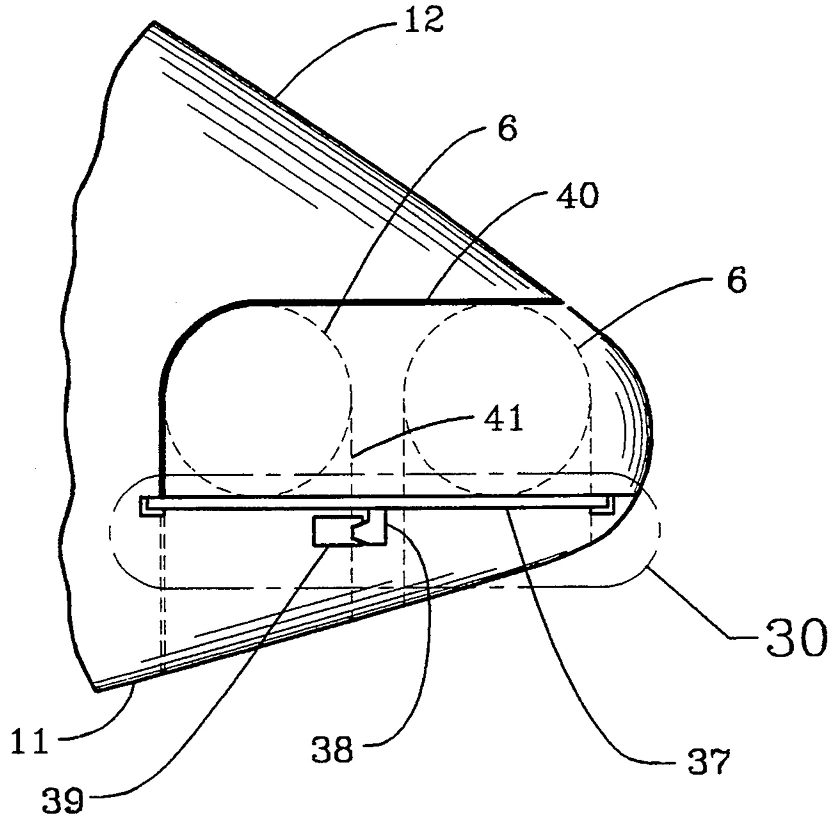
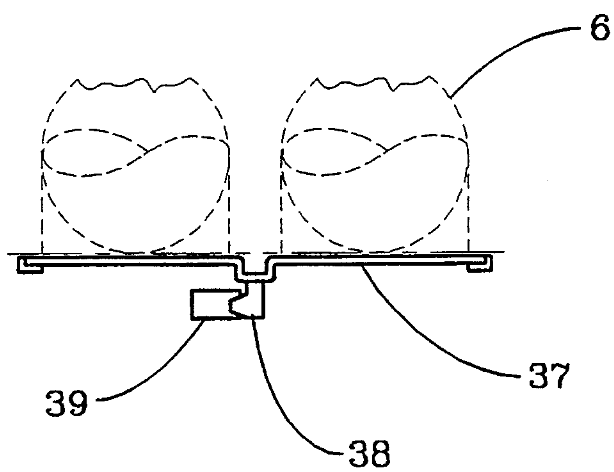


FIG. 30



VERTICAL TAKEOFF AND LANDING (VTOL) FLYING DISC

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to discoidal-shaped aircraft, and more particularly, to a discoidal-shaped aircraft capable of vertical takeoff and landing operations.

2. Description of the Prior Art

As seen in the prior art, there have been numerous efforts directed toward the designing and development of an aircraft which is capable of vertical takeoff and landing (VTOL) operations while still being able to move in a generally horizontal flight path at great speeds and efficiency.

The most common configuration of vertical takeoff and landing aircraft is the helicopter. The helicopter is capable of true vertical flight, including the ability to hover in place, fly forward and aft, and from side to side. Unfortunately, the helicopter has many limitations, the most significant thereof being its mechanical complexity and high operational expense. Moreover, the principles of aerodynamics result in obvious limitations on performance, most notably, the low maximum attainable forward velocities and reduced range when compared with fixed wing aircraft.

The prior art efforts exerted toward developing an operational procedure for a VTOL aircraft have been directed mainly toward the use of aircraft in which a takeoff or landing operation usually has the longitudinal axis of the fuselage disposed in a plane perpendicular to the ground so that the aircraft is propelled upwardly in a vertical direction and, upon reaching desired altitude, the aircraft is then rotated by means of the propulsion units to assume a horizontal position which is the normal flight attitude of an airplane. Similarly, efforts have been exerted toward developing an operational procedure wherein the spinning disc principle is used to produce vertical lift during takeoff or hovering of the craft, as well as to aid the discoidal spinning wing to move through ambient air and therefore aid in horizontal flight.

The problems in the prior art aircraft have been in developing an aircraft capable of both helicopter-type hovering flight and also high speed horizontal flight while still maintaining safety, reliability in operation, and being generally economical to manufacture, maintain, and use. In an aircraft operation of this type, the greatest difficulty is in carrying forth such a flight operation which entails the turning and rotating of the aircraft when in one position to the other position, in other words, from horizontal to vertical flight, while at the same time maintain the aircraft in a proper airborne altitude to prevent the same from falling or crashing to the surface.

The present invention is directed to a VTOL flying disc which is capable of making the transition from vertical to conventional flight without the need of the "spinning disc" effect, and which, by virtue of its power plant location and its lifting body-type fuselage, results in enhanced performance both in vertical takeoff and horizontal flight modes.

SUMMARY OF THE INVENTION

In accordance with the instant invention, there is disclosed a VTOL aircraft in the form of a flying disc capable of both helicopter-type hovering flight and also high speed horizontal flight. The present invention reduces the cost of traveling, and makes airport runways obsolete. The present invention is unsinkable on water, has a reduced noise level, and is environmentally friendly. It has a horizontal flight speed comparable to a jumbo jet aircraft. The dimensional size of the present invention is about 5 ft. larger than the wing span and about 31 ft. smaller than the fuselage or airframe length of the Boeing 747 jumbo jet. The overall measurements are approximately 200 ft. in diameter with a maximum body height of 50 ft. The passenger deck configuration has a seating arrangement for approximately 756 passengers including flight crew and flight attendants. However, size of the aircraft is optional, allowing the instant invention to have both commercial and military applications.

The materials used for the aircraft's construction are to be of all available lightweight material, such as aluminum alloy, magnesium alloy, synthetic alloys, etc. where applicable or practical.

The aircraft configuration comprises a circular disc-like airfoil-shaped wing structure having a convex upper surface and a concave lower surface with a leading edge and a trailing edge. At least one propulsion or thrust-producing unit, preferably in the form of a jet engine, is attached at each of the leading and trailing edges, respectively, to aid in both VTOL and horizontal flight. Furthermore, a plurality of other thrust-producing units, preferably in the form of ducted fan assemblies, are mounted symmetrically about the circular wing structure, and they too aid in both VTOL and horizontal flight.

Each thrust-producing unit has attached thereto a thrust deflector assembly for angularly adjusting the thrust produced by the thrust-producing unit, thereby allowing the aircraft to fly both vertically and horizontally.

A substantial volume of helium gas is stored within the inner upper hull of the aircraft. The helium gas is of primary importance because it gives the flying disc greater lift capacity. As a result, the jet engines and ducted fan assemblies are not required to lift the full cross weight and payload of the flying disc in order to become airborne. In addition, the fuel consumption is reduced in both VTOL and horizontal flight.

The outer skin of the upper hull consists essentially of a plurality of solar panels for delivering power to a plurality of devices, both in and on the aircraft. The solar panels cover virtually the entire upper hull surface.

In accordance with the present invention, it is an object thereof to provide an aircraft generally of the discoidal type which is capable of vertical takeoff and landing operations while still being able to move in a horizontal flight path at great speeds and efficiency.

Another object is to provide a flying craft with a plurality of thrust-producing units mounted symmetrically about the circular wing structure, each thrust-producing unit having attached thereto a thrust deflector assembly for angularly adjusting the thrust produced by the thrust-producing unit.

A further object is to provide a flying craft as described, wherein a substantial volume of helium gas is stored within the inner upper hull of the craft.

A still further object is to provide a flying craft as described, wherein the outer skin of the upper hull consists essentially of a plurality of solar panels for delivering power to a plurality of devices.

In accordance with these and other objects which will be apparent hereinafter, the instant invention will now become described with particular reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front view of the VTOL flying disc;

FIG. **2** is a view in perspective of the VTOL flying disc;

FIG. **3** is a view taken generally along line **3**—**3** in FIG. **2**;

FIG. **4** is a side elevational view of the VTOL flying disc having portions broken away;

FIG. **5** is a view generally along line **5**—**5** of FIG. **4**;

FIG. **6** is a view generally along line **6**—**6** of FIG. **4**;

FIG. **7** is a view generally along line **7**—**7** of FIG. **5**;

FIG. **8** is a view generally along line **8**—**8** of FIG. **5**;

FIG. **9** is a detail of section **9** of FIG. **5**;

FIG. **10** is a view generally along line **10**—**10** of FIG. **9**;

FIG. **11** is a detail of section **11** of FIG. **10**;

FIG. **12** is a view generally along line **12**—**12** of FIG. **9**;

FIG. **13** is a view generally along line **13**—**13** of FIG. **12**;

FIG. **14** is a detail of section **14** of FIG. **13**;

FIG. **15** is a view generally along line **15** of FIG. **5**;

FIG. **16** is a detail of section **16** of FIG. **15**;

FIG. **17** is a view generally along line **17**—**17** of FIG. **15**;

FIG. **18** is a view generally along line **18**—**18** of FIG. **15**;

FIG. **19** is a view generally along line **19**—**19** of FIG. **17**;

FIG. **20** is a detail of section **20** of FIG. **9**;

FIG. **21** is a view generally along line **21**—**21** of FIG.

FIG. **22** is a detail of section **22** of FIG. **10**;

FIG. **23** is a view generally along line **23**—**23** of FIG. **20**;

FIG. **24** is a view generally along line **24**—**24** of FIG. **15**;

FIG. **25** is a view generally along line **25**—**25** of FIG. **24**;

FIG. **26** is a view generally along line **26**—**26** of FIG. **24**;

FIG. **27** is a view generally along line **27**—**27** of FIG. **28**;

FIG. **28** is a view illustrating the gear drive and gear track assembly of the jet engine assembly.

FIG. **29** is a view generally along line **29**—**29** of FIG. **28**;

FIG. **30** is a view generally along line **30**—**30** of FIG. **29**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to the several views of the drawings, there is depicted a VTOL aircraft in the form of a flying disc, generally characterized by the reference numeral **1**. As shown in FIGS. **1**, **2** and **4**, the aircraft is a circular disc-like airfoil-shaped wing structure having an upper hull **12** with a convex surface and a lower hull **11** with a concave surface. The aircraft has a leading edge **10** and a trailing **10'** with at least one propulsion or thrust-producing unit **6** attached at each of the leading **10** and trailing **10'** edges, respectively, to aid in both VTOL and horizontal flight, as will be described in detail hereinafter. In the preferred embodiment, the thrust-producing unit **6** is a jet engine assembly. As seen in FIGS. **2** and **5**, a plurality of other propulsion units **7**, preferably of the ducted fan assembly variety, are mounted symmetrically about the circular wing structure and they too aid in both VTOL and horizontal flight, as will be described in greater detail hereinafter.

Referring to FIGS. **2**, **4**, **5** and **6**, the flying disc **1** is shown with passenger deck **2** having a seating arrangement **23** for approximately 756 passengers, including flight crew and flight attendants. A storage area **4** for cargo, fuel, landing gear, etc. is located below the floor **13** of passenger deck **2**. Floodlights **16** are installed in lower hull **11**. An inlet duct **14** and an outlet duct **15** are provided for the jet engines **6**. A plurality of retractable landing gear assemblies and landing gear doors **9** and wheel wells **17** for the landing gear assemblies **9** are provided. Window panels **19** for the flight crew, and window panels **22** for scenic viewing for the passengers, are also included. Stairways **20** for ingress and egress of the aircraft are provided. Cargo doors **21** provide access to storage area **4**. An additional storage area **26** is also provided, along with lavatories **24** and kitchen areas **25**.

The ceiling **18** of passenger deck **2** provides a floor for housing helium gas **3**, wherein the housing has as its upper boundary upper hull **12** and as its lower boundary passenger deck ceiling **18**. A substantial volume of helium gas **3** is stored within the inner upper hull and is of primary importance because it gives the flying disc **1** greater lift capacity. As a result, the jet engines **6** and ducted fan assemblies **7** are not required to lift the full cross weight and payload of the aircraft **1** in order for the aircraft **1** to become airborne. In addition, the fuel consumption is reduced in both VTOL and horizontal or conventional flight.

The outer skin of upper hull **12** consists essentially of lightweight, high efficiency solar panels **5** which cover virtually the entire upper hull surface. The solar panels **5** may deliver electrical power for a plurality of devices; for example, the floodlights **16**, all appliances, the heating and air conditioning systems, the landing gear assemblies **9**, the cargo doors **21**, all electric gear drives (described in detail hereinafter), and possibly power for the ducted fan assemblies **7**, as will be described in greater detail hereinafter.

The ducted fan assemblies **7** may be powered either by solar panels **5**, or individually powered by an alternative power means **8**. As best seen in FIGS. **2** and **15**, each alternative power means **8** is mounted co-longitudinally to its corresponding ducted fan assembly **7**. Alternative power means **8** may be an electric motor, a power generator, a small gas-driven turbo engine, or any suitable power plant known in the art.

Referring now to FIGS. **15**–**19**, there is shown a ducted fan assembly **7** comprising fan blades **27** and structural support members **28** as known in the art. Alternative power plant **8** is mounted to structural support sleeve **36**, which is itself connected to support members **28**. Fuel feeder lines from a master fuel tank or tanks, dedicated to each individual jet engine **6**, ducted fan assembly **7**, or power plant **8**, are connected through the nearest structural support member **28**. Similarly, electric wiring to control start-up and RPM of power plants **8** are connected through the nearest structural support member **28**. A plurality of vanes or louvers **29** are pivotally mounted by bearing **47** to a rotatable sleeve **34** proximate the outlet of the fan assembly **7**. Member **30** is pivotally mounted to the vanes **29** and is transverse to the vanes **29**, such that if any one of the vanes is pivoted, all the vanes are correspondingly pivoted. A stationary sleeve **35** is also proximate the outlet of fan assembly **7** and is positioned below rotatable sleeve **34**.

Referring now to FIGS. **15**, and **24–26**, an electric drive **31** is pivotally attached to rotatable sleeve **34**, and is further pivotally attached to one of the vanes **29**. Power may be delivered to electric drive **31** by the solar panels **5**. When electric drive **31** is activated, it pivots, causing the vane **29** attached to electric drive **31** to pivot, which in turn causes each of the vanes **29** to pivot as described above. In so doing, the thrust produced by the ducted fan assembly **7** may be angularly adjusted to facilitate either VTOL or horizontal flight. Furthermore, a gear track assembly **32** and a gear drive assembly **33** are attached to rotatable sleeve **34** and stationary sleeve **35**, respectively, such that when gear drive **33** is activated, it engages gear track **32**, causing rotatable sleeve **34** to rotate. In the preferred embodiment, rotatable sleeve **34** is configured for 90° of rotation. The foregoing configuration permits a three-dimensional pivoting of vanes **29**, allowing the thrust produced by fan assembly **7** to be angularly adjusted to accommodate either VTOL or horizontal flight. Each ducted fan assembly's electric drive **31**, gear drive **33** and gear track **32**, may be controlled individually, or may be synchronized to control directional change of the thrust produced by the fan assembly **7**, thereby facilitating roll, pitch, yaw, and directional control of the flying disc **1**.

Referring now to FIGS. **9–14** and FIGS. **20–23**, there is shown a thrust deflector assembly **41**. A plurality of vanes or louvers **48** are pivotally mounted by bearing **49**, to a rotatable sleeve **42**, proximate the outlet of the thrust deflector assembly **41**. Member **50** is pivotally mounted to the vanes **48**, and is transverse to the vanes **48**, such that if any one of the vanes is pivoted, all the vanes are correspondingly pivoted. Ball bearings **43** are equally spaced around the circumference of both thrust deflector assembly **41**, and sleeve **42**, to ensure proper rotation. A dowel or lock pin **52** is mounted to thrust deflector assembly **41** and aids in holding thrust deflector assembly **41** in a secure position. A half retainer ring **53** is mounted to engine **6** to accommodate the thrust deflector assembly **41**. Another half retainer ring **54** is mounted to the inner periphery of thrust deflector assembly **41** to ensure correct engagement and disengagement of thrust deflector assembly **41** with engine **6**. An alternate embodiment of a joint mounting which provides quick connect and disconnect between engine **6** and thrust deflector assembly **41** is shown in FIGS. **13**, **14**, **21** and **22**.

An electric drive **51**, is pivotally attached to rotatable sleeve **42**, and is further pivotally attached to one of the vanes **48**. Power may be delivered to electric drive **51** by the solar panels **5**. When electric drive **51** is activated, it pivots, causing the vane **48** attached to electric drive **51** to pivot, which in turn causes each of the vanes **48** to pivot as described above. In so doing, the thrust produced by the jet engine **6** may be angularly adjusted to facilitate VTOL flight. In addition, thrust converters **46** are attached to the inner periphery of thrust deflector assembly **41**, and aid in the deflection of thrust produced by jet engine **6**. Furthermore, a gear track assembly **44** and a gear drive assembly **45** are attached to rotatable sleeve **42** and thrust deflector assembly **41**, respectively, such that when gear drive **45** is activated, it engages gear track **44**, causing rotatable sleeve **42** to rotate. In the preferred embodiment, rotatable sleeve **42** is configured for 90° of rotation. The foregoing configuration permits a three-dimensional pivoting of vanes **48**, allowing the thrust produced by the jet engines **6** to be angularly adjusted to accommodate either VTOL or horizontal flight. Each thrust deflector assembly's electric drive **51**, gear drive **45**, and gear track **44**, may be synchronized to control directional change of the thrust produced by the thrust deflector assembly **41**, thereby facilitating roll, pitch, yaw, and directional control of the flying disc **1**.

Once the desired vertical altitude has been achieved, the transition to horizontal flight is as follows. The 90° thrust deflector assembly **41** will automatically retract as hereinafter described. Referring to FIGS. **9–14**, **20–23**, and **27–30**, a gear track assembly **58** and a gear drive assembly **59** are attached to thrust deflector assembly **41** and to outlet duct assembly **40**, respectively, such that when gear drive **59** is activated, it engages gear track **58**, causing thrust deflector assembly **41** to move or retract. After thrust deflector assembly **41** is retracted, retractable cover **37** is closed as follows. A gear track assembly **38** and a gear drive assembly **39** are attached to retractable cover **37** and the understructure of outlet duct assembly **40**, respectively, such that when gear drive **39** is activated, it engages gear track **38**, causing retractable cover **37** to close. After closing retractable cover **37**, another retractable cover **55** is closed as follows. A gear track assembly **56** and a gear drive assembly **57** are attached to retractable cover **55** and to the understructure of outlet duct assembly **40**, respectively, such that when gear drive **57** is activated, it engages gear track **56**, causing retractable cover **55** to close. The above-described transition is reversed for the vertical takeoff and landing mode.

The instant invention has been shown and described herein in what is considered to be the most practical and preferred embodiment. It is recognized, however, that departures may be made therefrom within the scope of the invention and that obvious modifications will occur to a person skilled in the art.

What is claimed is:

1. A vertical takeoff and landing (VTOL) flying disc comprising:

a circular disc-like airfoil-shaped wing structure having a convex upper surface and a concave lower surface, said wing structure further having a leading edge and a trailing edge;

means for delivering power, said means for delivering power consisting essentially of the outer skin of said convex upper surface;

means for storing helium gas, said means for storing helium gas having an upper boundary defined by said convex upper surface and a lower boundary defined by a passenger deck;

means for producing thrust, said means for producing thrust connected to said circular wing structure; and

means for angularly adjusting the thrust produced by said means for producing thrust, said means for angularly adjusting comprising a plurality of vanes pivotally attached to a rotatable sleeve, said rotatable sleeve being attached proximate the outlet of said means for producing thrust, said rotatable sleeve further being positioned above a stationary sleeve;

a member pivotally mounted to said vanes, said member being transverse to said vanes; and

means for selectively pivoting said vanes three-dimensionally

2. The VTOL flying disc of claim 1, wherein said means for delivering power is a plurality of solar panels.

3. The VTOL flying disc of claim 1, wherein said means for producing thrust includes the combination of:

jet engine members; and

ducted fan assemblies.

4. The VTOL flying disc of claim 3, wherein at least one turbofan or turbojet engine is mounted on each of said leading and trailing edges.

5. The VTOL flying disc of claim 3, wherein at least two turbofan or turbojet engines are mounted on each of said leading and trailing edges.

6. The VTOL flying disc of claim 3, wherein said ducted fan assemblies are mounted symmetrically about the circumference of said wing structure.

7. The VTOL flying disc of claim 6, wherein said ducted fan assemblies are powered by said means for delivering power.

8. The VTOL flying disc of claim 7, wherein each of said ducted fan assemblies is powered individually by a second means for delivering power.

9. The VTOL flying disc of claim 8, wherein said second means for delivering power is mounted co-longitudinally to said ducted fan assemblies.

10. The VTOL flying disc of claim 9, wherein said second means for delivering power is an electric motor, a power generator, or a gas-driven turbo engine.

11. The VTOL flying disc of claim 1, wherein said means for selectively pivoting includes the combination of:

a gear drive assembly and a gear track assembly mounted to said stationary sleeve and said rotatable sleeve, respectively, wherein when said gear drive assembly is activated, said gear track assembly is engaged, thereby rotating said rotatable sleeve, causing said vanes to rotate; and

a second drive assembly pivotally attached to said rotatable sleeve, said second drive assembly further being pivotally attached to one of said vanes, wherein when said second drive assembly is activated, said vanes are pivoted.

12. A vertical takeoff and landing flying disc comprising:

a circular disc-like airfoil shaped wing structure having a convex upper surface and a concave lower surface, said wing structure further having a leading edge and a trailing edge;

a plurality of solar panels mounted to said convex upper surface, said solar panels for delivering power;

means for storing helium gas, said means for storing helium gas having an upper boundary defined by said convex upper surface and a lower boundary defined by a passenger deck;

means for producing thrust connected to said circular wing structure, said means for producing thrust including the combination of jet engine members and ducted fan assemblies, wherein at least one of said jet engine members is mounted to each of said leading and trailing edges respectively, wherein said ducted fan assemblies are mounted symmetrically about the circumference of said wing structure; and

means for angularly adjusting the thrust produced by said means for producing thrust, said means for angularly adjusting including

a plurality of vanes pivotally attached to a rotatable sleeve, said rotatable sleeve being attached proximate the outlet of said means for producing thrust, said rotatable sleeve further being positioned above a stationery sleeve,

a member pivotally mounted to said vanes, said member being transverse to said vanes,

a gear drive assembly and a gear track assembly mounted to said stationery sleeve and said rotatable sleeve, respectively, such that when said gear drive assembly is activated, said gear track assembly is engaged, thereby rotating said rotatable sleeve, causing said vanes to rotate, and

a second drive assembly pivotally attached to said rotatable sleeve, said second drive assembly further being pivotally attached to one of said vanes, wherein when said second drive assembly is activated, said vanes are pivoted.

* * * * *

US005503351A

United States Patent [19]

[11] **Patent Number: 5,503,351**

[45] **Date of Patent: Apr. 2, 1996**

Vass

[54] **CIRCULAR WING AIRCRAFT**

[76] Inventor: **Gabor I. Vass**, 118-10221 133A Street, Surrey, B.C., Canada, V3T 5J8

[21] Appl. No.: **300,757**

[22] Filed: **Sep. 6, 1994**

[51] **Int. Cl.**[6] **B64C 27/22**; B64C 39/06; B64C 29/00

[52] **U.S. Cl.** .... **244/34 A**; 244/7 A; 244/12.2; 244/23 C; 244/67; 244/73 C

[58] **Field of Search** .... 244/6, 54, 56, 244/7 A, 7 C, 8, 7 R, 10, 12.2, 17.11, 23 C, 34 A, 67, 73 B, 73 C

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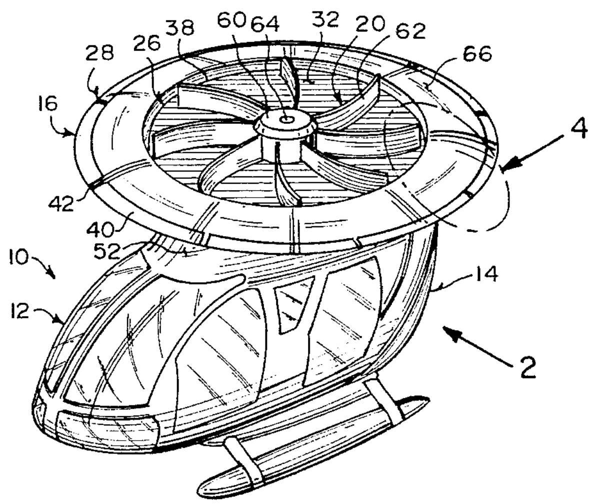
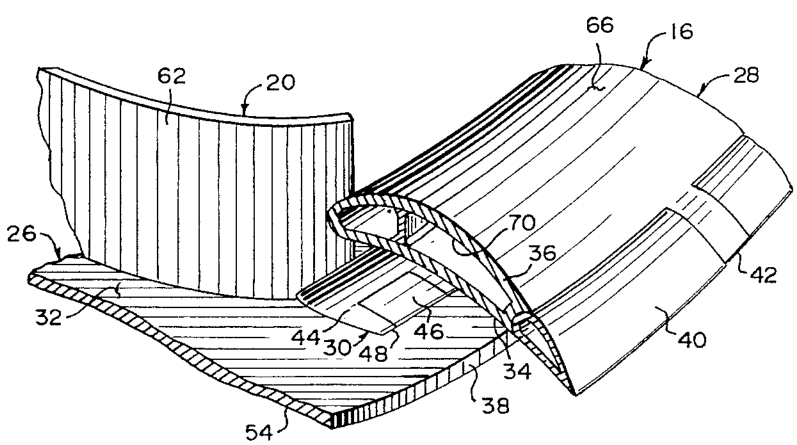
Primary Examiner—Andres Kashnikow
Assistant Examiner—Virna Lissi Mojica
Attorney, Agent, or Firm—Michael I. Kroll

[57] **ABSTRACT**

A circular wing aircraft in the form of a helicopter comprising a fuselage and a circular wing assembly. A structure is for mounting the circular wing assembly above the fuselage in a stationary manner. An air impeller unit is rotatively carried within the circular wing assembly. A device is for driving the air impeller unit to rotate about a central axis within the circular wing assembly, so as to provide lift and flight movement while yaw control is maintained.

8 Claims, 3 Drawing Sheets





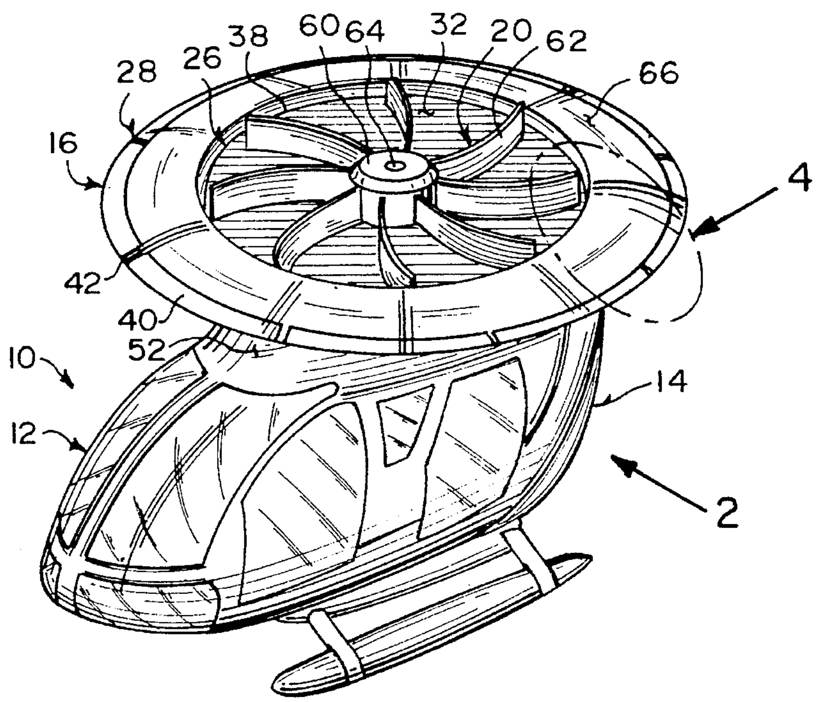

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Fig. 1

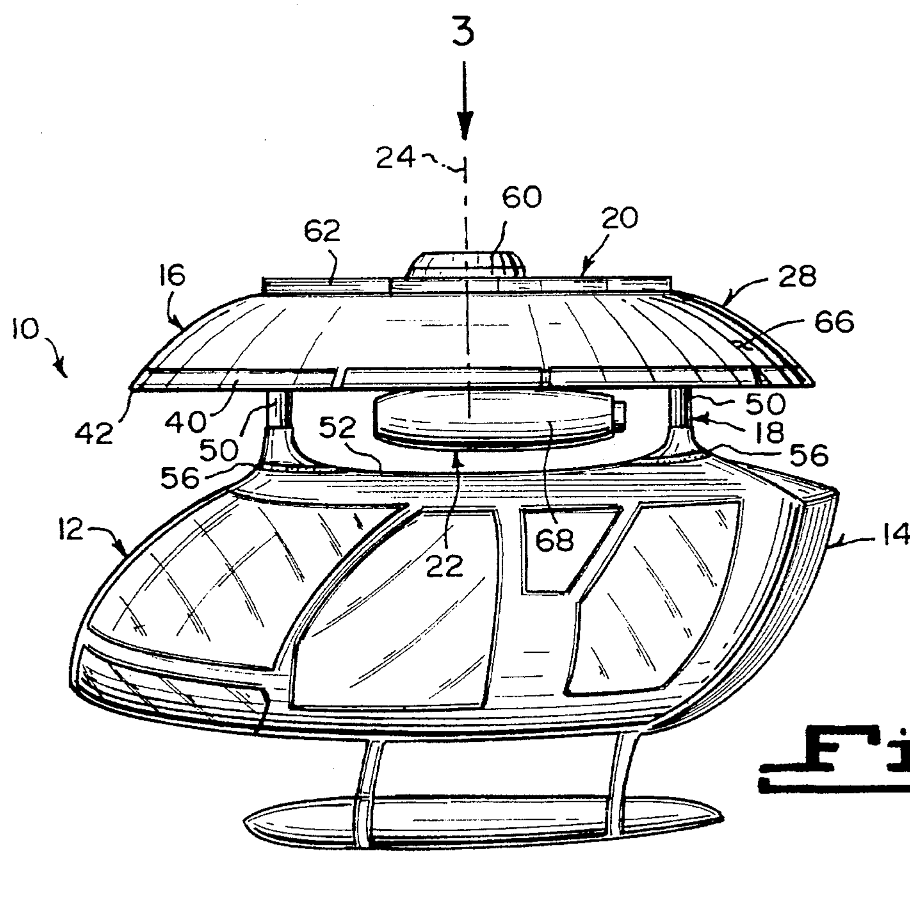
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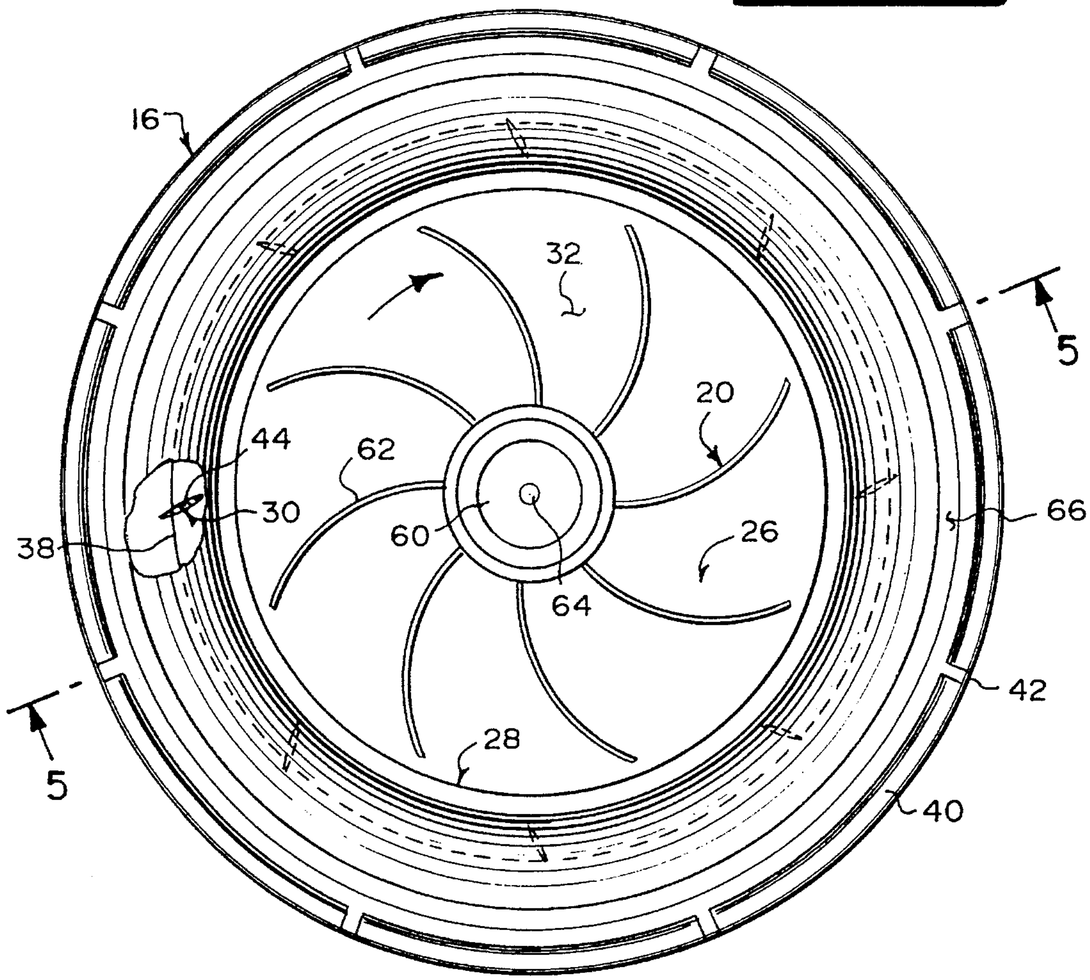
Fig. 2

Fig. 3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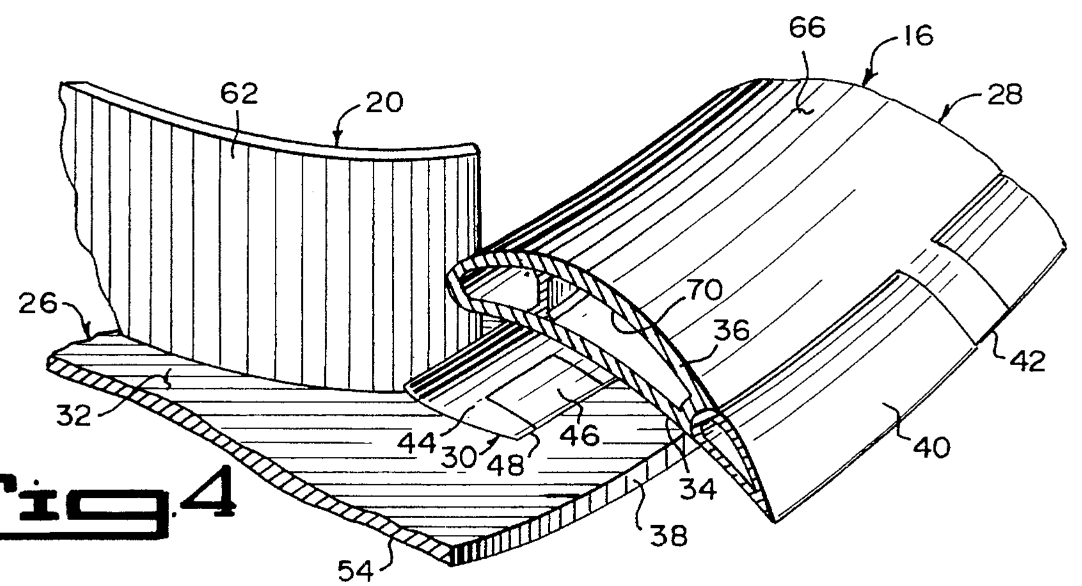
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Fig. 4

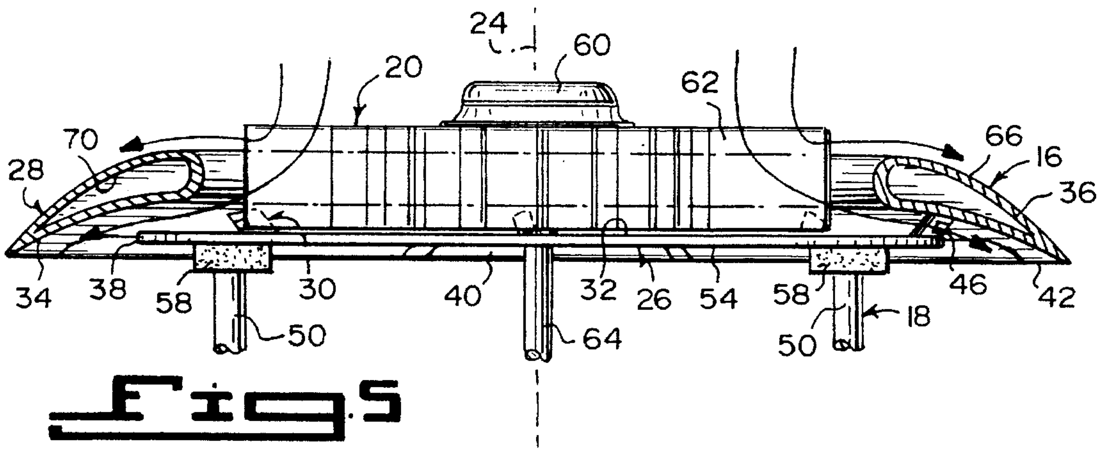

Fig. 5

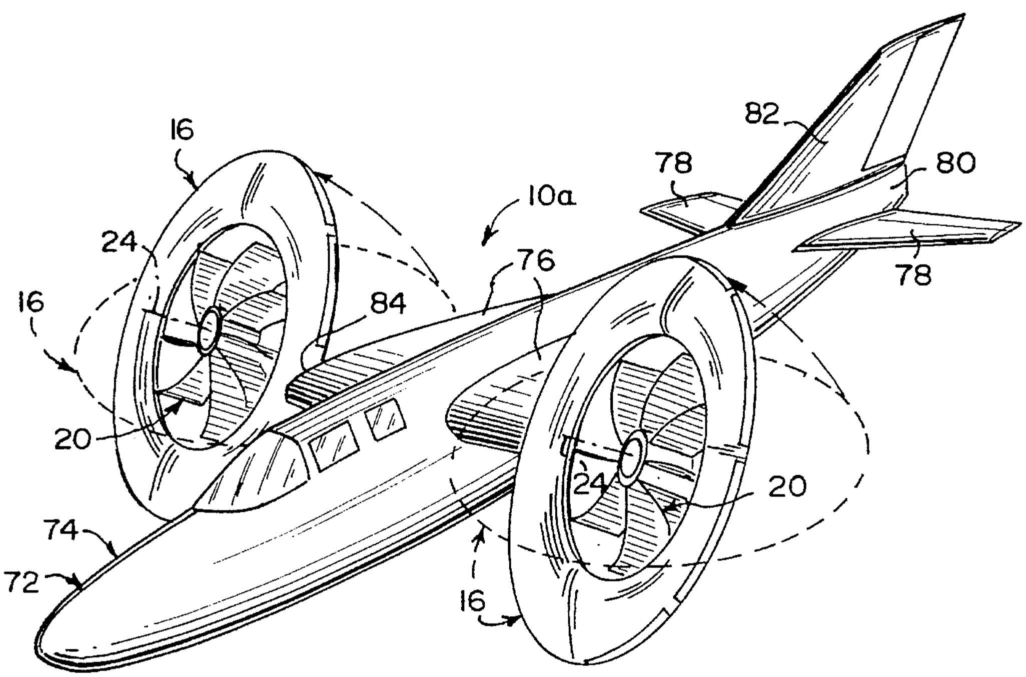

Fig. 7

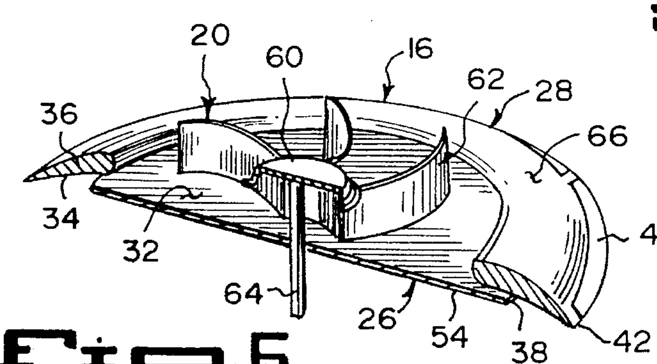

Fig. 6

CIRCULAR WING AIRCRAFT

BACKGROUND OF THE INVENTION

The instant invention is the subject matter of Disclosure Document No.: 353726, filed in the PTO on May 10, 1994, and it is respectfully requested that this document be retained beyond the two-year period so that it may be relied upon as evidence of conception of the invention during the prosecution phase of this application, should the need arise.

1. Field of the Invention

The instant invention relates generally to aircraft and more specifically it relates to a circular wing aircraft.

2. Description of the Prior Art

Numerous aircraft have been provided in prior art. For example, U.S. Pat. Nos. 3,486,715 to Reams; 4,598,888 to Beteille; 5,101,615 to Fassauer; 5,163,638 to Chaneac; 5,244,167 to Turk et al. and 5,255,871 to Ikeda all are illustrative of such prior art. While these units may be suitable for the particular purpose to which they address, they would not be as suitable for the purposes of the present invention as heretofore described.

An airborne device known as a helicopter wing device in combination with fixed wing aircraft. The helicopter wing device has a rotor mounted on a vertical shaft that consists of internal parts described in U.S. Pat. No. 3,314,483. The means of handling aboard and in flight down through an extendable launching tube and shielding therefore. Rest lugs are arranged to drop the helicopter wing device to thereby provide flight delivery to the destinations needing service of supply of heavier loads, or those critical such as medical supplies and personnel under direct or remote control devices to suit needs of user.

A fixed-wing aircraft with tandem lifting surfaces has monoplane main wings secured in an intermediate area of the fuselage and a horizontal tail surface with at least one stabilizer plane mounted at the tail of the fuselage. A third supporting surface on the fuselage is in tandem arrangement with the other supporting surfaces. The third supporting surface is a canard surface positioned ahead of the center of gravity of the aircraft.

An air-floated apparatus, such as a lawn mower or vacuum cleaner, is comprised of an endless housing having a bottom opening defined by a relatively flat plate member projecting inwardly from a bottom part of the housing. At least one air impeller is provided for pressurizing air within the housing sufficient to float the housing above a support surface. The plate member directs air laterally into the housing to inhibit the escape of air from the housing and maintain a relatively constant pressure in the housing. In one embodiment, the apparatus is comprised of a lawn mower having a rotatable cutting member mounted within the housing. The rotary action of the cutting member centrifuges grass cuttings within the housing. The plate member acts as a shelf to support the centrifuged grass cuttings and cooperates with an inner wall of the housing, to direct the grass cuttings into a discharge duct for collection in a bag or other receptacle.

An engine and lift unit for rotary wing aircraft together with means for balancing of the rotational torque of the wings is shown. The rotational torque is balanced by a blower propeller, disposed horizontally below the rotor, inside an enclosure including a vertical duct surrounding the blower propeller and whose lower open end exits under the fuselage of the aircraft. A horizontal duct opens into an intermediate zone of the vertical duct and exits out the rear of the aircraft. An adjustable shutter assembly is disposed in the junction of the two ducts allowing the creation of two adjustable air flows, one directed vertically downwards and the other directed towards the rear of the aircraft. The aircraft also has fixed wings, flaps, rudders and controls so the pilot can operate the aircraft in flight.

A lift augmentation system for aircraft which comprises a plurality of propellers parallel to an aircraft wing and inset parallel to and at the trailing edge of the wing. The propellers function to both directly produce vertical lift in the manner of helicopter blades and to augment air circulation over the wing to enhance lift produced by the wing. The propellers are set into the trailing edge of the wing along the length of the wing, with the inboard propellers preferably closely spaced to the fuselage to force air flow over the reducing taper of the fuselage. Each propeller is tiltable in all directions about the vertical axis through the propeller hub and the assembly of engine and propeller is hinged to the wing for pivoting in a plane substantially parallel to the aircraft axis.

A helicopter comprises a pair of rotors, each having a flap hinged to one of its edges. A seesaw rod is swingably supported above the rotors. A pair of auxiliary wings are fixed to opposite ends of the seesaw rod. A pair of connecting rods each connect one of the flaps with the seesaw rod above it. When the lift produced by one of the rotors becomes larger than that produced by the other, the auxiliary wing located above the rotor producing the larger lift rises and turns up the flap of the rotor to reduce its flap effect and decrease the rotor lift. The auxiliary wing located above the rotor producing the smaller lift lowers and turns down the flap of the rotor, to increase its flap effect and raise its lift. As a result, the lifts of the two rotors are regulated.

SUMMARY OF THE INVENTION

A primary object of the present invention is to provide a circular wing aircraft that will overcome the shortcomings of the prior art devices.

Another object is to provide a circular wing aircraft that utilizes fewer components than currently produced aircraft, thereby less maintenance requirements are needed.

An additional object is to provide a circular wing aircraft, in which in an autogiro form a smaller wingspan is required for similar aircraft weight and in a helicopter form the tail and tail rotor are eliminated, since the circular wing assembly maintains yaw control.

A further object is to provide a circular wing aircraft that is simple and easy to use.

A still further object is to provide a circular wing aircraft that is economical in cost to manufacture.

Further objects of the invention will appear as the description proceeds.

To the accomplishment of the above and related objects, this invention may be embodied in the form illustrated in the accompanying drawings, attention being called to the fact, however, that the drawings are illustrative only, and that changes may be made in the specific construction illustrated and described within the scope of the appended claims.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

FIG. **1** is a perspective view of the instant invention incorporated into a helicopter.

FIG. **2** is a side elevational view taken in the direction of arrow **2** in FIG. **1**.

FIG. **3** is a top view of the circular wing assembly per se taken in the direction of arrow **3** in FIG. **2**.

FIG. **4** is an enlarged perspective view of a portion of the circular wing assembly as indicated by arrow **4** in FIG. **1**.

FIG. **5** is a cross sectional view taken along line **5**—**5** in FIG. **3**.

FIG. **6** is a cross sectional perspective view of a modified circular wing assembly.

FIG. **7** is a perspective view of the instant invention incorporated into an autogiro.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Turning now descriptively to the drawings, in which similar reference characters denote similar elements throughout the several views, FIGS. **1** and **2** illustrate a circular wing aircraft **10** in the form of a helicopter **12**, comprising a fuselage **14** and a circular wing assembly **16**. A structure **18** is for mounting the circular wing assembly **16** above the fuselage **14** in a stationary manner. An air impeller unit **20** is rotatively carried within the circular wing assembly **16**. A device **22** is for driving the air impeller unit **20** to rotate about a central axis **24** within the circular wing assembly **16**, so as to provide lift and flight movement while yaw control is maintained.

The circular wing assembly **16**, as best seen in FIGS. **3** through **6**, consists of a lower disc wing **26** and an upper ring wing **28**. A plurality of wing mounts **30**, are radially spaced apart about the central axis **24** and affixed between a top surface **32** of the lower disc wing **26** and a bottom surface **34** of the upper ring wing **28**.

The upper ring wing **28** is airfoil-shaped **36** in a cross section and is sized to overlap the perimeter **38** of the lower disc wing **26**. The upper ring wing **28** contains a plurality of sectional flaps **40** that are independently controllable about the outer circumference **42**, for better lift and maneuverability. Each wing mount **30** is airfoil-shaped **44** in cross section and includes a movable flap **46** at its outer edge **48**, to increase and decrease a twisting force for yaw control.

The mounting structure **18** includes a plurality of suspension members **50** radially spaced apart about the central axis **24**. Each suspension member **50** extends between a top surface **52** of the fuselage **14** and a bottom surface **54** of the lower disc wing **26**. Each suspension member **50** is independently length adjustable. The circular wing assembly **16** can be tilted in any direction relative to the fuselage **14**, thus allowing the fuselage **14** to stay level in horizontal flight. A first rubber shock absorber connector **56** is at the top surface **52** of the fuselage **14**. A second rubber shock absorber connector **58** is at the bottom surface **54** of the lower disc wing **26**, so that vibration can be reduced, resulting in a low noise level in the fuselage **14**.

The air impeller unit **20** contains a hub **60**, with a plurality of curved blades **62** extending radially from the hub **60**. A drive shaft **64** extends from the hub **60** through the central axis **24** to the driving device **22**. The curved blades **62** can rotate with the hub **60** on the drive shaft **64**, to draw air from the top and blow the air out at a high velocity in radial directions over the top surface **32** of the lower disc wing **26**. This creates a low pressure zone on the top surface **32** with static air pressure beneath the lower disc wing **26**, providing a lifting force perpendicular to the bottom surface **54** of the lower disc wing **26**. The air is also blown above a top surface **66** and below the bottom surface **34** of the upper ring wing **28**, respectively creating an additional lift.

The driving device **22** is an engine **68** directly connected to the circular wing assembly **16** and coupled to the drive shaft **64**. The upper ring wing **28** can be hollow, as shown in FIGS. **4** and **5**, having an annular chamber **70** therein to be used as a fuel tank, thereby allowing maximum space within the fuselage **14** for a payload.

FIG. **7** shows a circular wing aircraft **10*a*** in the form of an autogiro **72**, comprising a fuselage **74**. A pair of short fixed wings **76**, each extend outwardly from an opposite side at the middle of the fuselage **74**. A pair of stabilizers **78**, each extend outwardly from an opposite side at the tail **80** of the fuselage **74**. A rudder **82** extends upwardly from the tail **80** of the fuselage **74**. A pair of circular wing assemblies **16**, are each pivotally mounted and controlled on a distal free end **84** of one short fixed wing **76**. A pair of air impeller units **20**, are each rotatively driven within one circular wing assembly **16**, to rotate about a central axis **24** by an engine (not shown), so as to provide lift and flight movement while yaw control is maintained.

LIST OF REFERENCE NUMBERS	
10	circular wing aircraft
10a	circular wing aircraft
12	helicopter for 10
14	fuselage of 12
16	circular wing assembly
18	mounting structure
20	air impeller unit
22	driving device
24	central axis
26	lower disc wing
28	upper ring wing
30	wing mount
32	top surface of 26
34	bottom surface of 28
36	air foil-shaped cross section of 28
38	perimeter of 26
40	sectional flap in 28
42	outer circumference of 28
44	air foil-shaped cross section of 30
46	movable flap in 30
48	outer edge of 30
50	suspension member of 18
52	top surface of 14
54	bottom surface of 26
56	first rubber shock absorber connector at 52
58	second rubber shock absorber connector at 54
60	hub of 20
62	curved blade on 60
64	drive shaft on 60
66	top surface of 28
68	engine for 22
70	annular chamber in 28
72	autogiro for 10a
74	fuselage of 72
76	short fixed wing
78	stabilizer on 80
80	tail of 74
82	rudder on 80
84	distal free end of 76

It will be understood that each of the elements described above, or two or more together may also find a useful application in other types of methods differing from the type described above.

While certain novel features of this invention have been shown and described and are pointed out in the annexed claims, it is not intended to be limited to the details above, since it will be understood that various omissions, modifications, substitutions and changes in the forms and details of the device illustrated and in its operation can be made by those skilled in the art without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention.

What is claimed is new and desired to be protected by Letters Patent is set forth in the appended claims:

1. A circular wing aircraft in the form of a helicopter comprising:

a) a fuselage;

b) a circular wing assembly, said circular wing assembly including a lower disc wing, an upper ring wing, and a plurality of wing mounts radially spaced apart about the central axis and affixed between a top surface of said lower disc wing and a bottom surface of said ring wing, said upper ring wing is airfoil-shaped in cross section and is sized to overlap the perimeter of said lower disc wing;

c) means for mounting said circular wing assembly above said fuselage;

d) an air impeller unit rotatively carried within said circular wing assembly; and

e) means for driving said air impeller unit to rotate about a central axis within said circular wing assembly, so as to provide lift and flight movement while way control is maintained.

2. A circular wing aircraft as recited in claim 1, wherein said upper ring wing includes a plurality of sectional flaps that are independently controllable about the outer circumference for better lift and maneuverability.

3. A circular wing aircraft as recited in claim 2, wherein each said wing mount is airfoil-shaped in cross section and includes a movable flap at its outer edge, to increase and decrease a twisting force for yaw control.

4. A circular wing aircraft as recited in claim 3, wherein said mounting means includes a plurality of suspension members radially spaced apart about the central axis, with each said suspension member extending between a top surface of said fuselage and a bottom surface of said lower disc wing.

5. A circular wing aircraft as recited in claim 4, wherein each said suspension member is independently length adjustable, allowing said circular wing assembly to be tilted in any direction relative to said fuselage, thus allowing said fuselage to stay level in horizontal flight and includes a first rubber shock absorber connector at the top surface of said fuselage and a second rubber shock absorber connector at the bottom surface of said lower disc wing, so that vibration can be reduced, resulting in a low noise level in said fuselage.

6. A circular wing aircraft as recited in claim 5, wherein said air impeller unit includes:

a) a hub;

b) a plurality of curved blades extending radially from said hub; and

c) a drive shaft extending from said hub through the central axis to said driving means, so that said curved blades can rotate with said hub on said drive shaft, to draw air from the top,and blow the air out at a high velocity in radial directions over the top surface of said lower disc wing, to create a low pressure zone on the top surface with static air pressure beneath said lower disc wing, providing a lifting force perpendicular to the bottom surface of said lower disc wing, while the air is also blown above a top surface and below the bottom surface of said upper ring wing, respectively creating an additional lift.

7. A circular wing aircraft as recited in claim 6, wherein said driving means is an engine directly connected to said circular wing assembly and coupled to said drive shaft.

8. A circular wing aircraft as recited in claim 7, wherein said upper ring wing is hollow having an annular chamber therein to be used as a fuel tank, thereby allowing maximum space within said fuselage for a payload.

* * * * *

US005653404A

United States Patent [19]
Ploshkin
[11] Patent Number: 5,653,404
[45] Date of Patent: Aug. 5, 1997

[54] **DISC-SHAPED SUBMERSIBLE AIRCRAFT**

[76] Inventor: **Gennady Ploshkin**, 5987 Chippewa Rd., R.R. #5, Duncan, B.C., Canada, V9L 4T6

[21] Appl. No.: **422,897**

[22] Filed: **Apr. 17, 1995**

[51] **Int. Cl.**[6] **B64C 29/00**; B64C 11/46; B64C 27/10

[52] **U.S. Cl.** .... **244/12.2**; 244/15; 244/23 C; 244/69; 244/73 C; 244/91

[58] **Field of Search** .... 244/12.2, 12.4, 244/12.5, 15, 23 R, 23 B, 23 D, 67, 69, 73 C, 91, 23 C; 119/312, 337, 338

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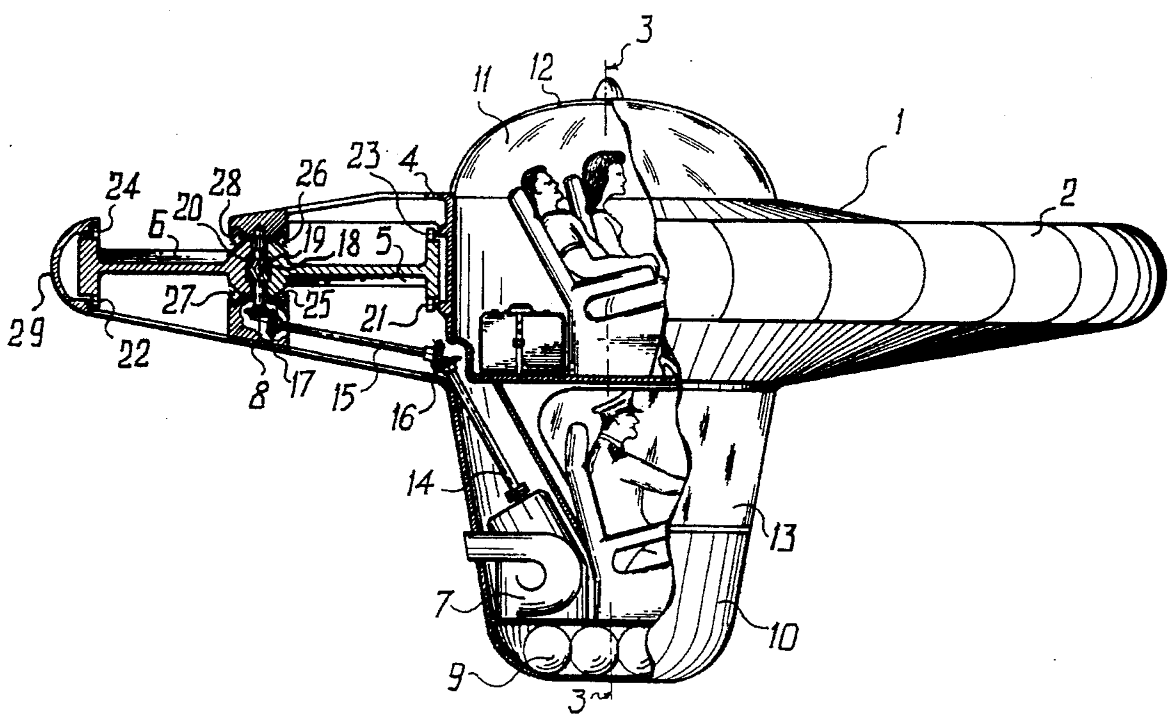
5,039,031	8/1991	Valverde	244/12.2
5,064,143	11/1991	Bucher	244/23 C
5,213,284	5/1993	Webster	244/23 C
5,303,879	4/1994	Bucher	244/23 D

Primary Examiner—Andres Kashnikow
Assistant Examiner—Virna Lissi Mojica
Attorney, Agent, or Firm—Thomas W. Secrest

[57] **ABSTRACT**

An aircraft of disc-shaped configuration provides the capability of vertical take-off and landing; straight horizontal flight; and three-dimensional maneuverability in the air by means of a plurality of counter-rotating lifting rotors assembled of fixed pitch or of self-adjusting pitch aerofoil blade elements; and, submersibility of the aircraft in water is achieved by means of a marine propulsion module using two counter-rotating hydrofoil rotors for up or down thrust, and a tunneled conventional marine propeller for horizontal travel. The marine propulsion module is detachable for emergency and for use with the main frame aircraft of a variety of other detachable modules for different tasks and missions. Exceptionally adaptable for any existing power plant, including nuclear, it is best suited for the environment-friendly types, like integrated steam motor on hydrogen and oxygen burning. The simplicity of the design and its mechanical efficiency are combined with several novel safety features, while displaying an attractive technological continuity for any conventional aircraft manufacturer. The downstream of air from the lifting rotors utilized for maneuvering by a system of vanes positioned below the rotors.

86 Claims, 11 Drawing Sheets



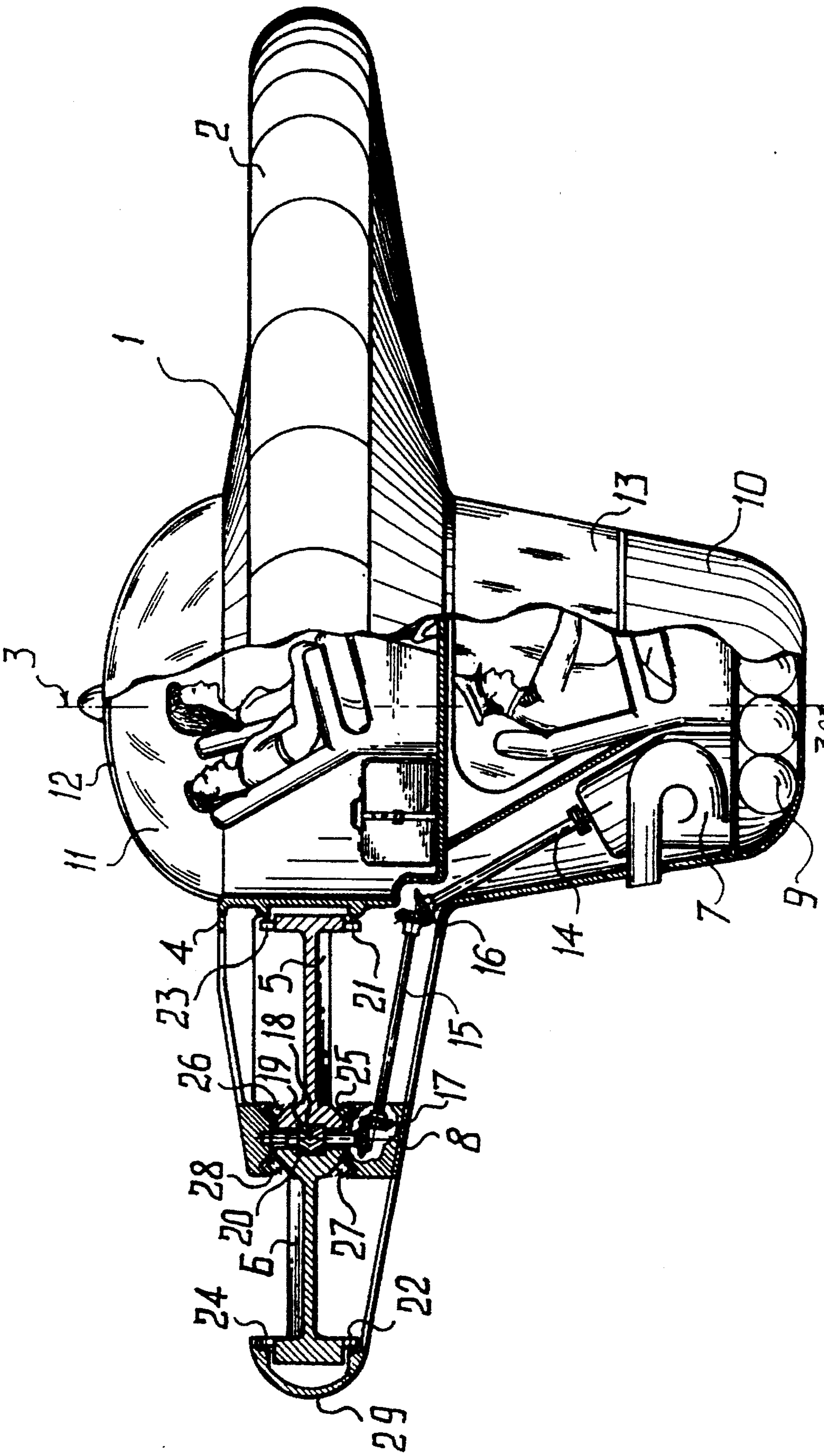

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FIG. 1

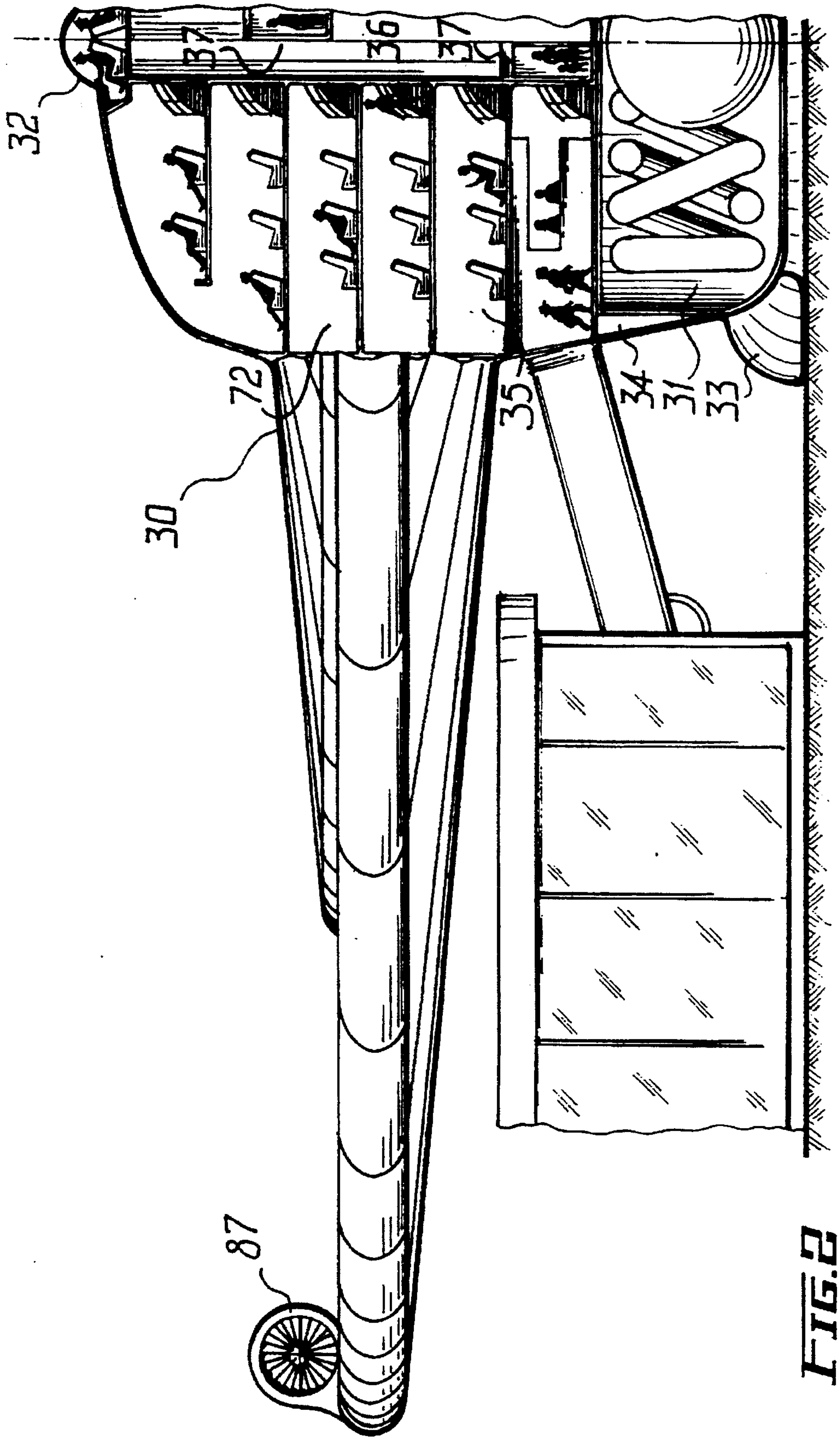

FIG.2

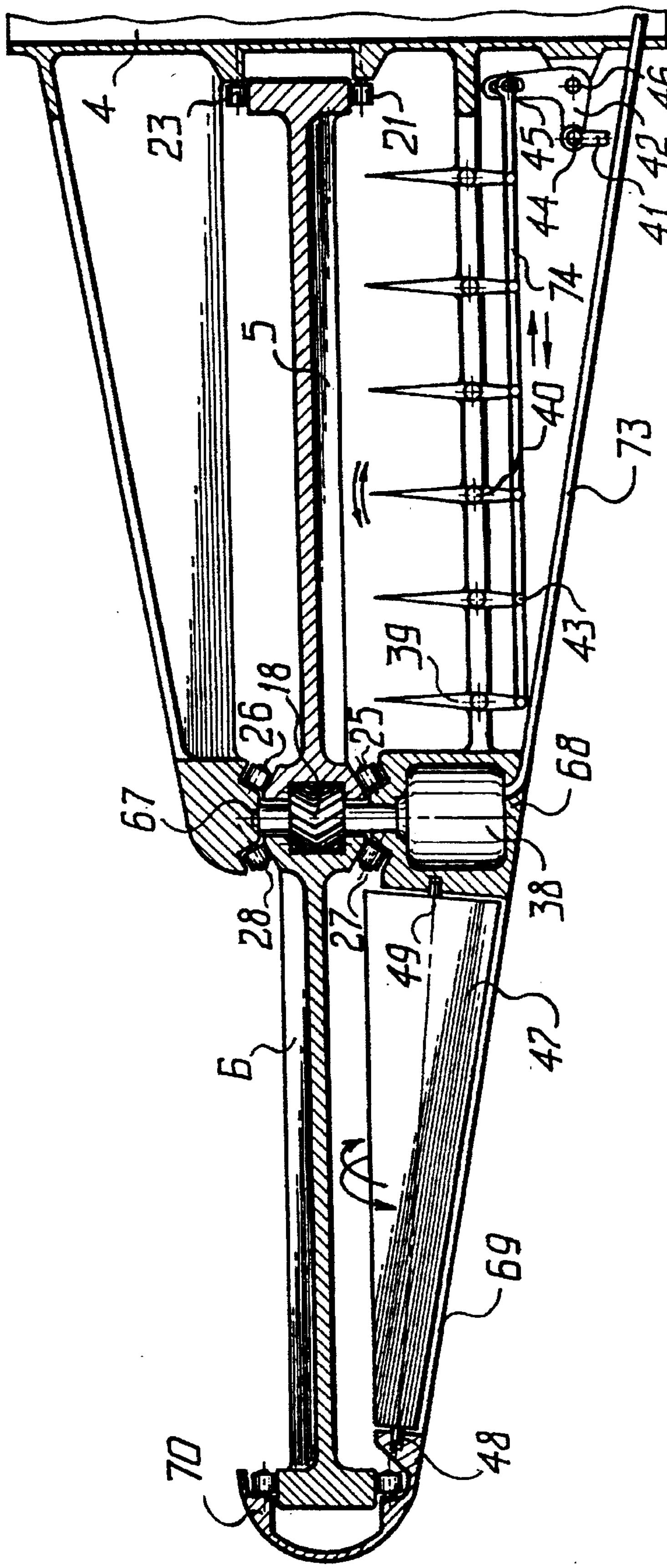
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FIG. 3

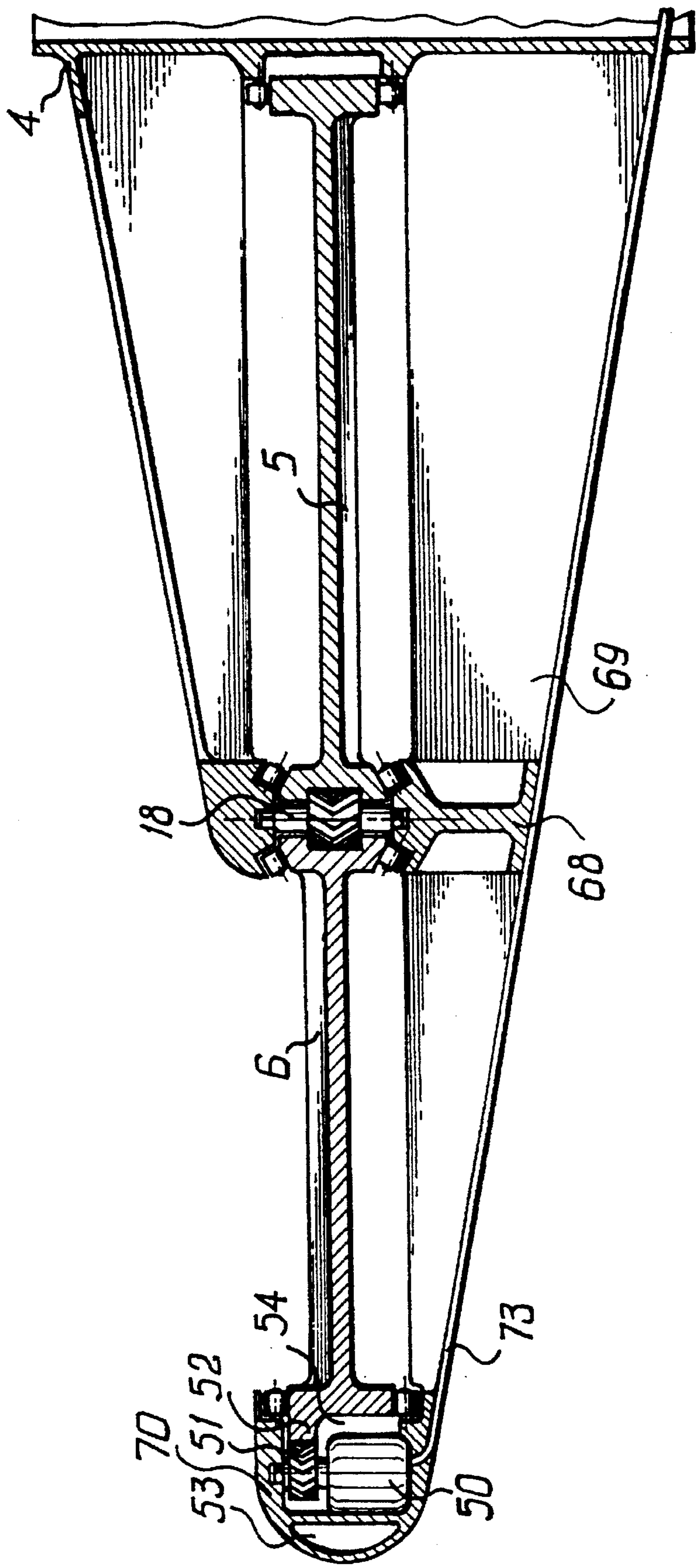

FIG. 4

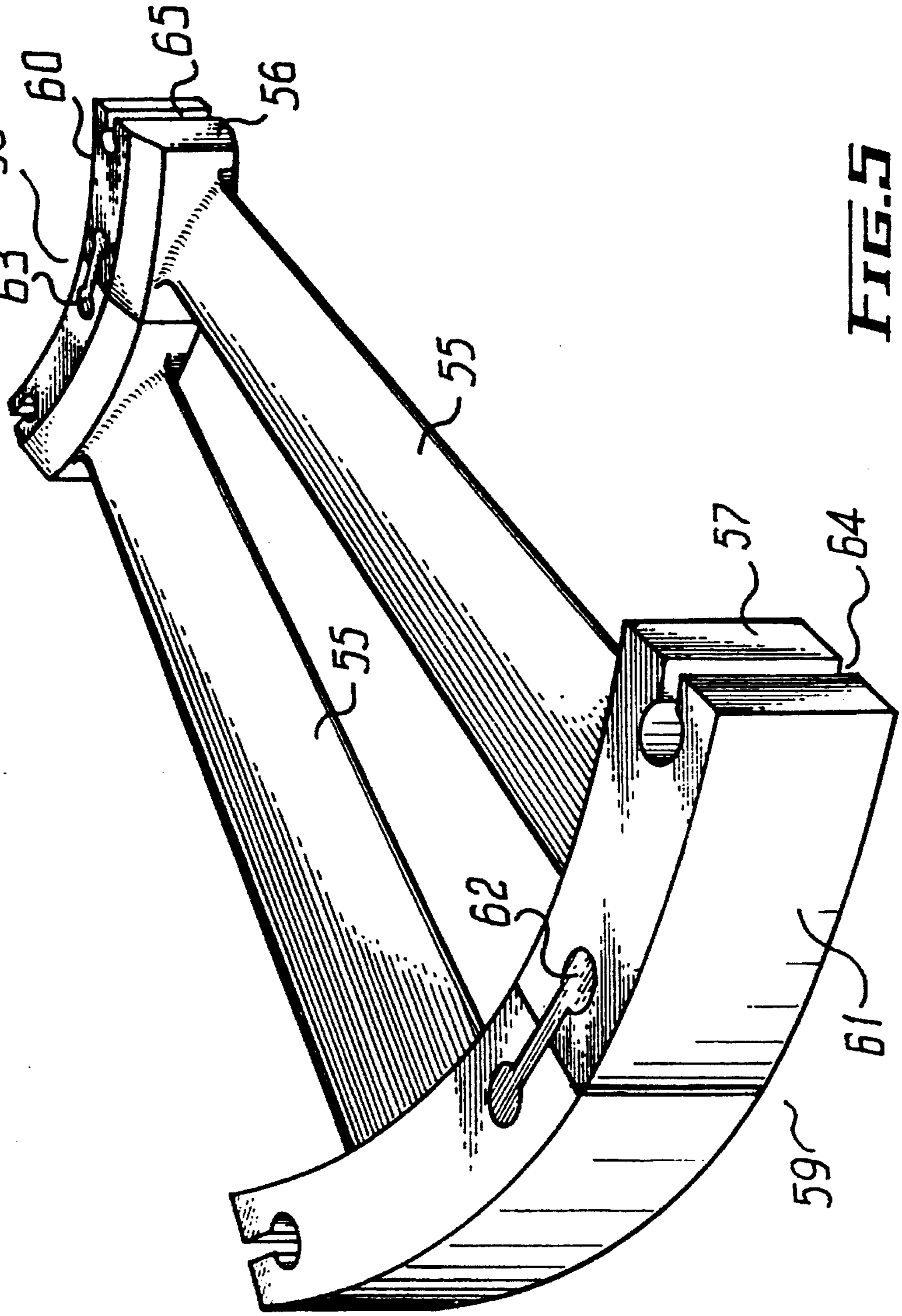

FIG. 5

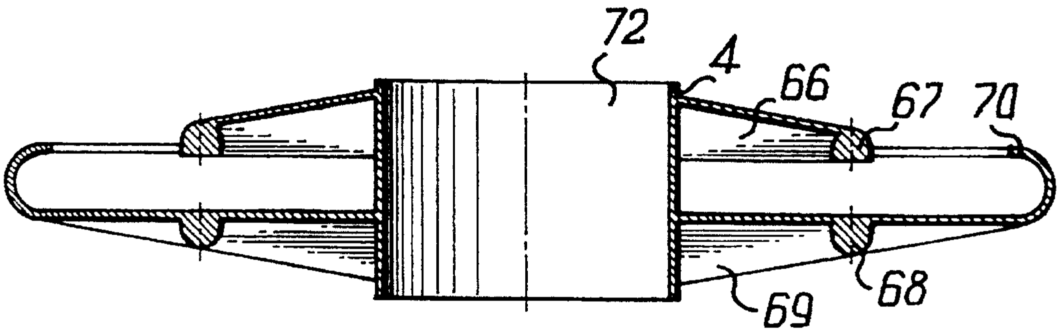

FIG. 6

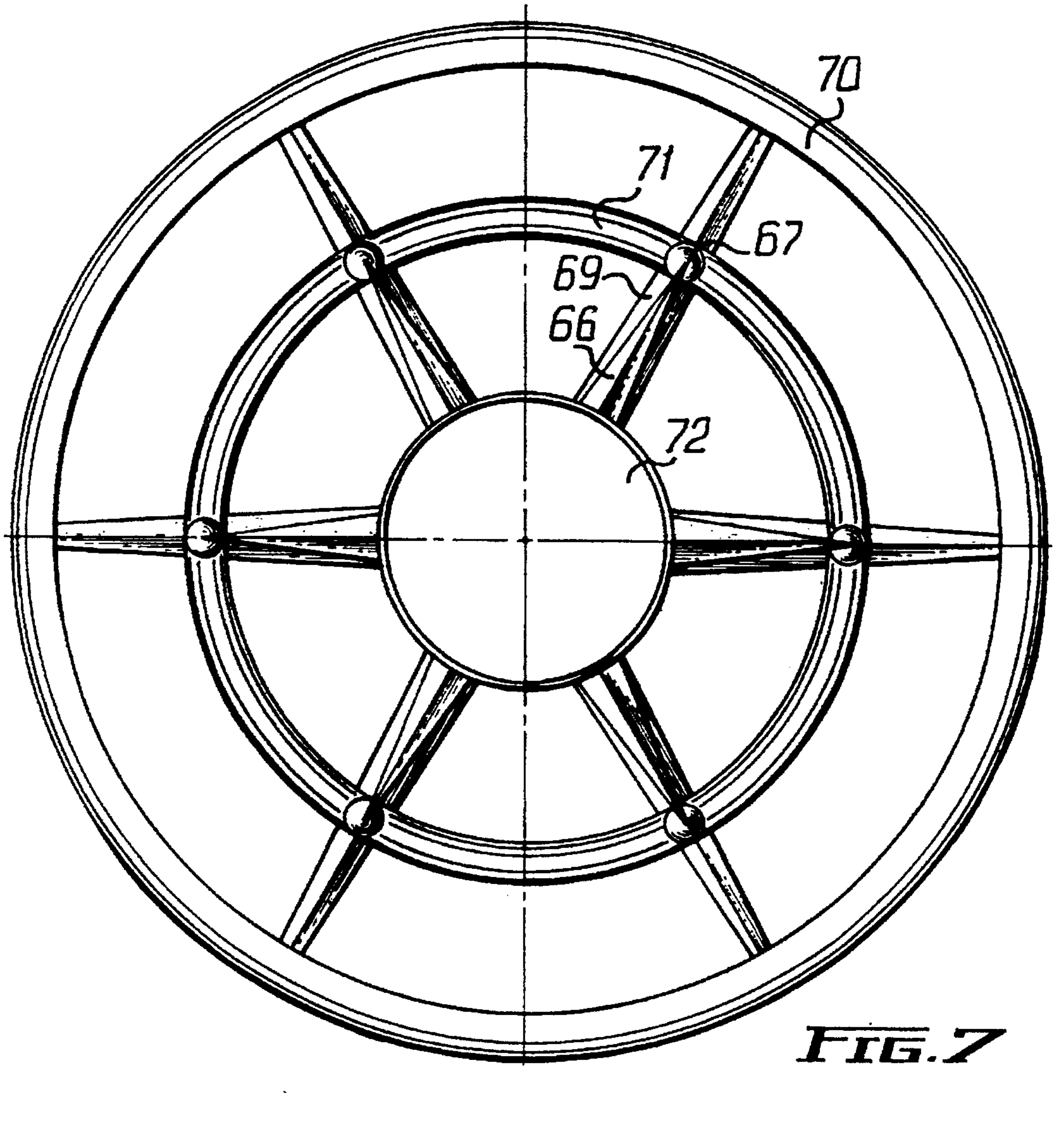

FIG. 7

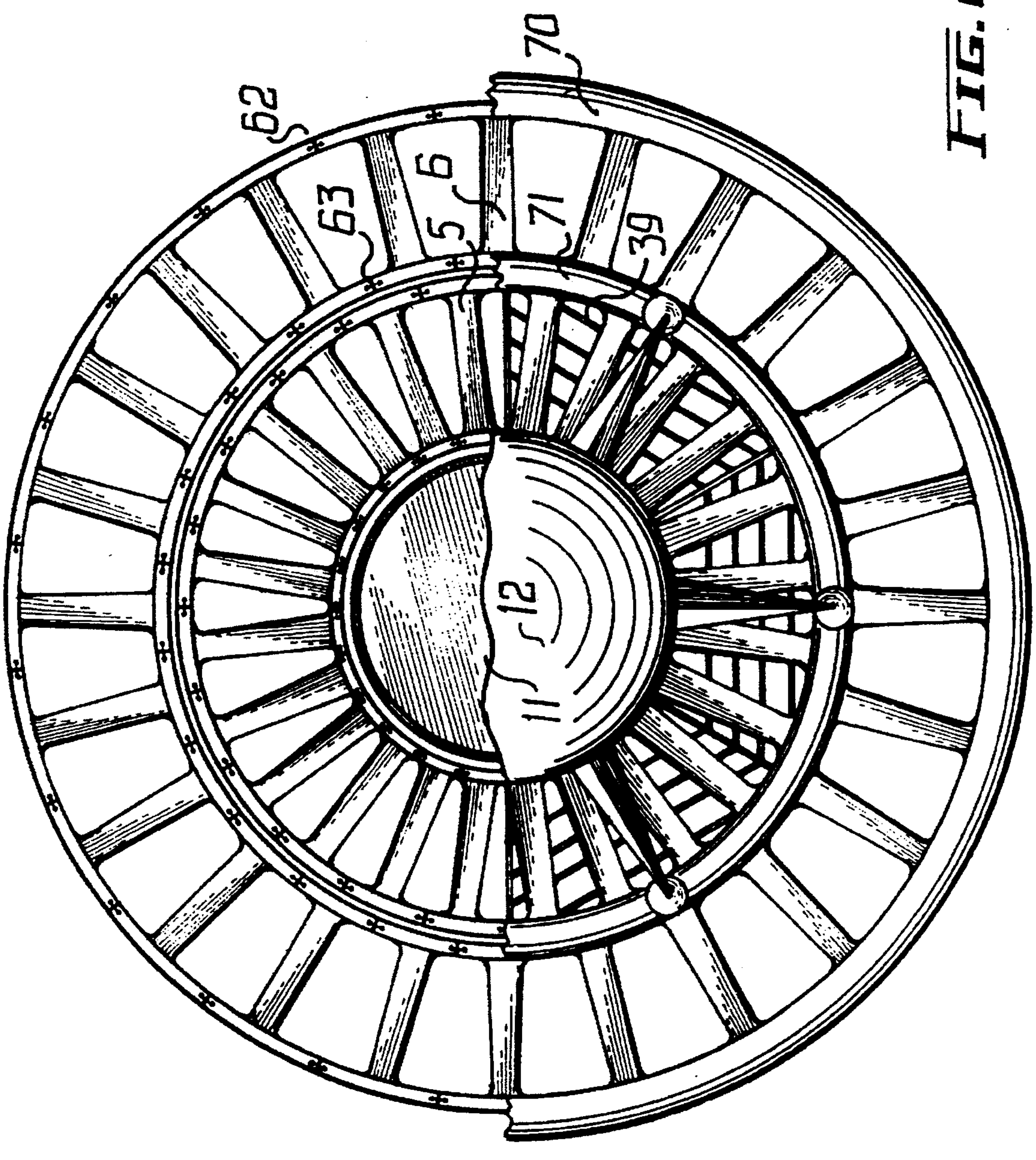

FIG. 8

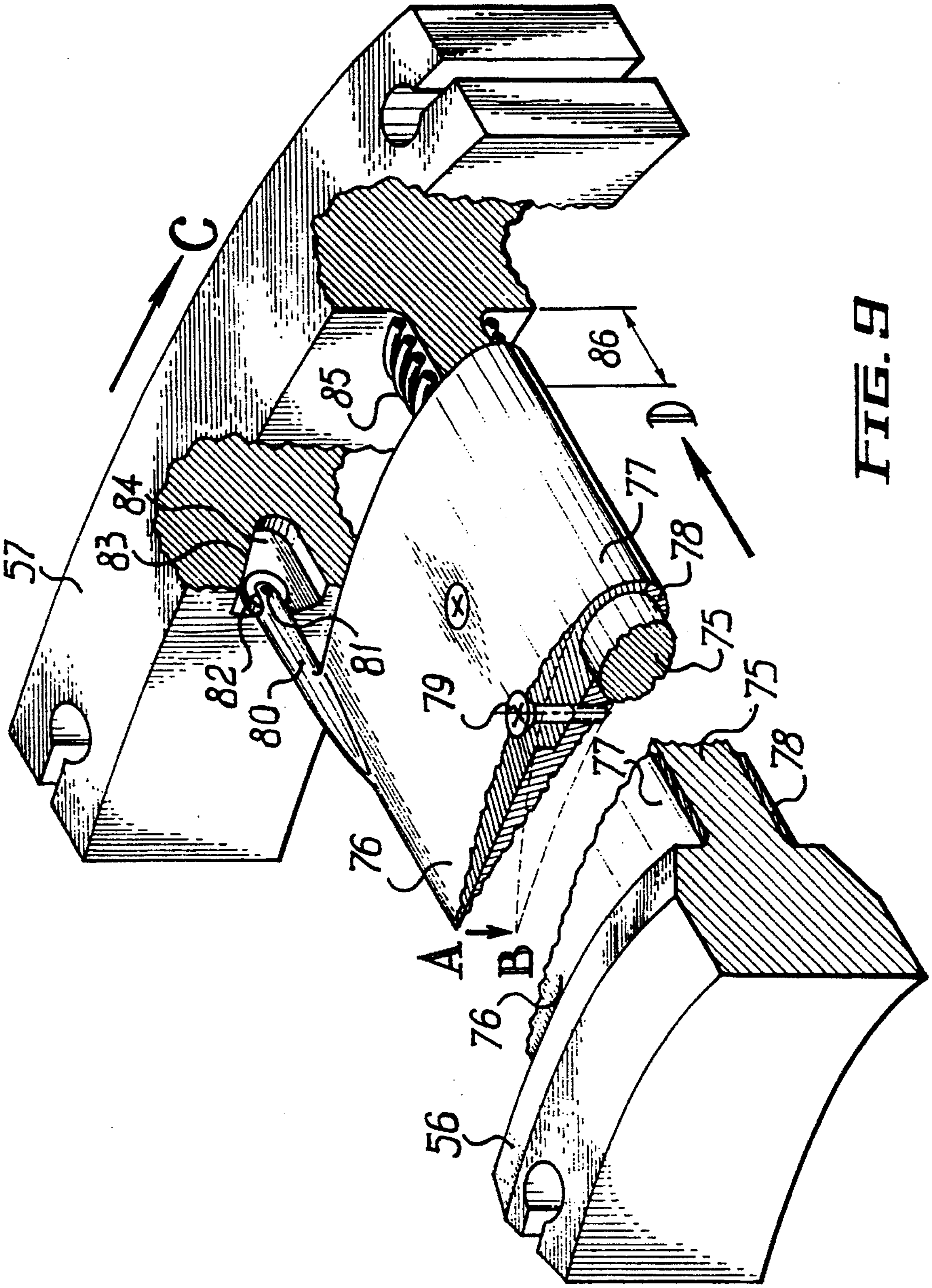

FIG. 9

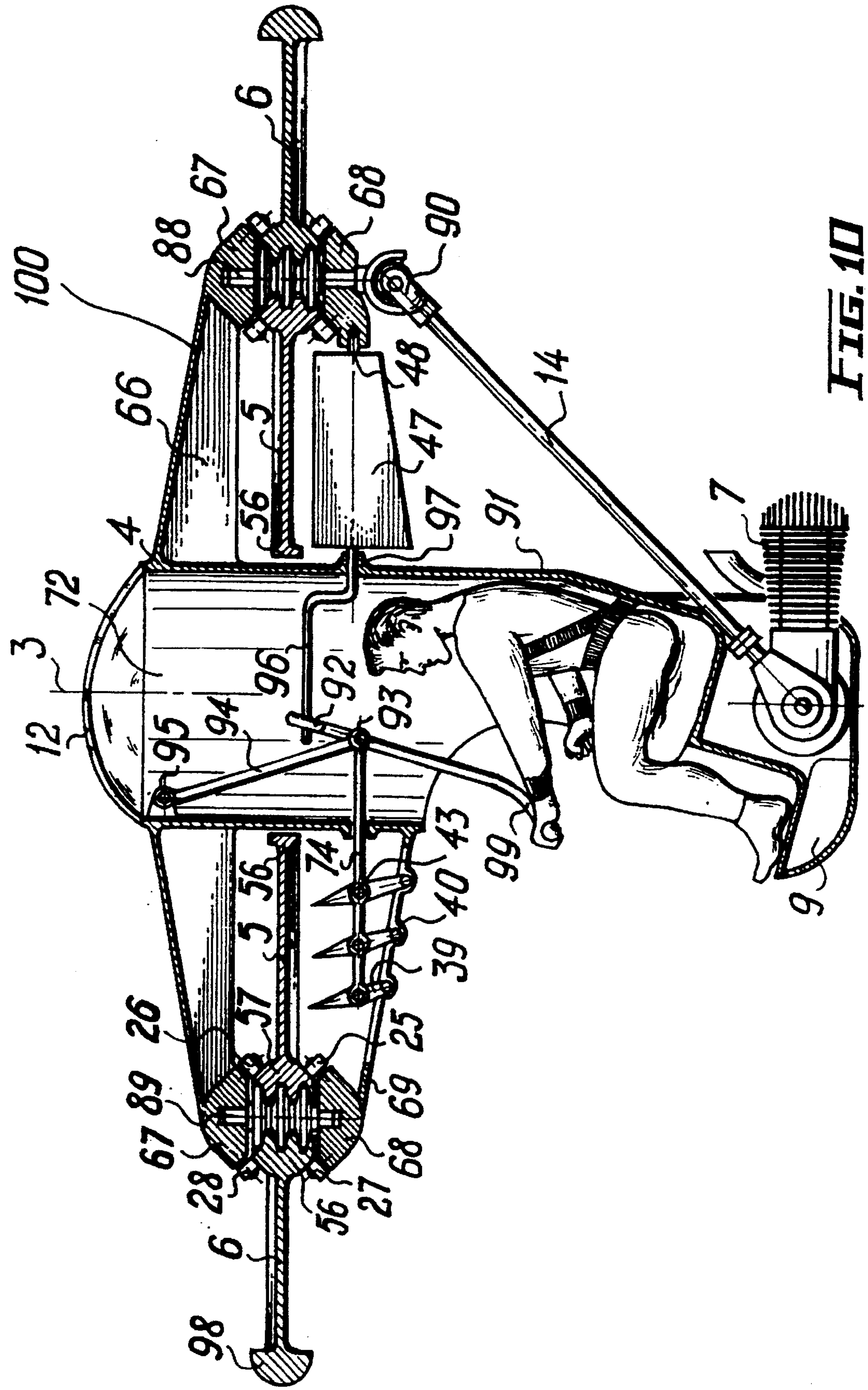
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FIG. 10

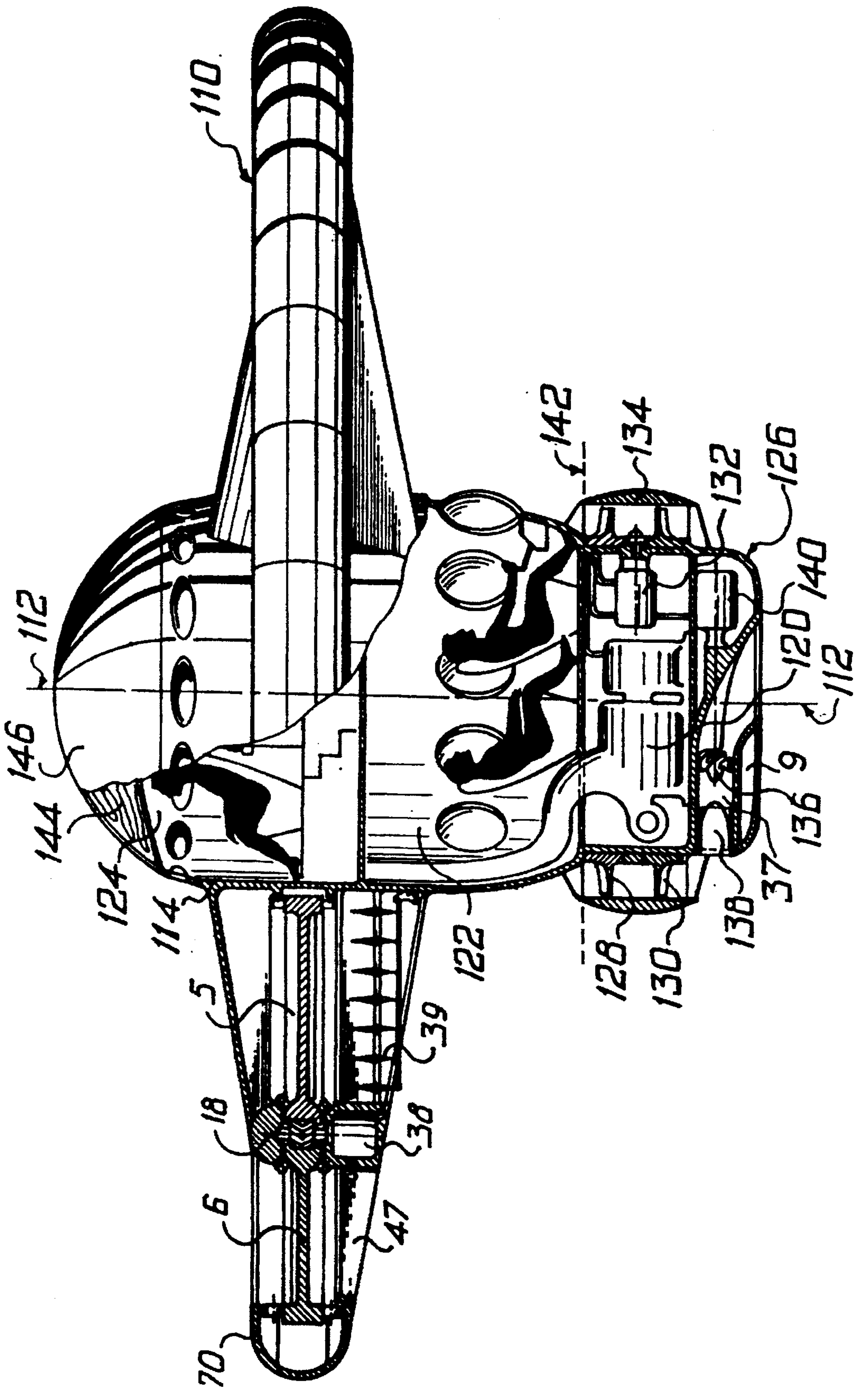
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FIG. 11

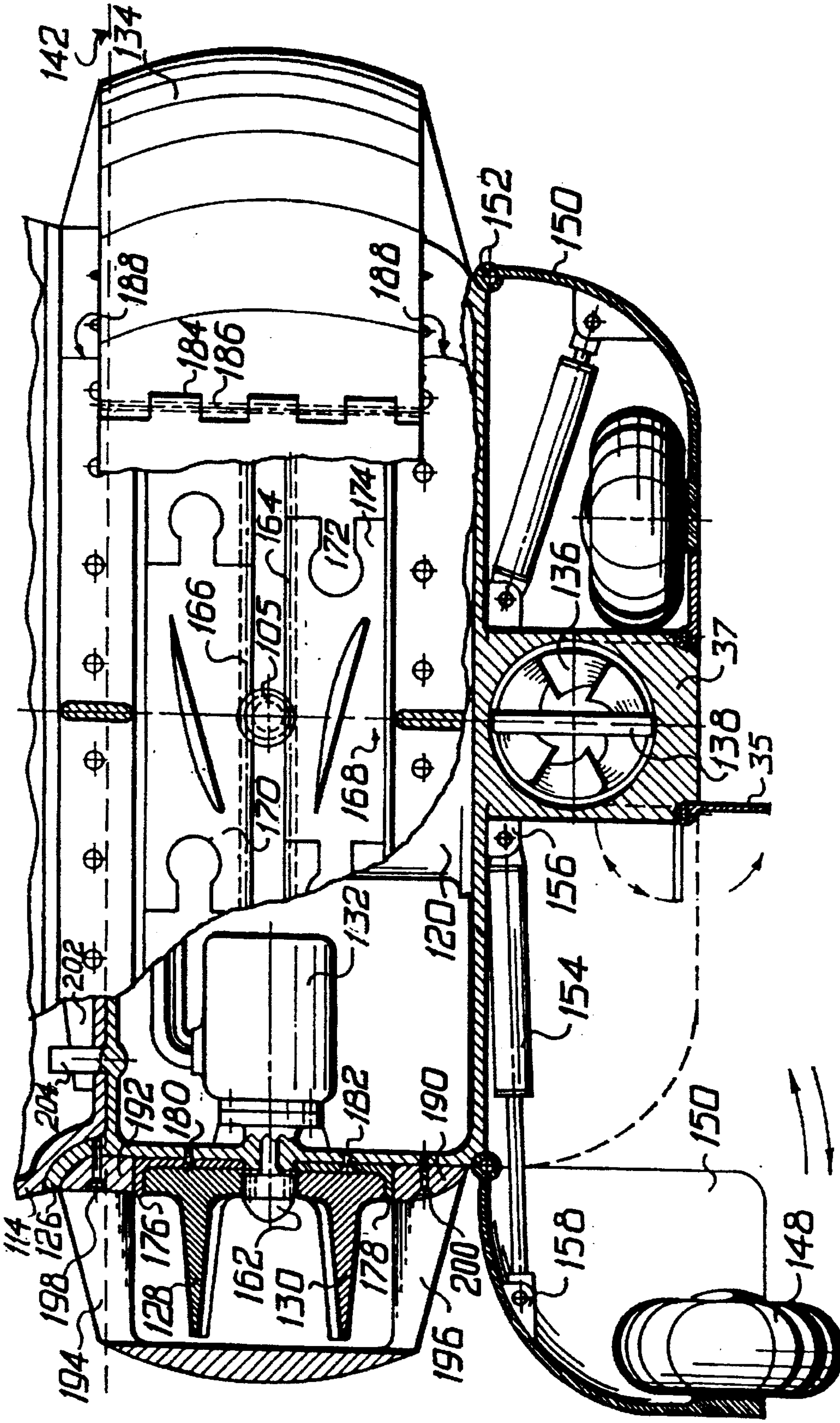
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FIG. 12

DISC-SHAPED SUBMERSIBLE AIRCRAFT

STATEMENT AS TO RIGHTS TO INVENTIONS

MADE UNDER FEDERALLY-SPONSORED RESEARCH AND DEVELOPMENT (if any)

This invention was conceived and developed to the present state with private money and without any financial assistance from the federal government.

CROSS-REFERENCE TO RELATED APPLICATIONS

There is an Integrated Steam Motor, pending U.S. patent application Ser. No. 08/103,546 of Aug. 9, 1993. This steam motor will be referred to as the best power source for the SUBMERSIBLE AIRCRAFT. However, this aircraft is not limited to any particular type of prime mover. Moreover, one of the advanced features of the aircraft is its adaptability to a wide variety of existing power plants.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to aircraft and, more particularly, to aircraft with vertical take-off and landing capability having counter-rotating rotors. Among the most successful concepts derived from the pursuit of an idea of aircraft of similar capabilities is the helicopter. Known for several severe disadvantages, the helicopter remains as primitive and inefficient in its use of power as it was at its inception. The most mechanically efficient way to turn a rotor for vertical flight would be not at its axis as in helicopter, but at the periphery similar to a starter turning a large flywheel of an engine. This approach dramatically improves the design of vertical take-off and landing aircraft in its variety adding a number of capabilities unattainable by helicopter concept.

Presently, there is considerable interest in providing improved types of vertical take-off and landing aircraft for wide variety of purposes, especially those which are energy-efficient and, therefore, environment and people-friendly.

The present invention relates to aircraft and, more particularly, to aircraft with vertical take-off and landing capability; three-dimensional freedom maneuverability in the air; and, three-dimensional freedom maneuverability in the water. Among the most successful concepts derived from the pursuit of an idea of aircraft of similar capabilities is the helicopter. Since first conceived by Leonardo da Vinci over 500 years ago, the idea of "screwing-up into the air with the help of the Archimedean (287–212 B.C.) screw", remains the most popular among aircraft manufacturers. This is so, regardless how mechanically inefficient and limited in performance, not to mention the technological costs, the helicopter remains. In my opinion, the most mechanically efficient, and, therefore, most economical way to turn a rotor for vertical lift-off, is not at its axis (da Vinci's idea used in helicopters), but at the periphery of the rotor. The way relatively small electric starters manage to turn multi-cylinder engines is to apply the torque to the outside rim of a large diameter flywheel as evidenced by a starter on a flywheel of an internal combustion engine. This results in "better leverage." This approach to the design of a vertical take-off and landing aircraft appears to be a radical departure from da Vinci's concept. However, torque applied at the periphery of the rotor rewards this new aircraft concept with major capabilities unattainable by the helicopter concept of an Archimedean screw. Therefore, the field of this invention is a multipurpose aircraft with V.T.O.L. (vertical take-off and landing) capabilities; three-dimensional maneuverability; capable of landing on water; and, operating underwater with three-dimensional freedom. This invention is superior to helicopters and any prior art in any size, powered by any engine. Simultaneously, it remains technologically less costly, easier, safer and more enviromental-friendly and people-friendly.

The present invention provides an improved aircraft of the above-mentioned type capable of performing hovering flight with controlled translational and vertical movement in all directions and also having good flight abilities in horizontal flight. This invention also provides an aircraft with counter-rotating rotors synchronized and balanced to eliminate any residual torque which would otherwise tend to spin the aircraft around its central axis. The rotors coaxially rotating inside each other at even speed provide an upward thrust and assembled of individual aerofoil blade units in a chain-link simple fashion. The aerofoil blades of the lifting rotors are of two types: with a fixed pitch and with a self-adjusting pitch. An aircraft constructed according to this invention may have fixed pitch aerofoil blades in its lifting rotors, or self-adjusting aerofoil blades, or a combination of both of these features. Apart from a favorable gyro-stabilizing effect of the counter-rotating rotors upon the aircraft, this invention provides an aircraft with a high mechanical efficiency at a comparatively lower technological cost than a conventional helicopter. This is so whether it is an ultra-light motocycle engine-powered model, or a nuclear-powered heavy lifting capacity multi-purpose aircraft constructed according to this invention.

(2) Description of the Related Art

The attempts to imitate U.F.O.s (unidentified flying objects) in shape, speed and maneuverability have been made by various inventors of, perhaps, many nationalities long before the phenomena was widely publicized. The Austrian inventor, Viktor Schauberger, had his "Schriever-Habermohl" flying disc, reportedly, in 1944. It was reported that this flying disc could climb vertically up to 12,000 meters in 3.12 minutes and could fly horizontally at a speed of 2,000 km/hr. It had a diameter of 1.5 meters, weighed 135 kg, and was started by an electric motor of 1/20 horsepower. The American and Russian scientists, familiar with Viktor Schauberger's experiments, did not develop these Schauberger's flying disc into a commercial success or are using his ideas for developing secret weaponry.

Until the force of gravity is fully manageable for commercial use, the dreamers, like myself, will keep trying to imitate the legendary spacecrafts. In this area of endeavor and among the patents found in my patentability research, there are two relevant patents, viz., Franz Bucher, U.S. Pat. No. 5,064,143, and Steven Webster, U.S. Pat. No. 5,213,284. Both inventors offer a rather complex engineering solution for the use of lifting rotors. The result is a product of a high technological cost and a low reliability. Apart from the fact that these inventors use counter-rotating lifting rotors for vertical take-off and landing, and vane systems, positioned below said rotors, to provide maneuverability, their patents and teachings are not in conflict in any way or form with the present invention.

PRIOR ART

Prior to preparing this patent application, I made this search of the patent art at the Sunnyvale Patent Library, Sunnyvale, Calif., as well as at the University of British

Columbia, Vancouver, Canada, and found the following interesting patents:

PATENTEE	PATENT NUMBER	YEAR
DAVIS	2,863,621	12/1958
GRAYSON	2,935,275	3/1960
FROST, et al	3,018,068	1/1962
LENT	3,034,747	5/1962
GIBBS	3,041,012	6/1962
BARR	3,067,967	12/1962
SLAUGHTER	3,123,320	3/1964
LENNON, et al	3,312,425	4/1967
HAGGERTY	3,606,570	9/1971
PINTO	3,774,865	11/1973
MACNEILL	4,014,483	3/1977
BUCHER	5,064,143	11/1991
VALVERDE	5,039,031	8/1991
WEBSTER	5,213,284	5/1993.

In reviewing these patents, I have found that none of the above-noted patents, either singularly or in combination, are seen to disclose the specific arrangement of concepts disclosed by the present invention.

SUMMARY OF THE INVENTION

There is disclosed an aircraft capable of movement in three directions, in Cartesian coordinate terms the x-y-z directions, in the air. The movement can be a combination of vertical and horizontal.

The aircraft comprises a frame, an engine or power plant and two counter-rotating rotors. The engine or power plant through suitable gearing rotate simultaneously the two counter-rotating rotors. There are vanes for vertically positioning and horizontally positioning the aircraft.

Further, this aircraft is submersible in water. This aircraft can move on water or below the surface of the water. The aircraft has three-dimensional movement in the water such has in the x-y-z directions. The aircraft can have various horizontal positions and also various depth positions in the water. The aircraft can move in the water, on the water and in the air.

OBJECTS AND ADVANTAGES

A primary object of this invention is to provide an aircraft of the above-mentioned characteristics and capable of performing movements with three-dimensional freedom and designed speed while retaining horizontal stability at all times, either in hovering over one spot, or flying unidirectionally at a maximum speed.

Another object of the invention is to provide an aircraft adaptable to many existing engines or power plant types, including nuclear power, while best suited for environment-friendly Hydrogen fired Integrated Steam Motor (pending U.S. patent application Ser. No. 08/103,546 of Aug. 9, 1993) offering quiet, vibration-free, exceptionally reliable service for both aero- and underwater operation;

A further object of this invention is to provide an aircraft capable of operating quieter than any existing rotary wing aircraft type by lowering the speed of rotation of the lifting rotors while spreading the load on a larger number of aerofoil blades of higher aspect ratio;

Still another object of this invention is to provide an aircraft with such a mechanical efficiency and lifting capacity as to be suitable for a nuclear power plant as its prime mover which would be providing an unlimited operational range in the air unattainable by conventional aircraft.

A still further object of this invention is to provide an aircraft of such exceptional inherent stability, derived from the gyro-stabilizing effect of its counter-rotation lifting rotors, as to assure its safe and reliable operation in practically any weather conditions in search and rescue missions, for example, over the sea;

Still another object of this invention is to provide an aircraft with outstanding survivability characteristics, featuring a detachable, in emergency, parachutable module of a marine propulsion unit, combined with power plant and fuel tanks, and other heavy items; also, including an automatically inflatable balloon/parachute combination, stored in the emergency gear compartment under the dome-like hood;

Still another object of this invention is to provide an aircraft of such technological continuity as to allow any conventional aircraft manufacturer switch to its production without major re-tooling and workforce re-training;

Yet another object of this invention is to provide an aircraft of such simplicity of construction and operation as to allow its owners/operators to switch to, let us say, scheduled operation of this aircraft with a minimum of retraining of conventional aircraft pilots and ground crews, while enjoying low operating costs, maximum safety and reliability;

Another object of this invention is to provide an aircraft of such low production and operating costs, simplicity, safety and dependability in its basic non-submersible version as to become a consumer means of mass and personal transportation comparable to the automobile;

Another object of this invention is to provide an aircraft adaptable to any, whichever is more suitable for the size and service type of the aircraft, power transmission drives within the craft, from a simple mechanical to hydraulic, electrical and even magnetic drives;

Yet another object of this invention is to provide an aircraft adaptable to a variety of detachable modules designed specifically for a particular task, or mission; such as marine propulsion, jet-propulsion, heavy lifting, fire-fighting, and so on, each detachable module having a different prime mover and fuel capacity, and type of landing gear;

Still another object of this invention, is to provide an aircraft with such a high mechanical efficiency and simplicity of design that allows a wide variation of its size from an ultra-light to a nuclear-powered inter-continental carrier without sacrifice of simplicity, reliability, mechanical efficiency and safety;

A further object of this invention is to provide an aircraft with underwater operational capabilities and underwater maneuverability presently affordable only by specialized submersible boat types, without complicating and sacrificing its aircraft capabilities and related hardware;

Another object of this invention is a self-adjustable aerofoil blade element connected to other blade elements in a chain-link fashion to comprise the lifting rotor. The self-adjustable pitch mechanism is simple, reliable, technologically cost-effective and requires minimum power at the aircraft start-up time, because all the aerofoil blades of the rotor would be positioned at zero pitch (no lifting thrust produced) for lack of centrifugal forces in the lifting rotor. Similarly, the chain-link fashion of assembling aerofoil and hydrofoil rotors for the aircraft of the present invention is a simple, reliable and technologically cost-effective way of assembling large and very large aerofoil and hydrofoil rotors, it also greatly reduces manufacturing and maintenance costs of such rotors.

Other and further features and objects of the invention will be more apparent to those skilled in the art upon a consideration of the appended drawings and the following description wherein a constructional form of apparatus for carrying out the invention is disclosed;

Additional objects, advantages and novel features of the invention will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following or may be learned by the practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a fragmentary vertical cross-sectional view of the aircraft embodying this invention constructed with a conventional mechanical power transmission as a limited range public transportation vehicle.

FIG. **2** is a fragmentary vertical cross-sectional view through a half of a nuclear-powered intercontinental passenger aircraft constructed in accordance with the teachings of this invention.

FIG. **3** is a partial cross-sectional view of counter-rotating lifting rotors with a speed-synchronizing gear drive and also showing maneuvering vanes;

FIG. **4** is a partial cross-sectional view of counter-rotating lifting rotors with a driving gear intermeshing with the outside rim of the outside (largest of the two) lifting rotors;

FIG. **5** is a perspective view of two typical fixed-pitch aerofoil blade elements for a lifting rotor and one of the ways to chain-link them into a rotor assembly;

FIG. **6** is a cross-sectional vertical view of the main frame for a typical aircraft constructed according to the teachings of this invention;

FIG. **7** is a top view of the main frame of FIG. **6**;

FIG. **8** is a top view of a typical aircraft constructed according to this invention, using the main frame of FIGS. **6** and **7** with a fragmentary exposure of the two counter-rotating lifting rotors;

FIG. **9** is a fragmentary perspective cut-away view of the self-adjusting pitch mechanism for an aerofoil blade element with a variable angle of attack for lifting rotors of an aircraft constructed according to the teachings of this invention; and,

FIG. **10** is a vertical cross-sectional view of an ultra-light model of an aircraft constructed according to the teachings of this invention and illustrating a simple mechanical transmission and friction drive for two counter-rotating lifting rotors.

FIG. **11** is a fragmentary vertical cross-sectional view of an aircraft embodying this invention with a marine propulsion capability for underwater travel and maneuvering; and,

FIG. **12** is a fragmentary vertical cross-sectional view of a detachable (for emergency surfacing or landing) marine propulsion/power plant/retractable landing gear module.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to the drawings, wherein like reference characters designate identical or corresponding parts, and more particularly to FIG. **1** the reference numeral **1** generally indicates one form of a heavier-than-air aircraft embodying this invention. The aircraft **1**, is comprised of a disk-shaped structure **2** which is substantially symmetrical about a vertical axis **3**. The disc-shaped structure **2** consists of a main frame **4**, which integrates and carries counter-rotating lifting rotors **5** and **6**, a prime mover **7** with a power transmission **8**, fuel tank **9**, a pilothouse **10**, and a payload compartment **11** covered with a weather-proof, transparent cover **12**, in which the pilothouse **10** is fitted with a weather-proof panoramic window **13**. The mechanical power transmission **8**, conveys a needed torque from the prime mover **7**, via the power train comprising shafts **14** and **15**, and bevel gears **16** and **17**, to a speed-synchronizing gear **18**, which drives the coaxial lifting rotors **5** and **6**, in opposite directions at an equal speed by means of toothed bands cut into rims **19** and **20** of the lifting rotors **5** and **6**. The weight of the lifting rotors **5** and **6** is supported by means of carrier bearings **21** and **22**, fitted to the main frame **4**, at several evenly spaced points around the main frame **4**, while the upward thrust from the lifting rotors **5** and **6**, when they rotate, is conveyed to the aircraft via thrust bearings **23** and **24**, also fitted to the main frame **4**, at the points directly opposite the carrier bearing **21** and **22**. While the carrier bearings **21** and **22**, and the thrust bearings **23** and **24**, restrict the up and down movement of the lifting rotors **5** and **6**, they allow some expansion, due to a temperature change, of the rotors outwardly and toward the center of their rotation. Also, to maintain an optimum clearance between toothed rims **19** and **20**, and the speed synchronizing gear **18**, intermeshing with both, bearings **25**, **26**, **27** and **28**, are fitted to the main frame **4**, which also extends into a protective semi-toroidal bumper **29**, guarding the lifting rotors from damage in a mid-air collision, etc. Propulsion means for horizontal flight and three-dimensional maneuvering of the aircraft **1** are not shown on FIG. **1** of a general arrangement and power transmission to the lifting rotors, so that the simplicity of the basic idea of a vertical take-off and landing aircraft adaptable to a variety of means for horizontal flight and maneuvering would not be obscured at this point. Also, an aircraft constructed according to the invention may have more than just two counter-rotating lifting rotors as shown on FIG. **1**, in which case other considerations of improving the mechanical and aerodynamic efficiency of an aircraft would be taken into account. What will remain the same or closely comparable is an exceptional stability of an aircraft constructed according to this invention due to its always low center of gravity along its center of rotation—vertical axis **3**, on one hand, and due to the gyro-stabilizing effect of the lifting rotors **5** and **6**, or more, on another. While FIG. **1** illustrates a basic form of an aircraft embodying this invention, shown in flight, FIG. **2**, represents a nuclear-powered long-range embodiment **30**, on its air-cushion type landing gear **33**, loading at an airport. Despite the apparent difference in size, the aircraft **30** is in many ways identical to the aircraft of FIG. **1**, in which the hollow cylindrical space **72** around the vertical axis **3**, is also utilized for carrying a pilothouse **32**, a payload (passenger accommodation) compartment **35**, and a detachable and parachutable (for emergency landing) power plant module **31**. Adding to the rigidity of a main frame **34**, there is a tubular elevator shaft **36**, with two elevator cars **37**, for convenience of the passengers and crew. A simple and reliable, easily stored in-flight air-cushion landing gear **33**, is best suited for this type of aircraft.

A lifting rotor drive mechanism and a horizontal flight and maneuvering vanes arrangement suitable for either aircraft **1** and **30**, are depicted in great detail on FIG. **3**. Also shown a hydraulic (or electric) transmission motor **38** with its power (fluid or electric) connection **73** from a prime mover. Horizontal flight of an aircraft constructed according to the invention is achieved by directing some of the downflow of air or fluid from the lifting rotors into a substantially horizontal stream opposite to a course chosen by the pilot. This being achieved by means of a system of vanes **39**, pivoted on pins **40**, fitted into the main frame **4**, and controlled, manually or via servo motors, by the pilot with the help of control rods **41** and **74**, linked together into a system by pins **43**, **44**, **45**, **46** and a lever **42**. The number and arrangement of the horizontal flight maneuvering vanes would differ from one aircraft to another, or absent altogether when substituted by an outside mounted propulsion device. However, the simplicity and effectiveness of vane systems in providing an immediate thrust in any direction of 360-degree circle of the aircraft would still be superior considering technological and other costs of external jet propulsion. A turning vane **47**, pivoted at its axis pins **48** and **49**, allows the pilot of an aircraft to turn his craft around its vertical axis **3**, either slow or fast, for only a few degrees or in a complete circle, as for example of having a panoramic view while hovering over one spot or flying in one direction. Again, the number of these vanes may differ from one embodiment of the invention to another, while their simplicity and effectiveness remains the same. Referring now to FIG. **4**, representing the most mechanically advantageous drive for the lifting rotors **5** and **6**, the way it is accomplished in the internal combustion engine starting gear, when a relatively small starter overcomes tremendous opposition of compression in, for example, a multi-cylinder Diesel. Whether hydraulic or electrical transmission is employed, a driving motor **50**, may either be hydraulic or electric. It provides a turning torque to a toothed rim **52**, of the lifting rotor **6**, by means of a gear wheel **51**, fitted to the shaft of the driving motor **50**. In this preferred embodiment of the lifting rotor drive the speed-synchronizing gear **18**, continues to play as an important link in the power transmission conveying a torque from the lifting rotor **6** to **5**, and further down toward the center of an aircraft to as many coaxial counter-rotating lifting rotors as there may be embodied according to the invention. Among other power transmission drives with high mechanical efficiency suitable for this system would be a linear induction motor fitted into a circular space **54** of the main frame **4**, and turning the rim **52** of the lifting rotor **6**, magnetically, rather than mechanically. A circular void space **53**, apart from being a good protective cover and bumper, could be used for storing an inflatable toroid ring for emergency landings to increase a parachute area of the descending aircraft constructed according to the invention, and also increase the buoyancy of same aircraft doing an emergency landing on water surface, for example. Also the void space **53** could be filled with a fire retardant for arresting ignition in a crash, or collision situation. With reference to FIG. **5** there are shown two identical aerofoil blade elements **55** of fixed pitch as compared to a variable, controllable, adjustable or somehow else regulated pitch. With minor variations from one lifting rotor to another for one or another aircraft constructed according to the invention, this is the principal novelty around which the present invention evolves. The simplicity of assembling rotors in chain-link fashion out of identical aerofoil blade elements extends further into the simplicity of maintenance, replacement of damaged ones, balance of the rotors, etc. And, as the result, out of simplicity come higher mechanical efficiency, lower technological cost and the overall cost efficiency of an aircraft constructed according to the invention, from its manufacturing to its operation. Returning now to FIG. **5**, there are hubs **56** and **57** of the blade element **55**, which, when linked to other identical elements by bonds **62** and **63**, form an inner rim **58** and an outer rim **59** of a lifting rotor. Surfaces **60** and **61** would normally carry either cut-in gear teeth, friction groves or, if it is an outer rim of the outside (largest in the system) rotor with a magnetic drive, elements of a linear induction motor, or any other adaptable power transmission means. The shape and positioning of the bonds **62** and **63** would differ from one embodiment of this invention to another, but the simplicity and rigidity of the assembly will remain.

In FIG. **6**, there is shown a cross-sectional vertical view of the main frame **4** of an aircraft constructed according to the teachings of the invention. There are radially extended support arms **66** having hubs **67** for incorporating the bearings **26** and **28** of FIGS. **1** and **3** and the upper bearing **68** of the speed-synchronizing gear **18**. There are hubs **68** incorporated into lower radially extended supporting arms **69**. These hubs serve as housings for the bearings **25** and **27** and the power transmission **8**, of FIG. **1**, or for the hydraulic (or electric) transmission motor **38** of FIG. **3**. These lower supporting arm hubs **68** of the main frame **4** also provide pivoting points for the vanes **39** and **47** of FIG. **3**. To further add to the structural rigidity of the main frame **4**, the lower radial supporting arms **69** are connected by a semi-toroidal rim **70**. The rim also serves as a protective cover for the outer lifting rotor rim **52** and the power transmission components **50** and **51** of FIG. **4**. The rim also serves as well as a housing for stator windings of a linear induction motor drive, when magnetic drive is chosen for use in this invention. A top view of the main frame **4** is shown on FIG. **7**. FIG. **7** outlines an important structural element of the main frame, otherwise hidden, a cover **71**. A semi-toroidal cover **71** connects the hubs **67** to its rigid ring and simultaneously covers the gap between the counter-rotating rotors **5** and **6** of FIGS. **1**, **3**, and **4** against unwanted elements. A void cylindrical space **72** of the main frame **4** is a perfect location at the center of gravity for housing a power plant, a payload compartment and a pilothouse as shown on FIGS. **1** and **2**. This cylindrical space and associated equipment provides for an exceptional stability unattainable by conventional aircraft. This void space **72** is easy to load and to drop off in emergency along with the above-mentioned parachutable modules comprising a power plant and the non-essentials.

With reference to FIG. **8**, it is seen that FIG. **8** is a top view of an aircraft constructed according to the invention. There is a fragmentary exposure of the two counter-rotating lifting rotors **5** and **6** of FIGS. **1**, **3**, **4** and the bonds **62** and **63** of FIG. **5**, between individual aerofoil blade elements **55**. The payload compartment **11** is covered with a dome-like cover **12**. The compartment **11** is shown empty in order to avoid any scale-related comparison while emphasizing the similarity of appearance regardless of the size of aircraft constructed according to the invention. Looking down on this embodiment of an aircraft, one can see the horizontal flight maneuvering vanes **39** of FIG. **3** arranged into **6** sectors of 60 degrees each covering the entire 360 degree circle around the central payload housing of the aircraft. Looking at this embodiment of the invention, it becomes apparent that with all the structural rigidity of the main frame **4**, the counter-rotating lifting rotors **5** and **6**, are sufficiently exposed to the airflow for a maximum aerodynamic efficiency. This is so regardless of the size of an aircraft and the number of the counter-rotating lifting rotors. A further development of the aerofoil blade element **55** of FIG. **5** is shown on FIG. **9**. The element **55** has a self-adjustable pitch from zero to maximum pitch. There is illustrated as Position A of the trailing edge of a blade **76**. Position A, in solid line, corresponds to zero pitch. Position

B, in broken line, corresponds to the maximum pitch. The aerofoil blade **76** can automatically turn from zero pitch to maximum pitch, from A to B of its trailing edge position in the following manner. The aerofoil blade **76** is assembled of two halves: top **77** and bottom **78** by means of screws **79**. The aerofoil blade **76** has a sufficient clearance around a connecting rod **75** to slide between the hubs **56** and **57**. This makes it possible to either open a gap **86**, maintained (when a lifting rotor, comprised of a plurality of these aerofoil blade elements, is not rotating) by a spring **85**. Or, to close the gap under the pressure of centrifugal force, acting upon the aerofoil blade **76** in the direction D when the lifting rotor turning in the direction C reaches a certain speed of rotation. The movement of the aerofoil blade **76** around the connecting rod **75** is limited to only two position of its trailing edge A and B by a control rod **80** integrated with the aerofoil blade **76**. The control rod **80** on its free end has a shaft **81** or pin **81** and on which rotates a roller **82**. This roller **82** and the rod **80** position the aerofoil blade **76**.

In a hovering position the lifting rotor comprised of these self-adjustable aerofoil blade elements, the spring **85** is pushing the aerofoil blade **76** to its start-up position close to the hub **56**, while simultaneously overcoming the weight of the aerofoil blade and keeping it in Position A. In Position A trailing edge of aerofoil blade **76** corresponds to Zero Pitch. Upon starting the rotation of the blades **76** the pitch is Zero Pitch of the blade **76** is in Position A, solid line. As the lifting rotor **5** and **6** reaches a certain speed of rotation, the weight of the aerofoil blade **76**, increased by centrifugal force, will overcome the resistance of the spring **85** and begin to close the gap **86** and move toward the hub **57**. In the process the control rod **80** with roller **82** will move along a guiding path **83** of a control slot **84**. This secures the trailing edge of the aerofoil blade **76** in the Position B, in broken line, corresponding to a Maximum Pitch. The aerofoil blade **76** remains in Position B as long as the rotating speed of the lifting rotor **5** or **6** remains the same or higher. After an aircraft has landed and its lifting rotors **5** or **6** begin to slow their rotation, disengaged from the power source, the G-forces acting upon the aerofoil blade **76** decrease to the point where the spring **85** can return the blade **76** to the initial Zero Pitch Position A. The lifting rotors **5** or **6** of an aircraft constructed according to the invention may have only the fixed-pitch aerofoil blade elements; only the self-adjustable ones; or a combination of both. Both types in their preferred embodiment are interchangeable. The last of the preferred embodiments of the present invention is shown on FIG. **10** in a form of ultra-light aircraft **100** constructed in accordance with the invention. To emphasize the similarity between the different embodiments of the invention already discussed, the same reference numerals are being used as long as the difference between embodiments is minor and superficial. The aircraft **100** is substantially disc-shaped and symmetrical about its vertical axis **3**, having a main frame **4** with a hollow cylindrical space **72** along its vertical axis extending downward into a compartment **91** serving as a housing for a prime mover **7**, a fuel tank **9** and a pilot with manual controls **99**. The pilot and the controls are covered from the weather with a dome-like transparent cover **12** securely fastened to the cylindrical top of the main frame **4**. A plurality of support arms **66** radially extend from the main frame to bearing hubs **67**. Similarly, in a mirror reflection fashion relative to the upper supporting arms **66**, there are lower supporting arms **66** and **69** radially extending to respective bearing hubs **68**. The number of the supporting arms **66** and **69** with bearing hubs will vary from one embodiment to another embodiment of the invention but cannot be fewer than shown on FIG. **10**. That is two upper and two lower supporting arms with respective bearing hubs at their ends.

Unlike the embodiment of aircraft **2** of FIG. **1** which two lifting rotors **5** and **6** are driven by means of a toothed gear **18**. The gear is in the gap between the toothed rims **19** and **20** of said counter-rotating lifting rotors **5** and **6**. The ultra-light aircraft **100** has its lifting rotors **5** and **6** driven by a friction wheel and shaft **88**. The shaft **88** extends downwardly and keys into a universal joint **90**. The shaft **88** receives its power and torque from universal joint **90** which operatively connects with shaft **14**. The shaft **14** is driven by an engine **7** serving as a prime mover. The friction wheel and shaft combination **88** represents a cylinder with tapered ribs and grooves. These ribs and grooves intermesh with similar ribs and grooves of the inner rim **56** of the outer lifting rotor **6** and with similar ribs and grooves of the outer rim **57** of the inner lifting rotor **5**. These tapered ribs and grooves, similar to the well-known v-belt drive transmission, are not the only means to multiply friction between surfaces of limited area. These tapered ribs and grooves are well-known in the art and, therefore, are not detailed here. Further, the means to multiply friction may widely differ from one embodiment of the invention to another embodiment. There is a substantial difference between the above-mentioned preferred embodiments **2** and **100** of an aircraft constructed according to the invention and the suspension means for their counter-rotating lifting rotors. Namely, the inner rim **56** of the inner lifting rotor **5**, and the outer rim **98** of the outer lifting rotor **6** are not restricted in their deflection by bearings in either upwardly or downwardly movement. An ultra-light size of aircraft constructed according to the invention will have enough stiffness in the lifting rotors **5** and **6** to render such bearings unnecessary. With respect to FIG. **3** bearings **25**, **26**, **27** and **28**, fitted to the bearing hubs **67** and **68**, keep the rims **56** and **57** of respective lifting rotors **5** and **6** in an intermeshing relationship. In FIG. **10**, the driving friction wheel and shaft **88** with the idler (speed-synchronizing) friction wheel **89**, simultaneously serve as thrust bearings and bearings **25**, **26**, **27** and **28** as a means to maintain a constant pressure on the friction surfaces. For further reducing an overall weight of the aircraft **100**, its main frame's lower supporting arms **69** end up at the bearing hubs **68**, rather than extending further out to the semi-toroidal cover **29** of the FIG. **1** embodiment. The ultra-light embodiment **100**, for simplicity, is equipped with only one system of vanes **39** for horizontal ahead or reverse movements. If a pilot desires to make a 90 degree turn, he would have to use a turning vane **47** to face the new direction. The vanes **39** would be aligned with the new course of travel.

These maneuvers are easily executed by manual control means consisting of levers, control rods and pivoting pins. With respect to FIG. **10** and shown in flight the preferred embodiment **100** of an ultra-light aircraft is in a forward horizontal flight corresponding to a forward position of a control stick **99** pushed forward by the pilot. This movement of the control stick **99** is conveyed to the vanes **39** by a control rod **74**. The vanes **39** are pivoted through pins **43** to the control rod **74**. The vanes **39** have freedom of turning around pivoting pins **40** which are secured in the lower supporting arm **69** of the main frame **4**. The thrust of the airstream from the lifting rotor **5** upon the vanes **39** may bring the desired horizontal movement effect to the aircraft **100**. The control stick **99** controls the horizontal propulsion and maneuvering vanes **39** when moved ahead or in reverse around its pivoting point **95** and extension **94**. The control stick can also turn around a ball-joint **93** to move a crank **96** to the right or to the left of the center line of the turning vane **47**. The vane is pivoted at points **48** and **97** of the main frame **4** of the aircraft **100**. There is fork connection **92** between the control stick **99** and the crank **96** of the turning vane **47**. The pilot is able to control with a single hand the horizontal flight and maneuvering of aircraft **100**. With the other hand the pilot can control the vertical flight by increasing or decreasing the output revolutions of the prime mover **7** or engine **7** by throttling its fuel supply.

With reference to the drawings, wherein like reference characters designate identical or corresponding parts, and more particularly to FIG. **11** the reference numeral **110** indicates one form of a heavier-than-air aircraft embodying this invention. The aircraft **110**, a disk-shaped structure, is substantially symmetrical about a vertical axis **112**. The aircraft **110** comprises a main frame **114** for radially extending its integral structural members to carry the load and the thrust from two counter-rotating lifting rotors **5** and **6**. Power is provided by a prime mover **120**. The prime mover **120** generates either electric or hydraulic power and which power is transmitted to a driving motor **38**. The motor **38** drives the lifting rotors **5** and **6** by means of a speed-synchronizing gear **18**. The gear **18** intermeshes, simultaneously, with both rotors **5** and **6**. A three-dimensional maneuverability in the air is provided by the use of said counter-rotating lifting rotors **5** and **6**, vanes **39**, and vanes **47**. Vanes **39** provide for horizontal thrust in a chosen direction of flight, forwardly or in reverse. Vanes **47** make it possible to rotate the aircraft **110** around its axis **112**. This allows the pilot to face a new flight direction, or in hovering posture, to have a full panoramic view of the area below. This embodiment of the present invention is provided with two passengers and a crew, or two payload compartments: **122** and **124**. **122** and **124** are located one above another inside the central cylindrical-in-shape section of the main frame **114**.

The heaviest part of the aircraft, which provides for a lower center of gravity and also contributes for an exceptional stability of this craft, is the marine propulsion module **126**. This module is a multi-functional housing for the prime mover **120**, fuel tankage **9**, counter-rotating diving rotors **128** and **130**, and their drive motor **132**. The diving rotors **128** and **130** are provided with a shroud **134**. The shroud **134** provides for better thrust efficiency and protection. Horizontal thrust for sub-surface travel or submersible travel in water is provided by a marine propeller **136** located also for a better efficiency and protection, in a nozzle-like tunnel. An inside rudder **138** provides for a change of course, or a 360 degree spin, whether the aircraft is fully submerged or partially submerged in water. The marine propeller **136** is powered by a motor **140**, either electric or hydraulic. The motor **140** is operatively connected, like the motors **38** and **132**, to the prime mover **120**. The prime mover **120** also provides power for the landing gear's deployment for landing and withdrawal when it is not needed.

The marine propulsion module **126** can be detached along a separation joint line **142** from the main frame **114**. This may be advantageous in an emergency. The module **126** is the heaviest part of the aircraft **110** and is detachable from the main part of the aircraft **110**. The module **126** can be sent parachuting down while the aircraft **110** is in an emergency situation. The aircraft **110** may have inflated its balloon/parachute combination **144**, stored normally under a hood **146**, to ensure a soft landing. Similarly, when the aircraft is in trouble while submersed in water the detachability of the module **126**, together with the inflating of the rescue balloon **144**, would be a very useful safety net. Among other safety features of the aircraft **110** of FIG. **11** is a semi-toroidal rim **70** of the main frame **114**. The rim **70** provides bumper-protection for the lifting rotor **6** while carrying its upward thrust. This "bumper" rim **70** allows this type of aircraft to fly in a tight "bumper-to-bumper" formation. The rim **70** also makes it possible to "dock" the aircraft while hovering in a rescue mission alongside a ship in trouble or wall of a burning sky-scraper or a high cliff.

FIG. **12** illustrates the marine propulsion module **126** which is also the engine room of this aircraft and where the prime mover **120** is housed along with a landing gear. There are two major equally important reasons for making this module detachable. A first reason is for emergency landing or surfacing. Another reason is to make the "main frame" aircraft more versatile. The main frame is adaptable to a variety of modules equipped with different types of prime movers; different landing gear; or, a jet-propulsion to improve the speed of horizontal flight, etc. By having the heaviest part of the aircraft **110** detachable there is an increased possibility of survivability in the air and also greater buoyancy underwater.

With reference to FIG. **12** it is seen that the marine propulsion module **126** allows this aircraft to land on land; to taxi from land into the water; or to roll up the landing ramp from the water onto land. This is achieved by a simple and reliable set of four spaced-apart wheels **148**. The wheels **148** can be "free-rolling", or electrically/hydraulically driven from their hubs. Each couple of wheels, spaced apart to ensure the needed balance, is attached to its hood **150**. The hood **150** is pivoted to the lower part of the module with a hinge **152**. Deployment of this landing gear from stored position and back to operational position is achieved by hydraulic (or other types) of jacks **154**. The jacks are pivoted at connecting points **156** and **158**. Complete enclosure of the landing gear inside the lower part of the marine propulsion module is assured by a simple flap-cover **35** which can be opened or closed by the wheels **148**. The marine propeller **136**, and the rudder **138**, are hidden in the nozzle **37** for better efficiency, protection, and aerodynamic compatibility with the rest of the aircraft **110**.

The submersibility of this aircraft in water is achieved by the diving rotors **128** and **130**. These rotors are provided to overcome the remaining buoyancy of the aircraft once the aircraft **110** has "landed" on water and has become semi-submerged. This point may be argued by a modern aircraft engineer trained to design aircraft as light as technologically possible. This is because the fixed wing concept is not mechanically efficient. The only way to increase the efficiency of a conventional aeroplane is to minimize its weight. This "rule of thumb" of minimum weight of conventional aircraft engineering is only partially true to the rotary aircraft whose full potential has not been fully explored. This is an important point on which the present invention rests.

An aircraft constructed according to the teachings of this invention does not have the limitations of the helicopter concept and the Archimedean screw concept. This is realized by virtue of its high mechanical efficiency as power is applied to the outside rim of the lifting rotors. Further, the diameter of the lifting rotor, a major factor of the lifting capacity, has no limitations of the helicopter concept. As a result this aircraft can lift heavier loads per unit of power than conventional fixed wing aircraft. The aircraft **2** can initially be heavier than conventional aircraft.

Submerging of the aircraft **110** in water is achieved (with or without the flooding of the conventional ballast tanks) by directing the entire prime mover's power output for driving the counter-rotating diving rotors **128** and **130** downward. Depending on the underwater maneuvering being exercised, this power output is then balanced between the vertical thrust and horizontal thrust requirements. The horizontal underwater thrust is provided by rather conventional propeller **136**. However, vertical underwater thrust is provided by reversing the diving rotors **128** and **130**.

Counter-rotating propellers were first used in torpedo designs to prevent a torpedo from spinning. Otherwise, it would be necessary to use large fin-stabilizers in a torpedo with all the unwanted side-effects. The counter-rotating diving rotors **128** and **130** provide vertical up or down thrust while balancing each others residual torque. There is the motor (electric or hydraulic) **132**, which drives the diving rotors **128** and **130** at equal speed and in the opposite direction by means of a gear wheel **162**. The gear wheel **162** meshes with the toothed rim **164** of the lower diving rotor **130** and the toothed rim **166** of the upper diving rotor **128**. Said rotors are assembled in a simple chain-link fashion out of hydrofoil elements **168** and **170** by means of "dove-tail" locks or bonds **172** and **174** of the elements to be linked. A similar construction is illustrated in FIG. **5** with inner rim **58**, and bonding recesses **65**. Bond **63** is in bonding recesses **65**. Similarly, there is an outer rim **59** having bonding recesses **64**. Bond **62** is in bonding recesses **64**. These locks **62** or bonds are secured by tack welding which is accepted in marine engineering practice. The rotors **128** and **130** slide around the cylindrical body of the marine propulsion module **126**, along the upper bearing track **176**, and lower bearing track **178**, respectively. These bearing tracks are made of materials widely used and readily accepted in marine engineering for water-lubricated bearings. They are assembled out of dove-tailed to each other sections and are securely fastened to said module **126** cylindrical sidewall by conventional screws **180** and **182**, respectively. The uniformly even gap between the toothed rims **164** and **166** of the upper and lower diving rotors **128** and **130**, is maintained by several spaced-apart gear wheels **162**. Some gear wheels are driving gear wheels (coupled with motors **132**) and others are idling gear wheels. The idling gear wheels **162** carry out the important function (like in case of counter-rotating lifting rotors **5** and **6**, of FIG. **1**) of speed synchronizing the rotational speed of the diving rotors **128** and **130**. The shroud **134** is assembled from several sections. The sections are joined at **184** by pins **186** on the outside, and along the split **188** of the lower inner rim **190** and the upper inner rim **192**. Struts **194** and **196**, provide a solid structural connection between the outside shroud **134**, and its inner rims which are bolted to said module by conventional fasteners **198** and **200**. The direction of the thrust (either upward or downward, diving or surfacing) is determined by the pilot at the controls by changing the direction of rotation of the motor **132**. Locking pins **202**, operated mechanically, electrically or hydraulically by the pilot in control of the aircraft, provide a secure attachment of the marine propulsion (and others) module to the main frame **114**, when inserted into locks **204**, belonging to said module(s). The number and type of the locking devices can vary from one size/type of the aircraft constructed according to this invention, to another. The locking devices are selected to be compatible with the size of the aircraft.

The self-adjusting blade is not restricted to this invention and rotor having a circular or continuous inner rim, a circular or continuous outer rim. The self-adjusting blade can be used with a rotor having an inner rim and a discontinuous outer rim. Such an application would be on a helicopter having a plurality of blades connected to a hub or shaft which could be continuous. There could be an outer rim for each blade making the outer rim discontinuous.

An aircraft having a three-dimensional freedom of movement and comprising a frame; a first rotating lifting rotor; a second rotating lifting rotor; said first rotor and said second rotor rotate in opposite directions; a prime mover operatively connecting with said frame; a first means operatively connecting together said prime mover and said first rotor for rotating said first rotor; a second means operatively connecting together said prime mover and said second rotor for rotating said second rotor; and, a control means for controlling the speed of rotation of said first rotor and said second rotor.

An aircraft having a three-dimensional freedom of movement and comprising a frame; a first rotating lifting rotor; a second rotating lifting rotor; said first rotor and said second rotor rotate in opposite directions; a prime mover operatively connecting with said frame; a first means operatively connecting together said prime mover and said first rotor for rotating said first rotor; a second means operatively connecting together said prime mover and said second rotor for rotating said second rotor; a control means for controlling the speed of rotation of said first rotor and said second rotor; moveable vanes operatively connecting with said frame and positioned to receive the flow of fluid from a rotor to assist in moving the aircraft in a substantially horizontal direction; and, a turning vane operatively connecting with said frame and positioned to receive the flow of fluid from a rotor to assist in moving the aircraft around a substantially vertical axis.

An aircraft having a three-dimensional freedom of movement and comprising a frame; a first rotating lifting rotor; a second rotating lifting rotor; said first rotor and said second rotor rotate in opposite directions; a prime mover operatively connecting with said frame; a first means operatively connecting together said prime mover and said first rotor for rotating said first rotor; a second means operatively connecting together said prime mover and said second rotor for rotating said second rotor; a control means for controlling the speed of rotation of said first rotor and said second rotor; moveable vanes operatively connecting with said frame and positioned to receive the flow of fluid from a rotor to assist in moving the aircraft in a substantially horizontal direction; a turning vane operatively connecting with said frame and positioned to receive the flow of fluid from a rotor to assist in moving the aircraft around a substantially vertical axis; said first rotor having a toroidal configuration having a first circular inner rim, a second circular outer rime, and a first aerofoil blade operatively connecting with said first inner rim and said second outer rim; said second rotor having a toroidal configuration having a third circular inner rim and a fourth circular outer rim and a second aerofoil blade operatively connecting with said third inner rim and said fourth outer rim; and, said fourth outer rim being of a smaller dimension than the dimension of said first inner rim.

An aircraft having a three-dimensional freedom of movement and comprising a frame; a first rotating lifting rotor; a second rotating lifting rotor; said first rotor and said second rotor rotate in opposite directions; a prime mover operatively connecting with said frame; a first means operatively connecting together said prime mover and said first rotor for rotating said first rotor; a second means operatively connecting together said prime mover and said second rotor for rotating said second rotor; a control means for controlling the speed of rotation of said first rotor and said second rotor; a third rotating diving rotor; a fourth rotating diving rotor;

said third diving rotor and said fourth diving rotor rotating in opposite directions; a control means for controlling the speed of rotation of said third rotor and said fourth rotor; a means operatively connecting together said prime mover and said third rotor and said fourth rotor for rotating said third rotor and said fourth rotor; a marine propeller for propelling said aircraft in water; a rudder for directing the course of movement of said aircraft in water; a marine module; an attaching means for attaching said marine module to said frame; said attaching means being capable of releasing said marine module from said frame; said marine module housing and operatively connecting with said third rotor and said fourth rotor, said marine propeller and said rudder; in said marine module there being a nozzle-like tunnel; said marine propeller being in said tunnel; said marine module being attached to the lower part of said frame; and, a turning vane operatively connecting with said frame and positioned to receive the flow of fluid from a lifting rotor to assist in moving the aircraft around a substantially vertical axis.

An aircraft having a three-dimensional freedom of movement and comprising a frame; a first rotating lifting rotor; a second rotating lifting rotor; said first rotor and said second rotor rotate in opposite directions; a prime mover operatively connecting with said frame; a first means operatively connecting together said prime mover and said first rotor for rotating said first rotor; a second means operatively connecting together said prime mover and said second rotor for rotating said second rotor; a control means for controlling the speed of rotation of said first rotor and said second rotor; said first rotor having a toroidal configuration having a first circular inner rim, a second circular outer rime, and a first aerofoil blade operatively connecting with said first inner rim and said second outer rim; said second rotor having a toroidal configuration having a third circular inner rim and a fourth circular outer rim and a second aerofoil blade operatively connecting with said third inner rim and said fourth outer rim; said fourth outer rim being of a smaller dimension than the dimension of said first inner rim; said second rotor being positioned inside of said first rotor; said second rotor and said first rotor being coplanar and rotating around the same vertical axis; a first region for housing an operator to control the operation of said aircraft; and, a second region for receiving and housing a payload.

A process for making an aircraft having a three-dimensional freedom of movement, said process comprising forming a frame; folding and operatively connecting a first rotating lifting rotor with said frame; forming and operatively connecting a second rotating lifting rotor with said frame; rotating said first rotor and said second rotor in opposite directions; operatively connecting a prime mover to said frame; operatively connecting together said prime mover and said first rotor for rotating said first rotor; operatively connecting together said prime mover and said second rotor for rotating said second rotor; controlling the speed of rotation of said first rotor and said second rotor; operatively connecting and positioning moveable vanes with said frame for receiving the flow of fluid from a rotor to assist in moving the aircraft in a substantially horizontal direction; operatively connecting and positioning a turning vane with said frame for receiving the flow of fluid from a rotor to assist in moving the aircraft around a substantially vertical axis; forming said first rotor to have a toroidal configuration to have a first circular inner rim and a second circular outer rim and a first aerofoil blade operatively connecting with said first inner rim and said second outer rim; forming said second rotor to have a toroidal configuration to have a third circular inner rim and a fourth circular outer rim and a second aerofoil blade operatively connecting with said third inner rim and said fourth outer rim; and, forming said fourth outer rim to be of a smaller dimension than the dimension of said first inner rim.

A process for making an aircraft having a three-dimensional freedom of movement, said process comprising forming a frame; forming and operatively connecting a first rotating lifting rotor with said frame; forming and operatively connecting a second rotating lifting rotor with said frame; rotating said first rotor and said second rotor in opposite directions; operatively connecting a prime mover to said frame; operatively connecting together said prime mover and said first rotor for rotating said first rotor; operatively connecting together said prime mover and said second rotor for rotating said second rotor; controlling the speed of rotation of said first rotor and said second rotor; forming and operatively connecting a third rotating diving rotor with said frame; forming and operatively connecting a fourth rotating diving rotor with said frame; rotating said third diving rotor and said fourth diving rotor in opposite directions; controlling the speed of rotation of said third rotor and said fourth rotor; operatively connecting together said prime mover and said third rotor and said fourth rotor for rotating said third rotor and said fourth rotor; operatively connecting a marine propeller with said prime mover for propelling said aircraft in water; incorporating a rudder in said aircraft for directing the course of movement of said aircraft in water; forming a marine module; attaching said marine module to said frame; attaching said marine module in such a manner that the marine module can be released from said frame; housing in said marine module and operatively connecting with said third rotor and said fourth rotor, said marine propeller and said rudder; forming said marine module with a nozzle-like tunnel; positioning said marine propeller in said tunnel; and, attaching said marine module to the lower part of said frame.

A process for making an aircraft having a three-dimensional freedom of movement, said process comprising forming a frame; forming and operatively connecting a first rotating lifting rotor with said frame; forming and operatively connecting a second rotating lifting rotor with said frame; rotating said first rotor and said second rotor in opposite directions; operatively connecting a prime mover to said frame; operatively connecting together said prime mover and said first rotor for rotating said first rotor; operatively connecting together said prime mover and said second rotor for rotating said second rotor; controlling the speed of rotation of said first rotor and said second rotor; forming and operatively connecting a third rotating diving rotor with said frame; forming and operatively connecting a fourth rotating diving rotor with said frame; rotating said third diving rotor and said fourth diving rotor in opposite directions; controlling the speed of rotation of said third rotor and said fourth rotor; operatively connecting together said prime mover and said third rotor and said fourth rotor for rotating said third rotor and said fourth rotor; and, operatively connecting a turning vane with said frame and positioning said turning vane to receive the flow of fluid from a lifting rotor to assist in moving the aircraft around a substantially vertical axis.

An aircraft having a three-dimensional freedom of movement and made by a process comprising forming a frame; forming and operatively connecting a first rotating lifting rotor with said frame; forming and operatively connecting a second rotating lifting rotor with said frame; rotating said first rotor and said second rotor in opposite directions;

operatively connecting a prime mover to said frame; operatively connecting together said prime mover and said first rotor for rotating said first rotor; operatively connecting together said prime mover and said second rotor for rotating said second rotor; controlling the speed of rotation of said first rotor and said second rotor; operatively connecting and positioning moveable vanes with said frame for receiving the flow of fluid from a rotor to assist in moving the aircraft in a substantially horizontal direction; operatively connecting and positioning a turning vane with said frame for receiving the flow of fluid from a rotor to assist in moving the aircraft around a substantially vertical axis; forming said first rotor to have a toroidal configuration to have a first circular inner rim and a second circular outer rim and a first aerofoil blade operatively connecting with said first inner rim and said second outer rim; forming said second rotor to have a toroidal configuration to have a third circular inner rim and a fourth circular outer rim and a second aerofoil blade operatively connecting with said third inner rim and said fourth outer rim; and, forming said fourth outer rim to be of a smaller dimension than the dimension of said first inner rim.

An aircraft having a three-dimensional freedom of movement and made by a process comprising forming a frame; forming and operatively connecting a first rotating lifting rotor with said frame; forming and operatively connecting a second rotating lifting rotor with said frame; rotating said first rotor and said second rotor in opposite directions; operatively connecting a prime mover to said frame; operatively connecting together said prime mover and said first rotor for rotating said first rotor; operatively connecting together said prime mover and said second rotor for rotating said second rotor; controlling the speed of rotation of said first rotor and said second rotor; forming and operatively connecting a third rotating diving rotor with said frame; forming and operatively connecting a fourth rotating diving rotor with said frame; rotating said third diving rotor and said fourth diving rotor in opposite directions; controlling the speed of rotation of said third rotor and said fourth rotor; and, operatively connecting together said prime mover and said third rotor and said fourth rotor for rotating said third rotor and said fourth rotor.

An aircraft having a three-dimensional freedom of movement and made by a process comprising forming a frame; forming and operatively connecting a first rotating lifting rotor with said frame; forming and operatively connecting a second rotating lifting rotor with said frame; rotating said first rotor and said second rotor in opposite directions; operatively connecting a prime mover to said frame; operatively connecting together said prime mover and said first rotor for rotating said first rotor; operatively connecting together said prime mover and said second rotor for rotating said second rotor; controlling the speed of rotation of said first rotor and said second rotor; operatively connecting a marine propeller with said prime mover for propelling said aircraft in water; incorporating a rudder in said aircraft for directing the course of movement of said aircraft in water; forming a marine module; attaching said marine module to said frame; attaching said marine module in such a manner that the marine module can be released from said frame; housing in said marine module and operatively connecting with said third rotor and said fourth rotor, said marine propeller and said rudder; forming said marine module with a nozzle-like tunnel; positioning said marine propeller in said tunnel; and, attaching said marine module to the lower part of said frame.

An aircraft having a three-dimensional freedom of movement and made by a process comprising forming a frame; forming and operatively connecting a first rotating lifting rotor with said frame; forming and operatively connecting a second rotating lifting rotor with said frame; rotating said first rotor and said second rotor in opposite directions; operatively connecting a prime mover to said frame; operatively connecting together said prime mover and said first rotor for rotating said first rotor; operatively connecting together said prime mover and said second rotor for rotating said second rotor; controlling the speed of rotation of said first rotor and said second rotor; and, operatively connecting a turning vane with said frame and positioning said turning vane to receive the flow of fluid from a lifting rotor to assist in moving the aircraft around a substantially vertical axis.

What I claim is:

1. A submersible aircraft having a three-dimensional freedom of movement in the air and in the water and comprising:

a. a frame;

b. a first rotating lifting rotor;

c. a second rotating lifting rotor;

d. said first rotor and said second rotor rotate in opposite directions;

e. a prime mover operatively connecting with said frame;

f. a first means operatively connecting together said prime mover and said first rotor for rotating said first rotor;

g. a second means operatively connecting together said prime mover and said second rotor for rotating said second rotor;

h. a control means for controlling the speed of rotation of said first rotor and said second rotor;

i. said first rotating lifting rotor having an inner diameter;

j. said second rotating lifting rotor having an outer diameter; and

k. said outer diameter being smaller than said inner diameter so as to allow said second rotating lifting rotor to be positioned inside of said first rotating lifting rotor.

2. An aircraft according to claim **1** and comprising:

a. moveable vanes operatively connecting with said frame and positioned to receive the flow of fluid from a rotor to assist in moving the aircraft in a substantially horizontal direction; and,

b. a turning vane operatively connecting with said frame and positioned to receive the flow of fluid from a rotor to assist in moving the aircraft around a substantially vertical axis.

3. An aircraft according to claim **1** and comprising:

a. said first rotor having a disc configuration having a first circular inner rim, a second circular outer rim, and a plurality of aerofoil blades operatively connecting with said first inner rim and said second outer rim;

b. said second rotor having a disc configuration having a third circular inner rim and a fourth circular outer rim and a plurality of aerofoil blades operatively connecting with said third inner rim and said fourth outer rim; and,

c. said fourth outer rim being of a smaller dimension than the dimension of said first inner rim.

4. An aircraft according to claim **1** and comprising:

a. a third rotating diving rotor;

b. a fourth rotating diving rotor;

c. said third diving rotor and said fourth diving rotor rotating in opposite directions;

d. a control means for controlling the speed of rotation of said third rotor and said fourth rotor; and

e. a means operatively connecting together said prime mover and said third rotor and said fourth rotor for rotating said third rotor and for rotating said fourth rotor.

5. An aircraft according to claim **4** and comprising:

a. a marine propeller for propelling said aircraft in water;

b. a rudder for directing the course of movement of said aircraft in water;

c. a marine module;

d. an attaching means for attaching said marine module to said frame;

e. said attaching means being capable of releasing said marine module from said frame;

f. said marine module housing and operatively connecting with said third rotor and said fourth rotor, said marine propeller and said rudder;

g. in said marine module there being a nozzle-like tunnel;

h. said marine propeller being in said tunnel; and,

i. said marine module being attached to the lower part of said frame.

6. An aircraft according to claim **4** and comprising:

a. a turning vane operatively connecting with said frame and positioned to receive the flow of fluid from a lifting rotor to assist in moving the aircraft around a substantially vertical axis.

7. An aircraft according to claim **3** and comprising:

a. said second rotor being positioned inside of said first rotor; and,

b. said second rotor and said first rotor being coplanar and rotating around the same vertical axis.

8. An aircraft according to claim **1** and comprising:

a. a first region for housing an operator to control the operation of said aircraft; and,

b. a second region for receiving and housing a payload.

9. A process for making submersible aircraft having a three-dimensional freedom of movement in the air and in the water, said process comprising:

a. forming a frame;

b. forming and operatively connecting a first rotating lifting rotor with said frame;

c. forming and operatively connecting a second rotating lifting rotor with said frame;

d. rotating said first rotor and said second rotor in opposite directions;

e. operatively connecting a prime mover to said frame;

f. operatively connecting together said prime mover and said first rotor for rotating said first rotor;

g. operatively connecting together said prime mover and said second rotor for rotating said second rotor;

h. controlling the speed of rotation of said first rotor and said second rotor;

i. forming said first rotating lifting rotor to have an inner diameter;

j. forming said second rotating lifting rotor to have an outer diameter; and

k. forming said outer diameter to be smaller than said inner diameter so as to allow said second rotating lifting rotor to be positioned inside of said first rotating lifting rotor.

10. A process according to claim **9** and comprising:

a. operatively connecting and positioning moveable vanes with said frame for receiving the flow of fluid from a rotor to assist in moving the aircraft in a substantially horizontal direction; and,

b. operatively connecting and positioning a turning vane with said frame for receiving the flow of fluid from a rotor to assist in moving the aircraft around a substantially vertical axis.

11. A process according to claim **10** and comprising:

a. forming said first rotor to have a disc configuration to have a first circular inner rim and a second circular outer rim and a plurality of aerofoil blades operatively connecting with said first inner rim and said second outer rim;

b. forming said second rotor to have a disc configuration to have a third circular inner rim and a fourth circular outer rim and a plurality of aerofoil blades operatively connecting with said third inner rim and said fourth outer rim; and,

c. forming said fourth outer rim to be of a smaller dimension than the dimension of said first inner rim.

12. A process according to claim **9** and comprising:

a. forming and operatively connecting a third rotating diving rotor with said frame;

b. forming and operatively connecting a fourth rotating diving rotor with said frame;

c. rotating said third diving rotor and said fourth diving rotor in opposite directions;

d. controlling the speed of rotation of said third rotor and said fourth rotor; and

e. operatively connecting together said prime mover and said third rotor and said fourth rotor for rotating said third rotor and for rotating said fourth rotor.

13. A process according to claim **12** and comprising:

a. operatively connecting a marine propeller with said prime mover for propelling said aircraft in water;

b. incorporating a rudder in said aircraft for directing the course of movement of said aircraft in water;

c. forming a marine module;

d. attaching said marine module to said frame;

e. attaching said marine module in such a manner that the marine module can be released from said frame;

f. enclosing said marine module and operatively connecting with said third rotor and said fourth rotor, said marine propeller and said rudder;

g. forming said marine module with a nozzle-like tunnel;

h. positioning said marine propeller in said tunnel; and

i. attaching said marine module to the lower part of said frame.

14. A process according to claim **12** and comprising:

a. operatively connecting a turning vane with said frame and positioning said turning vane to receive the flow of fluid from a lifting rotor to assist in moving the aircraft around a substantially vertical axis.

15. A submersible aircraft having a three-dimensional freedom of movement in the air and in the water and made by a process comprising:

a. forming a frame;

b. forming and operatively connecting a first rotating lifting rotor with said frame;

c. forming and operatively connecting a second rotating lifting rotor with said frame;

d. rotating said first rotor and said second rotor in opposite directions;

e. operatively connecting a prime mover to said frame;

f. operatively connecting together said prime mover and said first rotor for rotating said first rotor;

g. operatively connecting together said prime mover and said second rotor for rotating said second rotor;

h. controlling the speed of rotation of said first rotor and said second rotor;

i. forming said first rotating lifting rotor to have an inner diameter;

j. forming said second rotating lifting rotor to have an outer diameter; and

k. forming said outer diameter to be smaller than said inner diameter so as to allow said second rotating lifting rotor to be positioned inside of said first rotating lifting rotor.

16. An aircraft made by a process according to claim **15** and comprising;

a. operatively connecting and positioning moveable vanes with said frame for receiving the flow of fluid from a rotor to assist in moving the aircraft in a substantially horizontal direction; and,

b. operatively connecting and positioning a turning vane with said frame for receiving the flow of fluid from a rotor to assist in moving the aircraft around a substantially vertical axis.

17. An aircraft made by a process according to claim **15** and comprising:

a. forming said first rotor to have a toroidal configuration to have a first circular inner rim and a second circular outer rim and a first aerofoil blade operatively connecting with said first inner rim and said second outer rim;

b. forming said second rotor to have a toroidal configuration to have a third circular inner rim and a fourth circular outer rim and a second aerofoil blade operatively connecting with said third inner rim and said fourth outer rim; and,

c. forming said fourth outer rim to be of a smaller dimension than the dimension of said first inner rim.

18. An aircraft made by a process according to claim **15** and comprising:

a. forming and operatively connecting a third rotating diving rotor with said frame;

b. forming and operatively connecting a fourth rotating diving rotor with said frame;

c. rotating said third diving rotor and said fourth diving rotor in opposite directions;

d. controlling the speed of rotation of said third rotor and said fourth rotor; and

e. operatively connecting together said prime mover and said third rotor and said fourth rotor for rotating said third rotor and for rotating said fourth rotor.

19. An aircraft made by a process according to claim **15** and comprising:

a. operatively connecting a marine propeller with said prime mover for propelling said aircraft in water;

b. incorporating a rudder in said aircraft for directing the course of movement of said aircraft in water;

c. forming a marine module;

d. attaching said marine module to said frame;

e. attaching said marine module in such a manner that the marine module can be released from said frame;

f. enclosing said marine module and operatively connecting with said third rotor and said fourth rotor, said marine propeller and said rudder;

g. forming said marine module with a nozzle-like tunnel;

h. positioning said marine propeller in said tunnel; and

i. attaching said marine module to the lower part of said frame.

20. An aircraft made by a process according to claim **15** and comprising:

a. operatively connecting a turning vane with said frame and positioning said turning vane to receive the flow of fluid from a lifting rotor to assist in moving the aircraft around a substantially vertical axis.

21. An aircraft according to claim **1** and comprising:

a. each of said rotors having a self-adjusting blade;

b. each of said rotors having an inner rim;

c. a positioning shaft connecting with said inner rim;

d. an outer rim;

e. said positioning shaft connecting with said outer rim;

f. said blade being mounted on said positioning shaft in a manner to move lengthwise on said shaft and also to rotate around said shaft;

g. a yieldable means operatively connecting with said blade and urging said blade towards said inner rim; and,

h. a guide operatively connecting with said blade to rotate the blade on the shaft as the blade moves toward the outer rim.

22. An aircraft according to claim **21** and comprising:

a. said guide comprising a recess in a rim and said recess defining a cam; and,

b. a cam follower on said blade operatively connecting with said cam to cause the trailing edge of the blade to become lower in elevation as the blade moves toward the outer rim.

23. A process according to claim **9** and comprising:

a. forming each said rotors to have a self-adjusting blade;

b. forming each of said rotors to have an inner rim;

c. connecting a positioning shaft with said inner rim;

d. forming an outer rim;

e. connecting said positioning shaft with said outer rim;

f. mounting said blade on said positioning shaft in a manner to move lengthwise on said shaft and also to rotate around said shaft;

g. operatively connecting a yieldable means with said blade for urging said blade towards said inner rim; and,

h. positioning a guide to operatively connect with said blade to rotate the blade on said shaft as the blade moves toward the outer rim.

24. A process according to claim **23** and comprising:

a. forming said rotor to comprise a recess in a rim to define a cam; and

b. positioning a cam follower on said blade for operatively connecting with said cam to cause the trailing edge of said blade to become lower in elevation as the blade moves toward the outer rim.

25. An aircraft having a three-dimensional freedom of movement and made by a process according to claim **15** and comprising:

a. forming each said rotors to have a self-adjusting blade;

b. forming each of said rotors to have an inner rim;

c. connecting a positioning shaft with said inner rim;

d. forming an outer rim;

e. connecting said positioning shaft with said outer rim;

f. mounting said blade on said positioning shaft in a manner to move lengthwise on said shaft and also to rotate around said shaft;

g. operatively connecting a yieldable means with said blade for urging said blade towards said inner rim; and,

h. positioning a guide to operatively connect with said blade to rotate the blade on said shaft as the blade moves toward the outer rim.

26. An aircraft made by a process according to claim **25** and comprising:

a. forming said outer rim to comprise a recess in a rim to define a cam; and

b. positioning a cam follower on said blade for operatively connecting with said cam to cause the trailing edge of said blade to become lower in elevation as the blade moves toward the outer rim.

27. A rotor and a self-adjusting blade combination comprising:

a. said rotor having an inner rim;

b. a positioning shaft connecting with said inner rim;

c. an outer rim;

d. said positioning shaft connecting with said outer rim;

e. said blade being mounted on said positioning shaft in a manner to move lengthwise on said shaft and also to rotate around said shaft;

f. a yieldable means operatively connecting with said blade and urging said blade towards said inner rim; and,

g. a guide operatively connecting with said blade to rotate the blade on the shaft as the blade moves toward the outer rim.

28. A process for making a rotor and a self-adjusting blade combination and comprising:

a. forming said rotor to have an inner rim;

b. connecting a positioning shaft with said inner rim;

c. forming an outer rim;

d. connecting said positioning shaft with said outer rim;

e. mounting said blade on said positioning shaft in a manner to move lengthwise on said shaft and also to rotate around said shaft;

f. operatively connecting a yieldable means with said blade for urging said blade towards said inner rim; and,

g. positioning a guide to operatively connect with said blade to rotate the blade on said shaft as the blade moves toward the outer rim.

29. A combination of a rotor and a self-adjusting blade made by a process comprising:

a. forming said rotor to have an inner rim;

b. connecting a positioning shaft with said inner rim;

c. forming an outer rim;

d. connecting said positioning shaft with said outer rim;

e. mounting said blade on said positioning shaft in a manner to move lengthwise on said shaft and also to rotate around said shaft;

f. operatively connecting a yieldable means with said blade for urging said blade towards said inner rim; and,

g. positioning a guide to operatively connect with said blade to rotate the blade on said shaft as the blade moves toward the outer rim.

30. An aircraft according to claim **3** and comprising:

a. said first circular inner rim and second circular outer rim comprising first aerofoil blade elements; and

b. said first aerofoil blade elements being united by bonds to form said first rim and to form said second rim of said first rotor.

31. An aircraft according to claim **30** and comprising:

a. each said first inner rim having a first hub;

b. said adjacent first hubs being joined by said bond;

c. each said second outer rim having a second hub; and

d. said adjacent second hubs being joined by said bond.

32. An aircraft according to claim **31** and comprising:

a. said third circular inner rim and said fourth circular outer rim comprising second aerofoil blade elements;

b. said second aerofoil blade elements being united by bonds to form said third rim and said fourth rim of said second rotor;

c. each said third inner rim having a third hub

d. said adjacent third hubs being joined by said bond;

e. each said fourth outer rim having a fourth hub; and

f. said adjacent fourth hubs being joined by said bond.

33. An aircraft according to claim **31** and comprising:

a. adjacent first hubs having a recess;

b. adjacent second hubs having a recess;

c. each recess having an outer passageway connecting with an enlarged inner part;

d. said bond having a body and enlarged ends; and

e. said bond in a lateral cross-sectional view presenting the appearance of a dumbbell.

34. A process according to claim **11** and comprising:

a. forming said first circular inner rim and said second circular outer rim to comprise first aerofoil blade elements; and

b. uniting said first aerofoil blade elements by bonds to form said first rim and to form said second rim of said first rotor.

35. A process according to claim **34** and comprising:

a. forming each said first inner rim to have a first hub;

b. joining said adjacent first hubs by said bond;

c. forming each said second outer rim to have a second hub; and

d. joining said second adjacent hubs by said bond.

36. A process according to claim **35** and comprising:

a. forming said third circular inner rim and said fourth circular outer rim to comprise second aerofoil blade elements;

b. uniting said second aerofoil blade elements by bonds to form said third rim and said fourth rim;

c. forming each said third inner rim to have a third hub;

d. joining said adjacent third hubs by said bond;

e. forming each fourth outer rim to have a fourth hub; and

f. joining said adjacent fourth hubs by said bond.

37. A process according to claim **35** and comprising:

a. forming adjacent first hubs with a recess;

b. forming adjacent second hubs with a recess;

c. forming each recess to have an outer passageway connecting with an enlarged inner part;

d. forming said bond to have a body and enlarged ends; and

e. forming said bond to have in a lateral cross-sectional view the appearance of a dumbbell.

38. An aircraft made by a process according to claim **17** and comprising:

a. forming said first circular inner rim and said second circular outer rim to comprise first aerofoil blade elements; and

b. uniting said first aerofoil blade elements by bonds to form said first rim and to form said second rim of said first rotor.

39. An aircraft made by a process according to claim 38 and comprising:

a. forming each said first inner rim to have a first hub;

b. joining said adjacent first hubs by said bond;

c. forming each said second outer rim to have a second hub; and

d. joining said second adjacent hubs by said bond.

40. An aircraft made by a process according to claim 39 and comprising:

a. forming said third circular inner rim and said fourth circular outer rim to comprise second aerofoil blade elements;

b. uniting said second aerofoil blade elements by bonds to form said third rim and said fourth rim of said second rotor;

c. forming each said third inner rim to have a third hub;

d. joining said adjacent third hubs by said bond;

e. forming each fourth outer rim to have a fourth hub; and

f. joining said adjacent fourth hubs by said bond.

41. An aircraft made by a process according to claim 39 and comprising:

a. forming adjacent first hubs with a recess;

b. forming adjacent second hubs with a recess;

c. forming each recess to have an outer passageway connecting with an enlarged inner part;

d. forming said bond to have a body and enlarged ends; and

e. forming said bond to have in a lateral cross-sectional view the appearance of a dumbbell.

42. An aircraft according to claim 1 and comprising:

a. said prime mover being a nuclear powered prime mover.

43. An aircraft according to claim 1 and comprising:

a. said first means being a magnetic drive.

44. An aircraft according to claim 1 and comprising:

a. said first means being a hydraulic drive.

45. An aircraft according to claim 1 and comprising:

a. said first means being an electrical drive.

46. An aircraft according to claim 1 and comprising:

a. said first means being a mechanical drive.

47. A process for making an aircraft according to claim 9 and comprising:

a. selecting as said prime mover a nuclear powered prime mover.

48. A process according to claim 9 and comprising:

a. operatively connecting together said prime mover and said first rotor by means of a magnetic drive for rotating said first rotor.

49. A process according to claim 9 and comprising:

a. operatively connecting together said prime mover and said first rotor by means of a hydraulic drive for rotating said first rotor.

50. A process according to claim 9 and comprising:

a. operatively connecting together said prime mover and said first rotor by means of an electrical drive for rotating said first rotor.

51. A process according to claim 9 and comprising:

a. operatively connecting together said prime mover and said first rotor by means of a mechanical drive for rotating said first rotor.

52. An aircraft made by a process according to claim 15 and comprising:

a. selecting as said prime mover a nuclear powered prime mover.

53. An aircraft made by a process according to claim 15 and comprising:

a. operatively connecting together said prime mover and said first rotor by means of a magnetic drive for rotating said first rotor.

54. An aircraft made by a process according to claim 15 and comprising:

a. operatively connecting together said prime mover and said first rotor by means of a hydraulic drive for rotating said first rotor.

55. An aircraft made by a process according to claim 15 and comprising:

a. operatively connecting together said prime mover and said first rotor by means of an electrical drive for rotating said first rotor.

56. An aircraft made by a process according to claim 15 and comprising:

a. operatively connecting together said prime mover and said first rotor by means of a mechanical drive for rotating said first rotor.

57. An aircraft according to claim 1 and comprising:

a. said first rotating lifting rotor having a first toothed inner rim;

b. said second rotating lifting rotor having a second toothed outer rim;

c. a gear means operatively connecting with said first toothed inner rim and with said second toothed outer rim;

d. said first means operatively connecting together said prime mover and said first rotor for rotating said first rotor comprising said gear means; and

e. a second means operatively connecting together said prime mover and said second rotor for rotating said second rotor comprising said gear means.

58. An aircraft according to claim 1 and comprising:

a. said first rotating lifting rotor having a first toothed inner rim;

b. said second rotating lifting rotor having a second toothed outer rim;

c. a first gear means operatively connecting with said first toothed inner rim and with said second toothed outer rim;

d. said first rotating lifting rotor having a third toothed outer rim;

e. a second gear means operatively connecting with said third toothed outer rim;

f. said first means operatively connecting together said prime mover and said first rotor for rotating said first rotor comprising said second gear means; and

g. a second means operatively connecting together said prime mover and said second rotor for rotating said second rotor.

59. An aircraft according to claim 1 and comprising:

a. a housing on the lower part of said aircraft;

b. said housing comprising a first hood;

c. a first hinge means operatively connecting said first hood to said aircraft for rotation of said first hood with respect to said aircraft;

d. a first actuator connecting with said first hood and with said aircraft for rotating said first hood;

e. a first wheel operatively connecting with said first hood for contact with the ground;

f. with said first hood positioned away from the lower part of said aircraft the housing is open and the first wheel is in a position to contact the ground; and

g. with said first hood positioned underneath the aircraft there is said housing in an enclosed position for submersion of the aircraft in the water.

60. An aircraft according to claim **59** and comprising:

a. said housing comprising a second hood;

b. a second hinge means operatively connecting said second hood to said aircraft for rotation of said second hood with respect to said aircraft;

c. a second actuator operatively connecting with said second hood and said aircraft for rotation of said second hood;

d. a second wheel operatively connecting with said second hood for contact with the ground;

e. with said second hood positioned away from the lower part of said aircraft the housing is open and the second wheel is in a position to contact the ground; and

f. with said first hood and said second hood positioned underneath the aircraft there is said housing in an enclosed position for submersion of the aircraft in water.

61. An aircraft according to claim **60** and comprising:

a. said first wheel and a third wheel operatively connecting with said first hood for contact with the ground; and

b. said second wheel and a fourth wheel operatively connecting with said second hood for contact with the ground.

62. An aircraft according to claim **1** and comprising:

a. a housing on the lower part of said aircraft;

b. a nozzle in said housing; and

c. a propeller in said housing for propelling said aircraft.

63. An aircraft according to claim **1** and comprising:

a. a housing on the lower part of said aircraft;

b. a nozzle in said housing; and

c. a rudder operatively connecting with said housing for guiding said aircraft.

64. An aircraft according to claim **1** and comprising:

a. a housing on the lower part of said aircraft;

b. a nozzle in said housing;

c. a propeller in said housing for propelling said aircraft; and

d. a rudder operatively connecting with said housing for guiding said aircraft.

65. An aircraft according to claim **1** and comprising:

a. an upper hood attached to the upper part of the frame; and

b. said upper hood functioning as a housing for a balloon/parachute combination for emergency landing of the aircraft.

66. An aircraft according to claim **1** and comprising:

a. a protective rim operatively connecting with said frame; and

b. said protective rim encircling said first rotating lifting rotor and said second rotating lifting rotor.

67. A process for making a submersible aircraft according to claim **9** and comprising:

a. forming said first rotating lifting rotor with a first toothed inner rim;

b. forming said second rotating lifting rotor with a second toothed outer rim;

c. operatively connecting a gear means with said first toothed inner rim and with said second toothed outer rim;

d. using said first means to operatively connect together said prime mover and said first rotor for rotating said first rotor, and comprising said gear means; and

e. using said second means to operatively connect together said prime mover and said second rotor for rotating said second rotor, and comprising said gear means.

68. A process for making a submersible aircraft according to claim **9** and comprising:

a. forming said first rotating lifting rotor with a first toothed inner rim;

b. forming said second rotating lifting rotor with a second toothed outer rim;

c. operatively connecting a first gear means with said first toothed inner rim and with said second toothed outer rim;

d. forming said first rotating lifting rotor with a third toothed outer rim;

e. operatively connecting a second gear means with said third toothed outer rim;

f. using said first means to operatively connect together said prime mover and said first rotor for rotating said first rotors, and comprising said second gear means; and

g. using said second means to operatively connect together said prime mover and said second rotor for rotating said second rotor, and comprising said first gear means.

69. A process for making a submersible aircraft according to claim **9** and comprising:

a. forming a housing on the lower part of said aircraft;

b. forming said housing to comprise a first hood;

c. operatively connecting said first hood by a first hinge means to said aircraft for rotation of said first hood with respect to said aircraft;

d. connecting a first actuator with said first hood and with said aircraft for rotation of said first hood;

e. operatively connecting a first wheel with said first hood for contact with the ground;

f. positioning said first hood away from the lower part of said aircraft to open the housing so that the first wheel is in a position to contact the ground; and

g. positioning said first hood underneath said aircraft to enclose said housing for submersion of said aircraft in the water.

70. A process for making a submersible aircraft according to claim **69** and comprising:

a. forming said housing to comprise a second hood;

b. operatively connecting said second hood by a second hinge means to said aircraft for rotation of said second hood with respect to said aircraft;

c. connecting a second actuator with said second hood and with said aircraft for rotation of said second hood;

d. operatively connecting a second wheel with said second hood for contact with the ground;

e. positioning said second hood away from the lower part of said aircraft to open the housing so that the second wheel is in a position to contact the ground; and

f. positioning said second hood underneath said aircraft to enclose said housing for submersion of said aircraft in the water.

71. A process for making a submersible aircraft according to claim **70** and comprising:

a. operatively connecting said first wheel and a third wheel with said first hood for contact with the ground; and

b. operatively connecting said second wheel and a fourth wheel with said second hood for contact with the ground.

72. A process for making a submersible aircraft according to claim **9** and comprising:

a. forming a housing on the lower part of said aircraft;

b. positioning a nozzle in said housing; and

c. operatively connecting a propeller with said housing for propelling said aircraft.

73. A process for making a submersible aircraft according to claim **9** and comprising:

a. forming a housing on the lower part of said aircraft;

b. positioning a nozzle in said housing; and

c. operatively connecting a rudder with said housing for guiding said aircraft.

74. A process for making a submersible aircraft according to claim **9** and comprising:

a. forming a housing on the lower part of said aircraft;

b. positioning a nozzle in said housing;

c. operatively connecting a propeller with said housing for propelling said aircraft; and

d. operatively connecting a rudder with said housing for guiding said aircraft.

75. A process for making a submersible aircraft according to claim **9** and comprising:

a. attaching an upper hood to the upper part of the frame; and

b. positioning a balloon/parachute combination in said hood for emergency landing of the aircraft.

76. A process for making a submersible aircraft according to claim **9** and comprising:

a. operatively connecting a protective rim with said frame; and

b. said protective rim encircling said first rotating lifting rotor and said second rotating lifting rotor.

77. A submersible aircraft according to claim **15** and comprising:

a. forming said first rotating lifting rotor with a first toothed inner rim;

b. forming said second rotating lifting rotor with a second toothed outer rim;

c. operatively connecting a gear means with said first toothed inner rim and with said second toothed outer rim;

d. using said first means to operatively connect together said prime mover and said first rotor for rotating said first rotor, and comprising said gear means; and

e. using said second means to operatively connect together said prime mover and said second rotor for rotating said second rotor, and comprising said gear means.

78. A submersible aircraft according to claim **15** and comprising:

a. forming said first rotating lifting rotor with a first toothed inner rim;

b. forming said second rotating lifting rotor with a second toothed outer rim;

c. operatively connecting a first gear means with said first toothed inner rim and with said second toothed outer rim;

d. forming said first rotating lifting rotor with a third toothed outer rim;

e. operatively connecting a second gear means with said third toothed outer rim;

f. using said first means to operatively connect together said prime mover and said first rotor for rotating said first rotor, and comprising said second gear means; and

g. using said second means to operatively connect together said prime mover and said second rotor for rotating said second rotor, and comprising said second gear means.

79. A submersible aircraft according to claim **15** and comprising:

a. forming a housing on the lower part of said aircraft;

b. forming said housing to comprise a first hood;

c. operatively connecting said first hood by a first hinge means to said aircraft for rotation of said first hood with respect to said aircraft;

d. connecting a first actuator with said first hood and with said aircraft for rotation of said first hood;

e. operatively connecting a first wheel with said first hood for contact with the ground;

f. positioning said first hood away from the lower part of said aircraft to open the housing so that the first wheel is in a position to contact the ground; and

g. positioning said first hood underneath said aircraft to enclose said housing for submersion of said aircraft in the water.

80. A submersible aircraft according to claim **79** and comprising:

a. forming said housing to comprise a second hood;

b. operatively connecting said second hood by a second hinge means to said aircraft for rotation of said second hood with respect to said aircraft;

c. connecting a second actuator with said second hood and with said aircraft for rotation of said second hood;

d. operatively connecting a second wheel with said second hood for contact with the ground;

e. positioning said second hood away from the lower part of said aircraft to open the housing so that the second wheel is in a position to contact the ground; and

f. positioning said second hood underneath said aircraft to enclose said housing for submersion of said aircraft in the water.

81. A submersible aircraft according to claim **80** and comprising:

a. operatively connecting said first wheel and a third wheel with said first hood for contact with the ground; and

b. operatively connecting said second wheel and a fourth wheel with said second hood for contact with the ground.

82. A submersible aircraft according to claim **15** and comprising:

a. forming a housing on the lower part of said aircraft;

b. positioning a nozzle in said housing; and

c. operatively connecting a propeller with said housing for propelling said aircraft.

83. A submersible aircraft according to claim **15** and comprising:

a. forming a housing on the lower part of said aircraft;

b. positioning a nozzle in said housing; and

c. operatively connecting a rudder with said housing for guiding said aircraft.

84. A submersible aircraft according to claim **15** and comprising:

a. forming a housing on the lower part of said aircraft;

b. positioning a nozzle in said housing;

c. operatively connecting a propeller with said housing for propelling said aircraft;

d. operatively connecting a rudder with said housing for guiding said aircraft.

85. A submersible aircraft according to claim **15** and comprising:

a. attaching an upper hood to the upper part of the frame; and

b. positioning a balloon/parachute combination in said hood for emergency landing of the aircraft.

86. A submersible aircraft according to claim **15** and comprising:

a. operatively connecting a protective rim with said frame; and

b. said protective rim encircling said first rotating lifting rotor and said second rotating lifting rotor.

* * * * *

US005730391A

United States Patent [19]

Miller, Jr. et al.

[11] **Patent Number: 5,730,391**

[45] **Date of Patent: Mar. 24, 1998**

[54] **UNIVERSAL FLUID-DYNAMIC BODY FOR AIRCRAFT AND WATERCRAFT**

[76] Inventors: **John A. Miller, Jr.**, 1778 Potrero Dr., San Jose, Calif. 95124-1752; **William A. Losey**, deceased, late of Santa Maria, Calif.; **by Marion E. Losey**, executor, 1600 E. Clark, #107, Santa Maria, Calif. 93455

[21] Appl. No.: **458,868**

[22] Filed: **Jun. 5, 1995**

[51] **Int. Cl.**[6] **B64C 3/54**; B64C 1/38; B63B 1/00

[52] **U.S. Cl.** .... **244/36**; 244/35 A; 244/23 C; 244/218; 244/130; 114/56; D12/300; D12/319; D12/325

[58] **Field of Search** .... 244/35 A, 36, 244/218, 130, 23 C, 35 R; 114/271, 56; D12/300, 308, 309, 319, 325, 326

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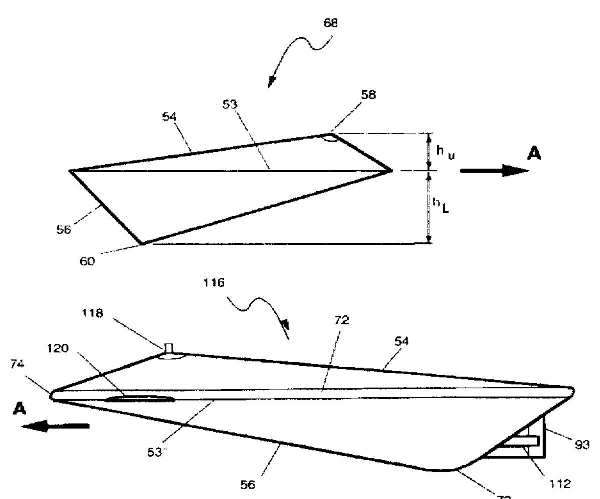
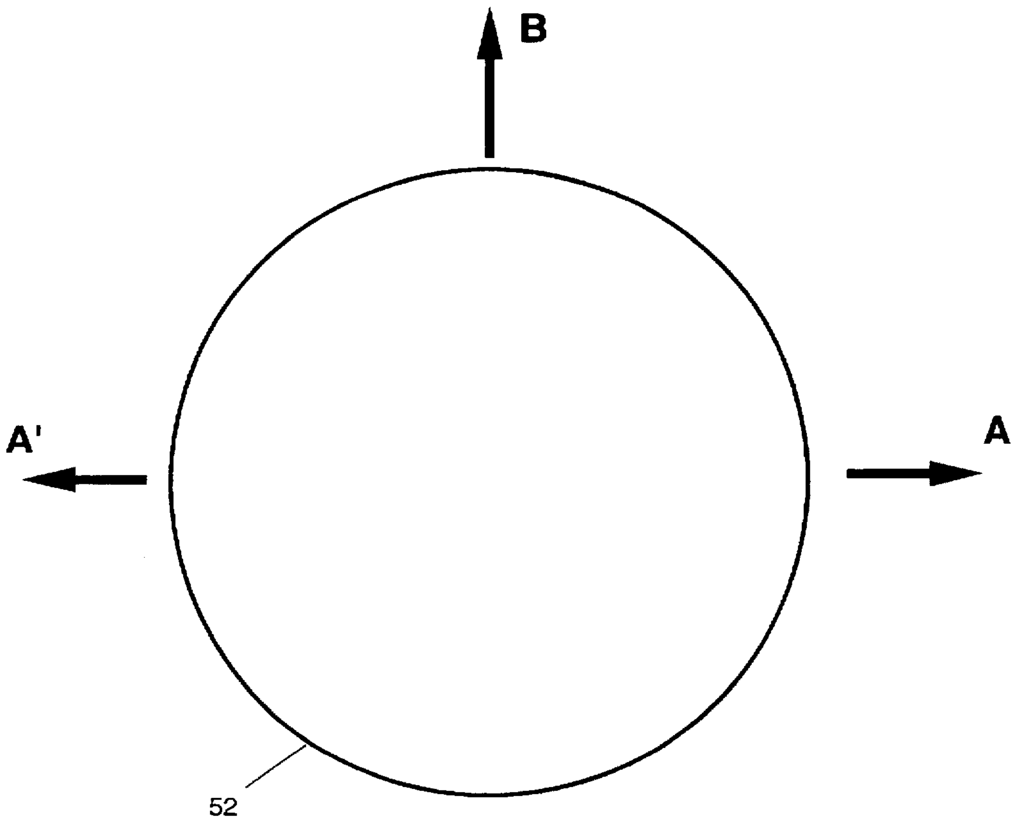
Primary Examiner—Virna Lissi Mojica

[57] **ABSTRACT**

A body configuration for improving the fluid-dynamic performance efficiency of aircraft and watercraft comprises a generally conical upper segment (**54**) and a generally conical lower segment (**56**) that are joined at a common base plane (**53**), achieved by inverting the conical lower segment (**56**). The slopes of the conical surfaces are determined by the prescribed planform of the craft or vehicle and by the height of the conical segments wherein the height of the conical upper segment (h_u) is less than and typically two-thirds that of the conical lower segment (h_L). Although not limited to elliptical planforms, a generally circular planform (**52**) is preferred for a vertical takeoff and landing aircraft operating in the subsonic flight regime and an elliptical planform (**68**), with a large aspect ratio for takeoff and low-speed flight, then rotating to a low-aspect-ratio orientation for supersonic flight operation, is preferred for supersonic transport and single-stage-to-orbit type aircraft. The unique conical configuration allows the aircraft to take off and operate at low-speeds with the high lift and efficiency of the large aspect ratio orientation, operate as an oblique all-wing aircraft during climb and acceleration to higher flight speeds, and then fully transition to the low aspect ratio orientation for high-speed operation, including transonic, supersonic, and hypersonic flight. Allowable modifications are defined to optimize and adapt the universal fluid-dynamic body to satisfy unique functional requirements of potential vehicle applications, including submersible and surface-effects type watercraft.

16 Claims, 13 Drawing Sheets





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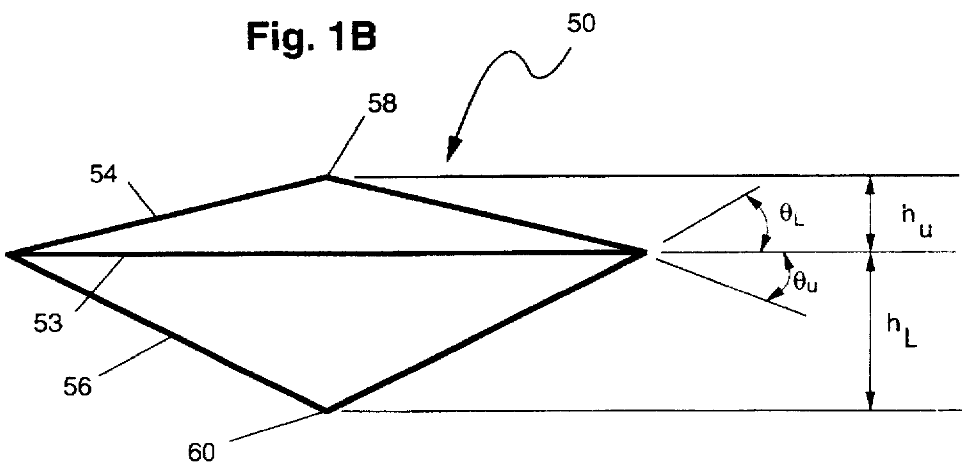

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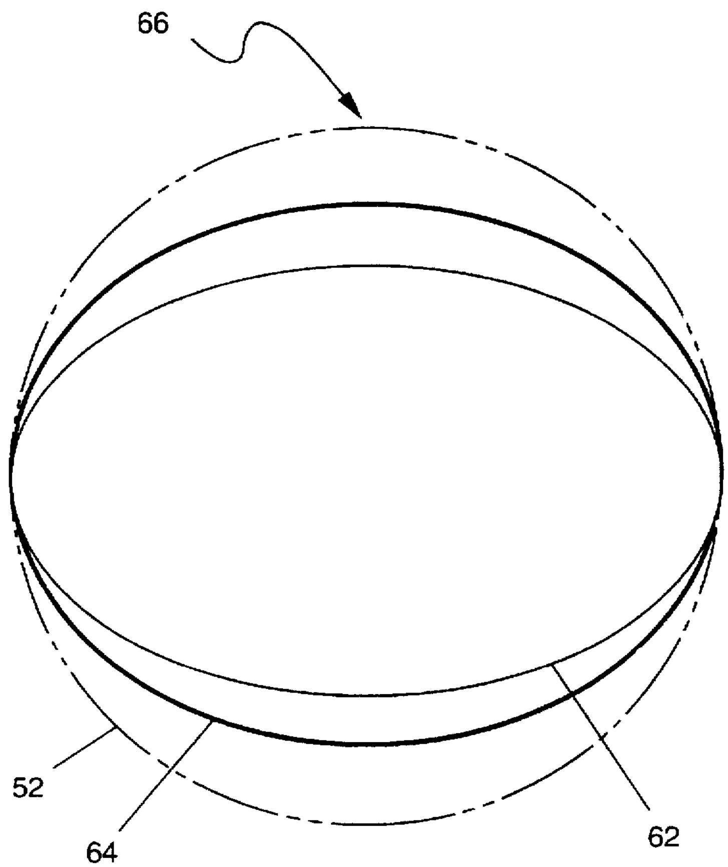

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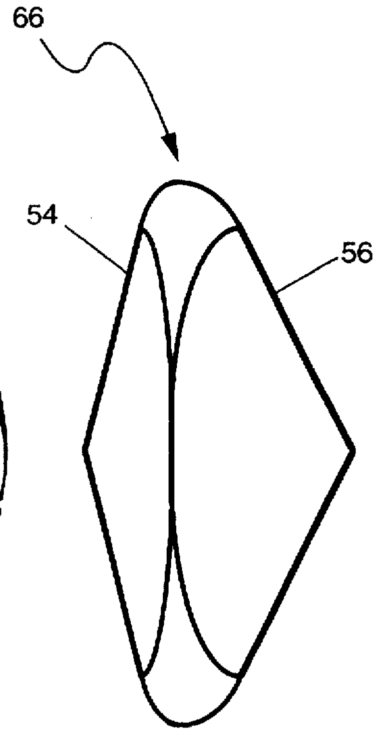

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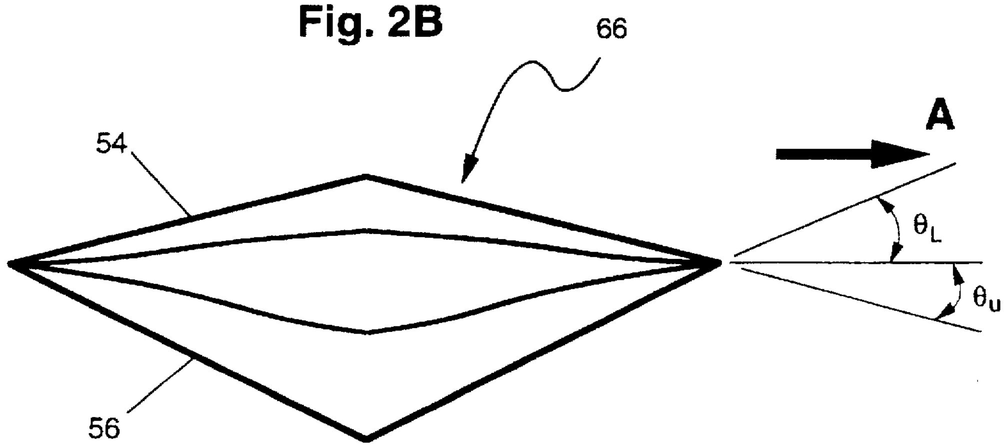

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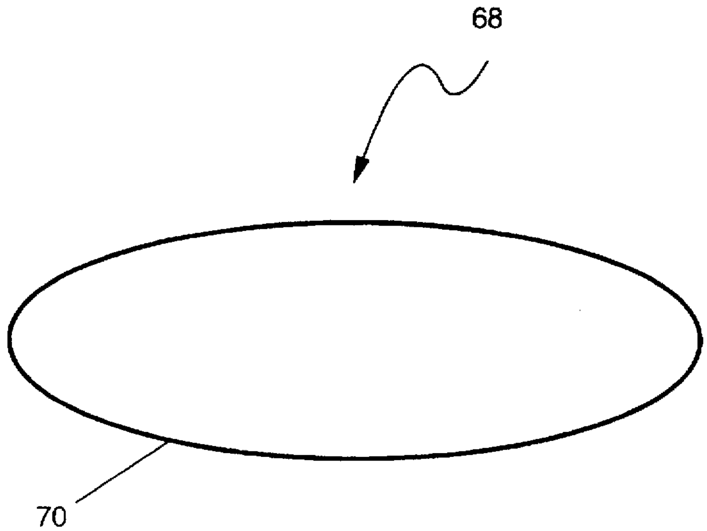


Fig. 3B

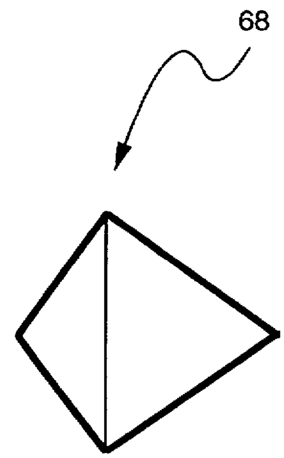
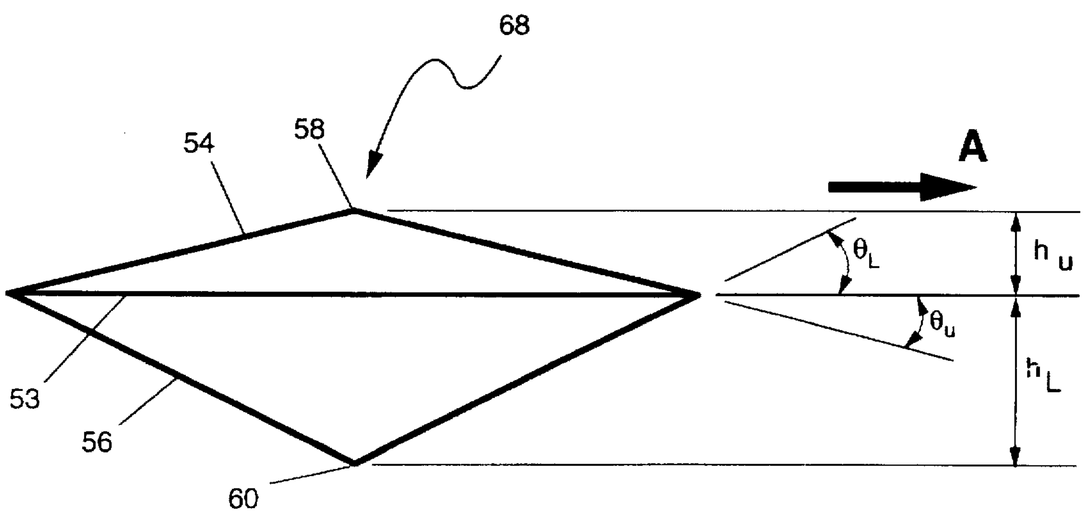


Fig. 3C



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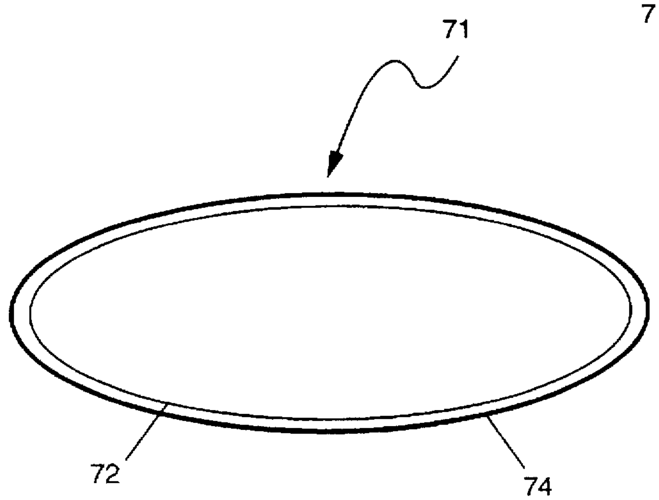

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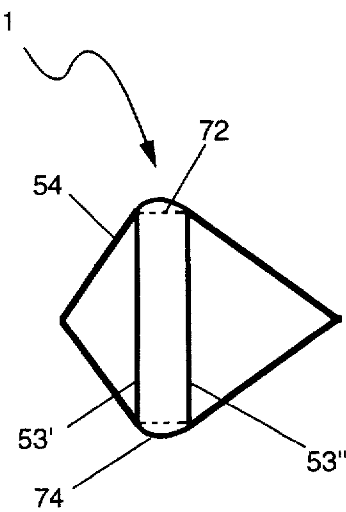
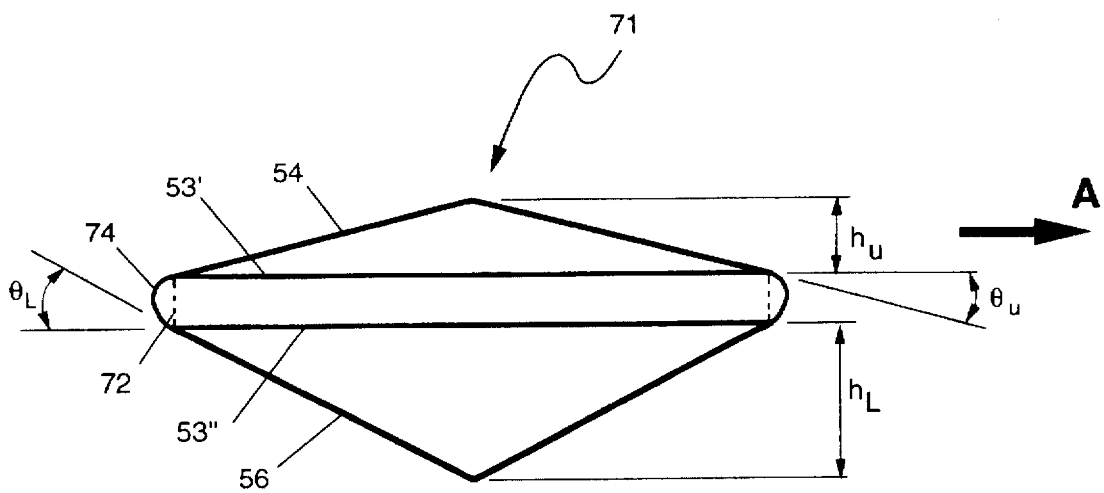


Fig. 4C



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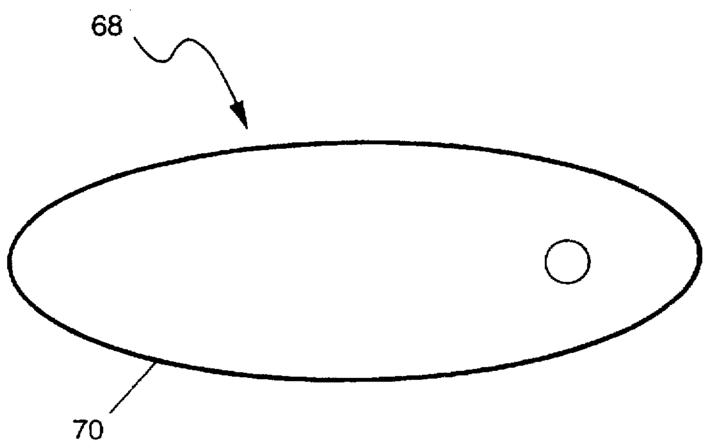

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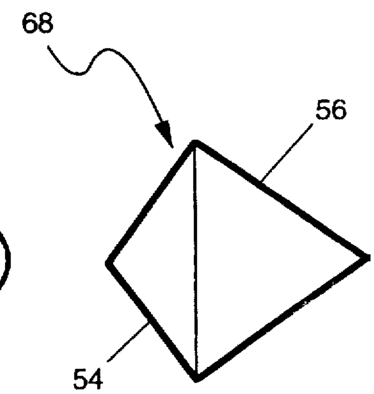

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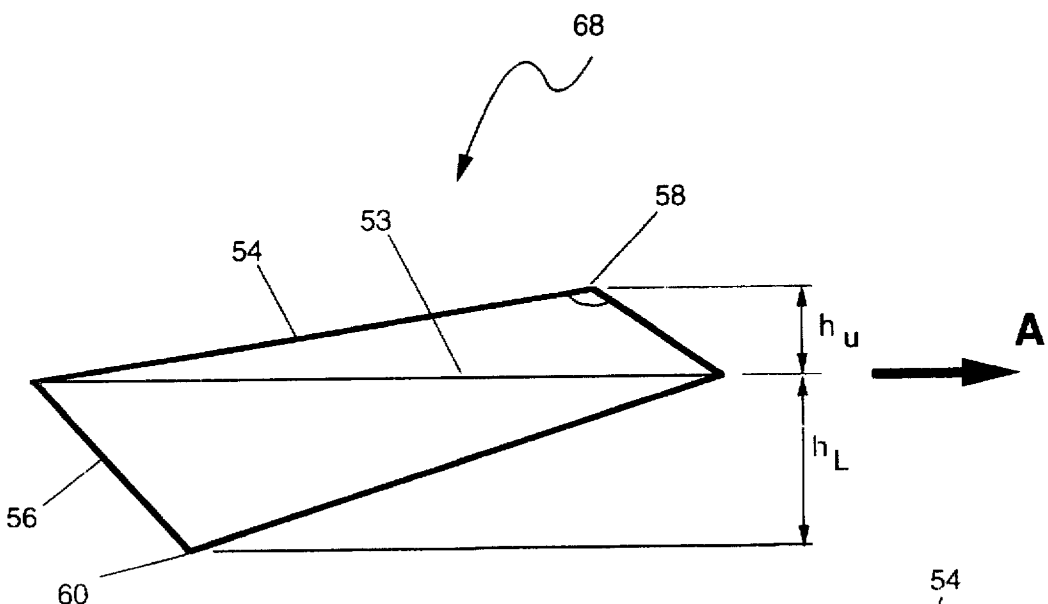

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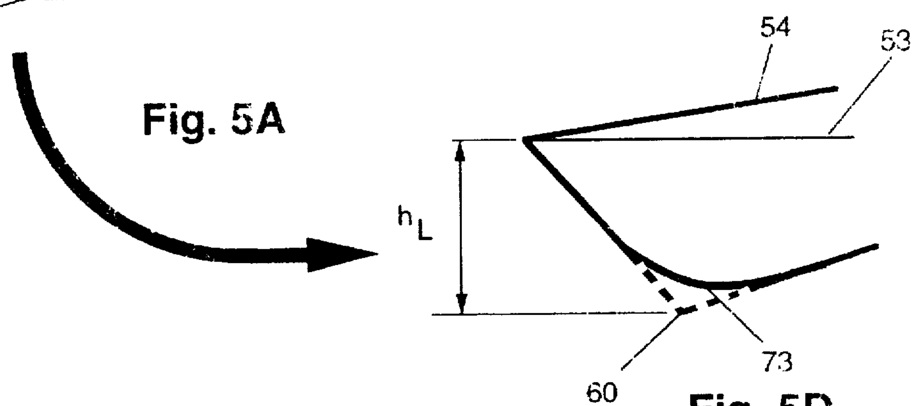

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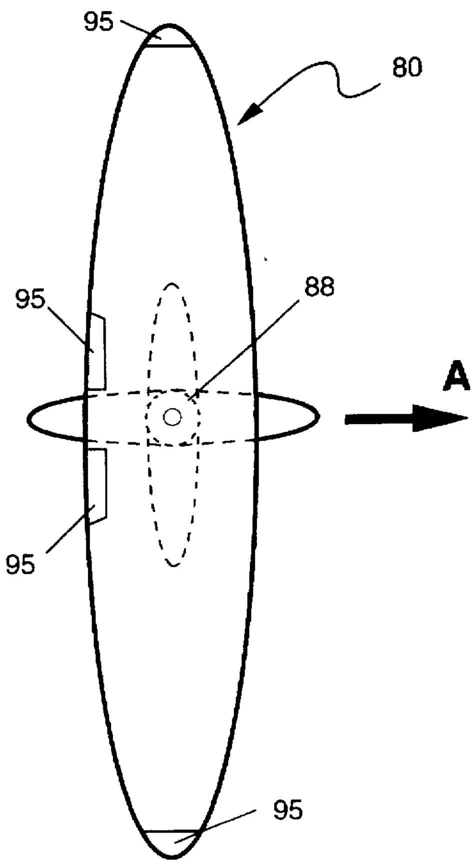


Fig. 6B

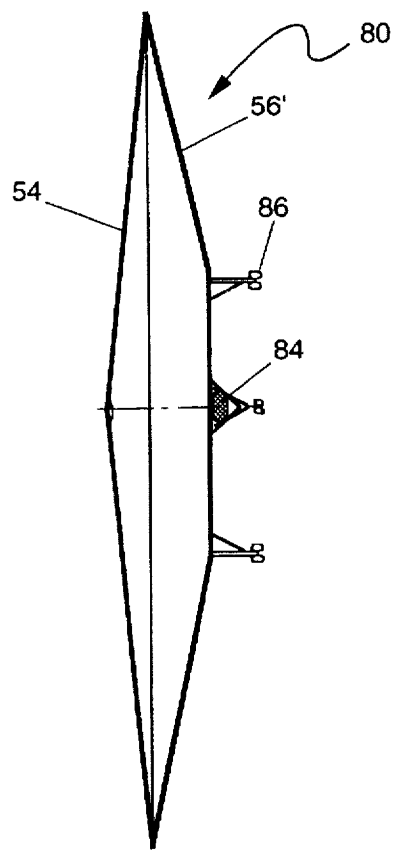


Fig. 6C

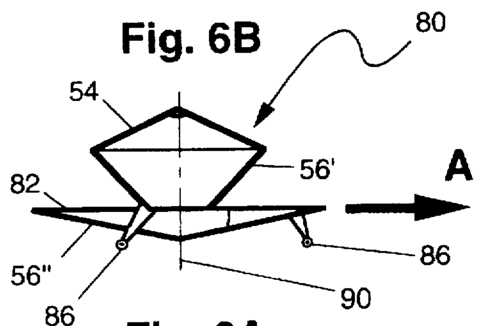
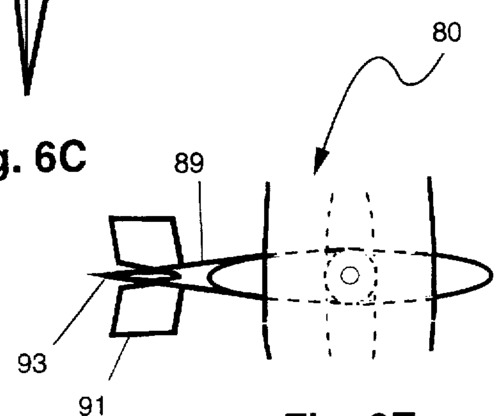


Fig. 6A



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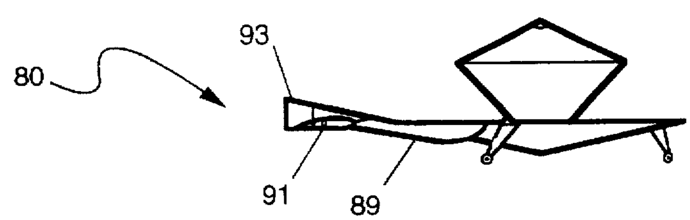

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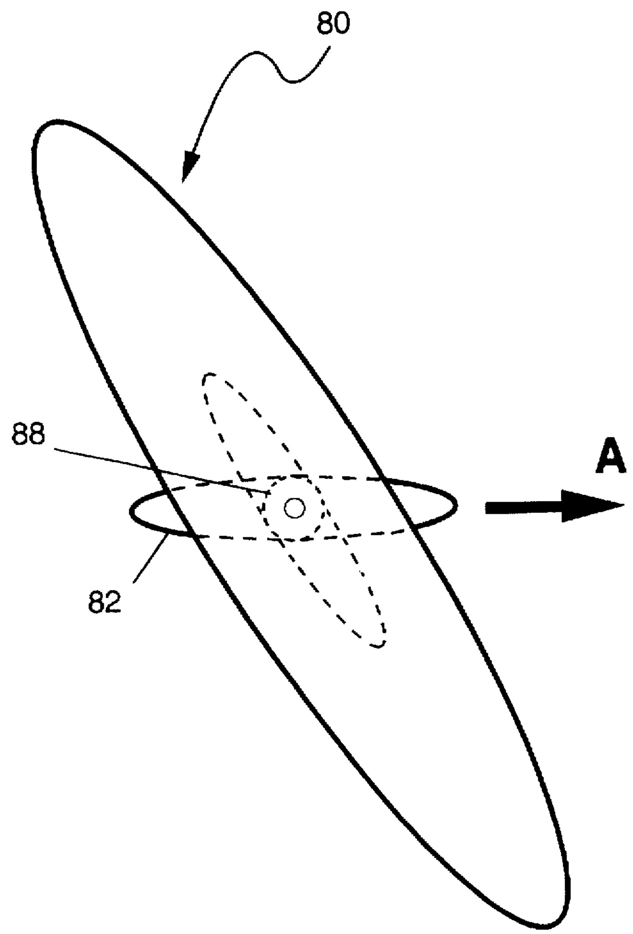
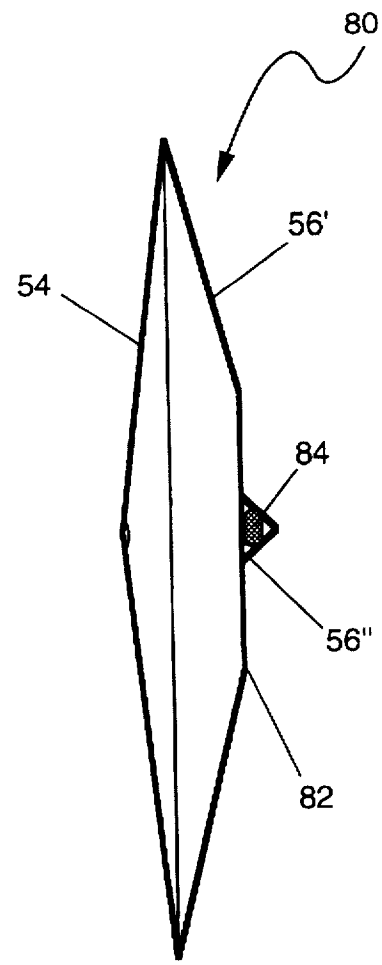


Fig. 6G



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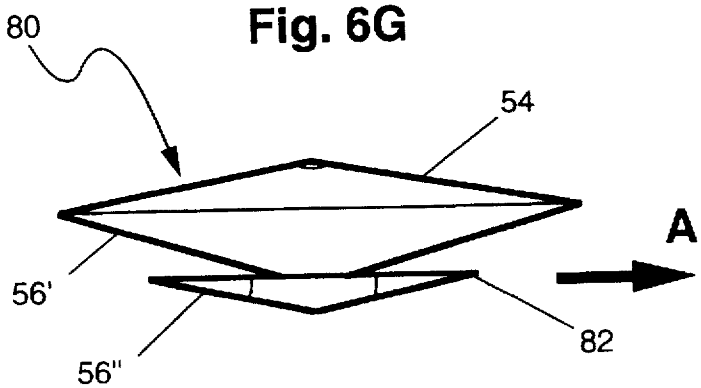

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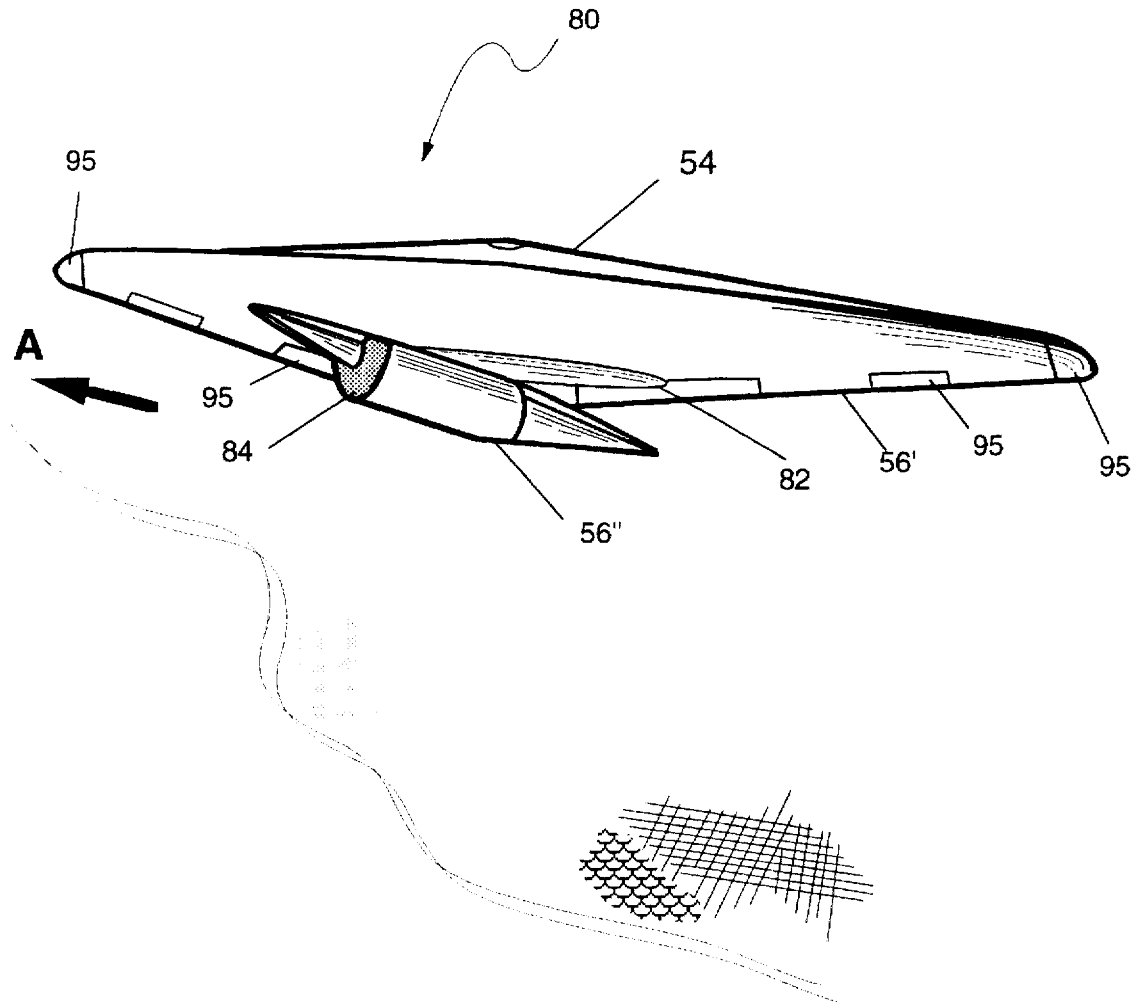
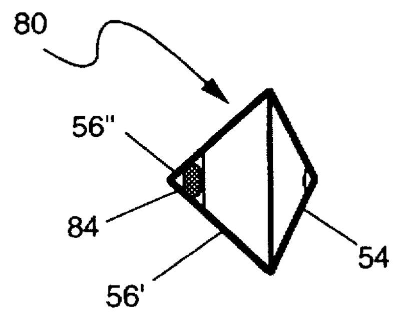


Fig. 6I



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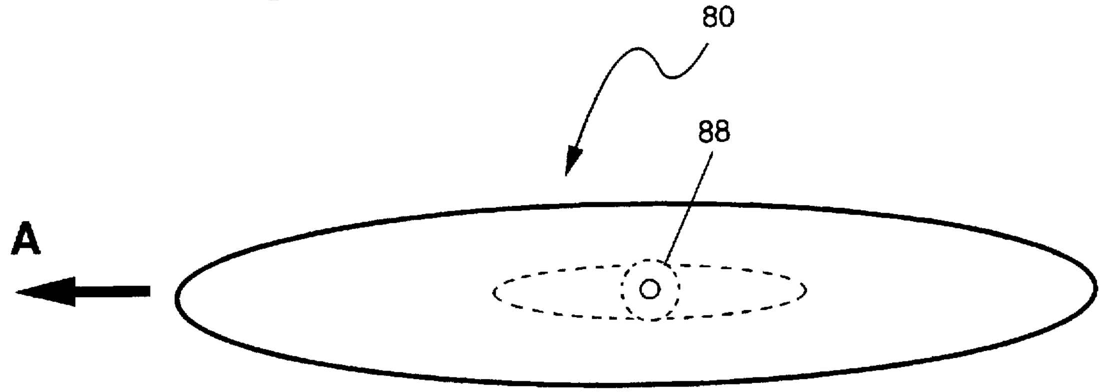

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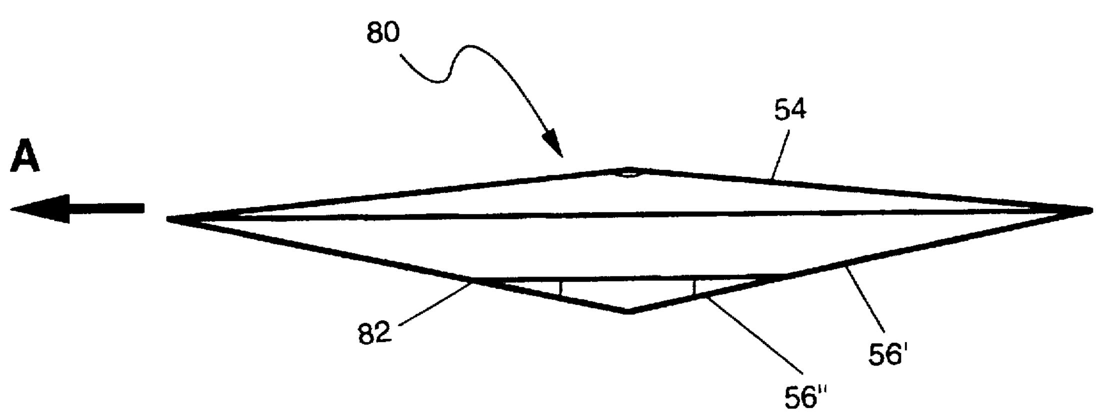

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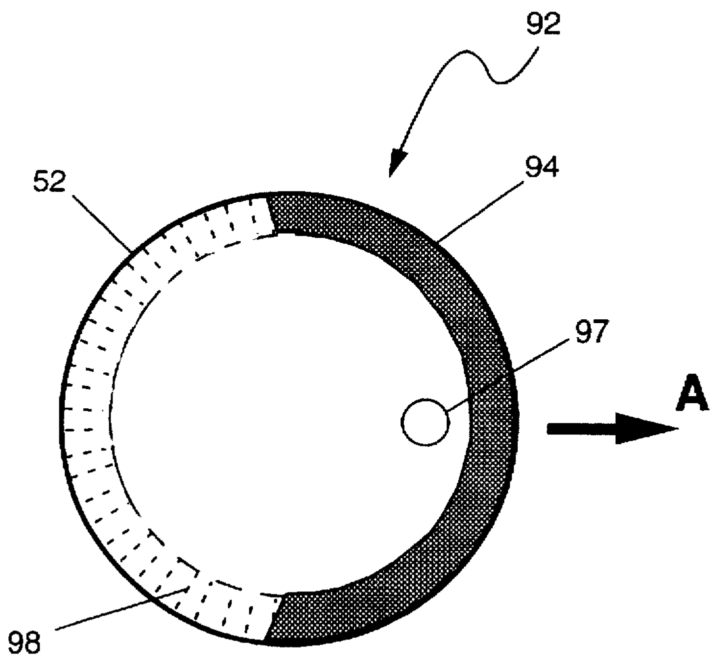


Fig. 7B

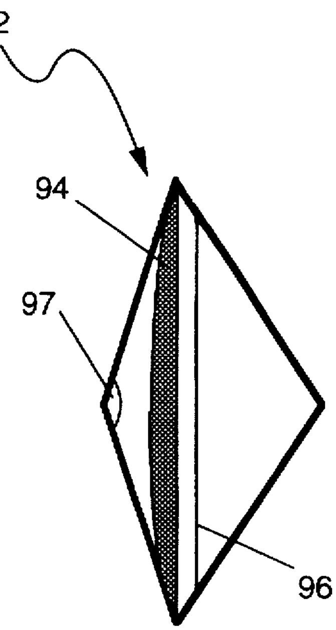


Fig. 7C

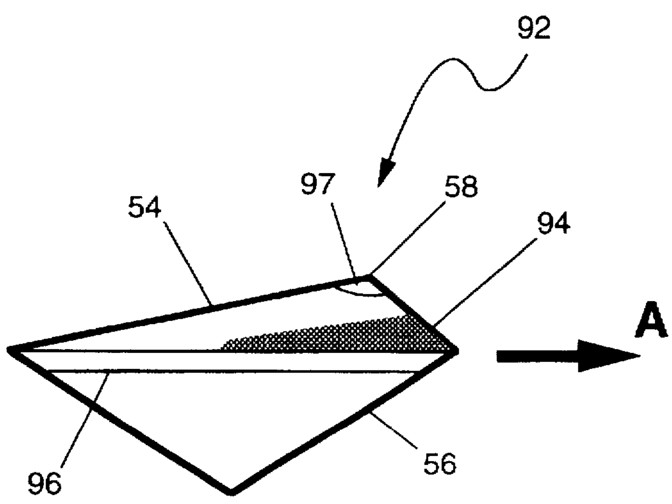
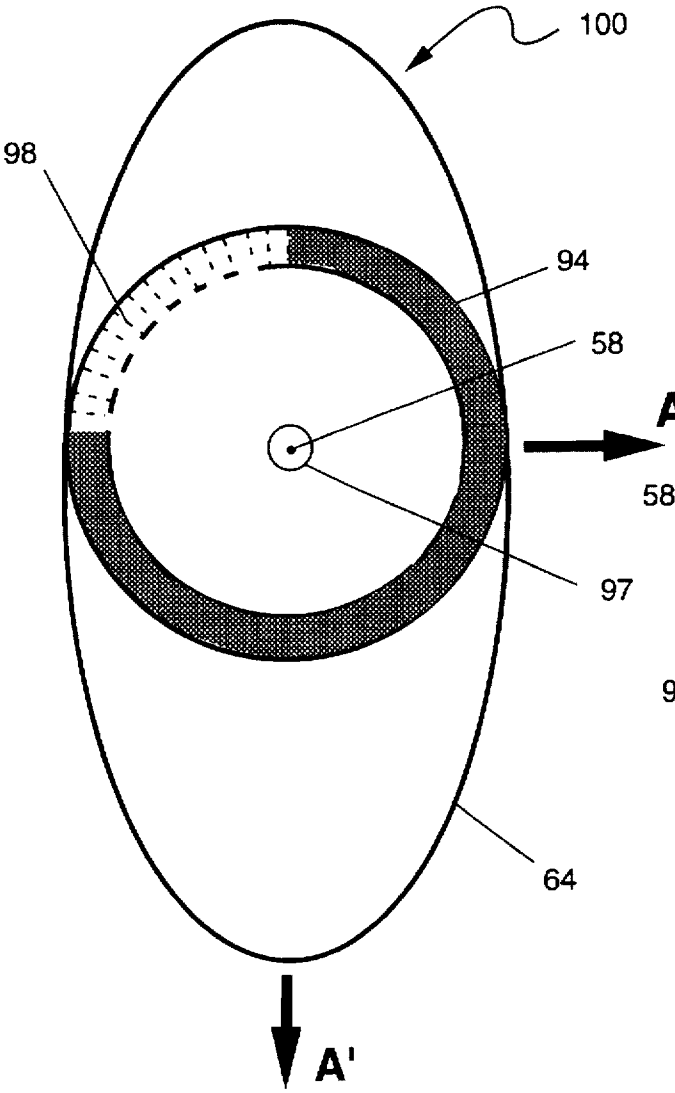


Fig. 7A



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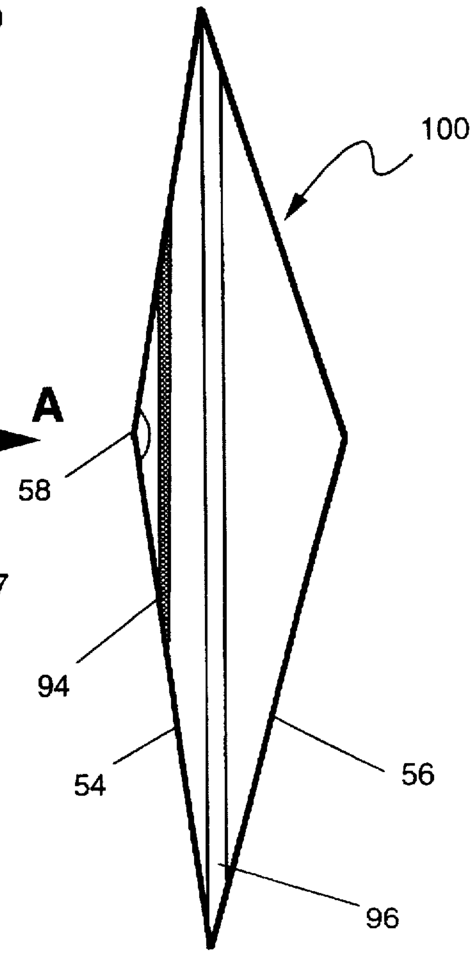

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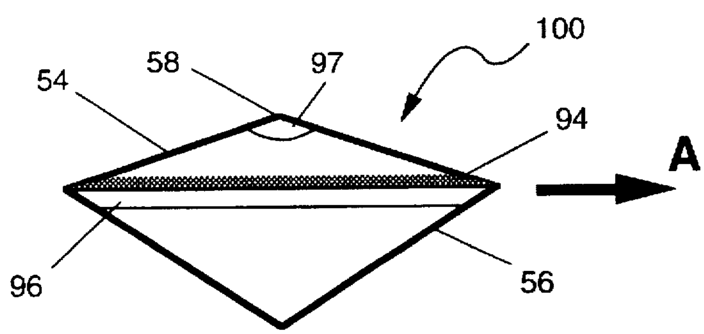
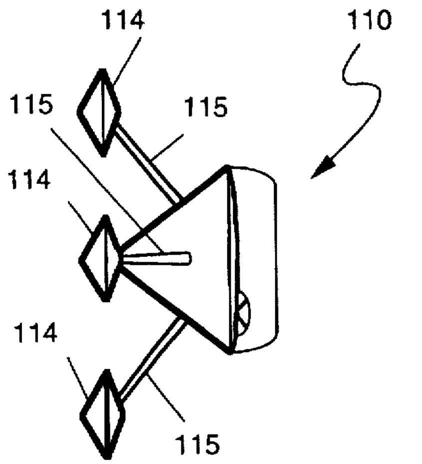


Fig. 8A



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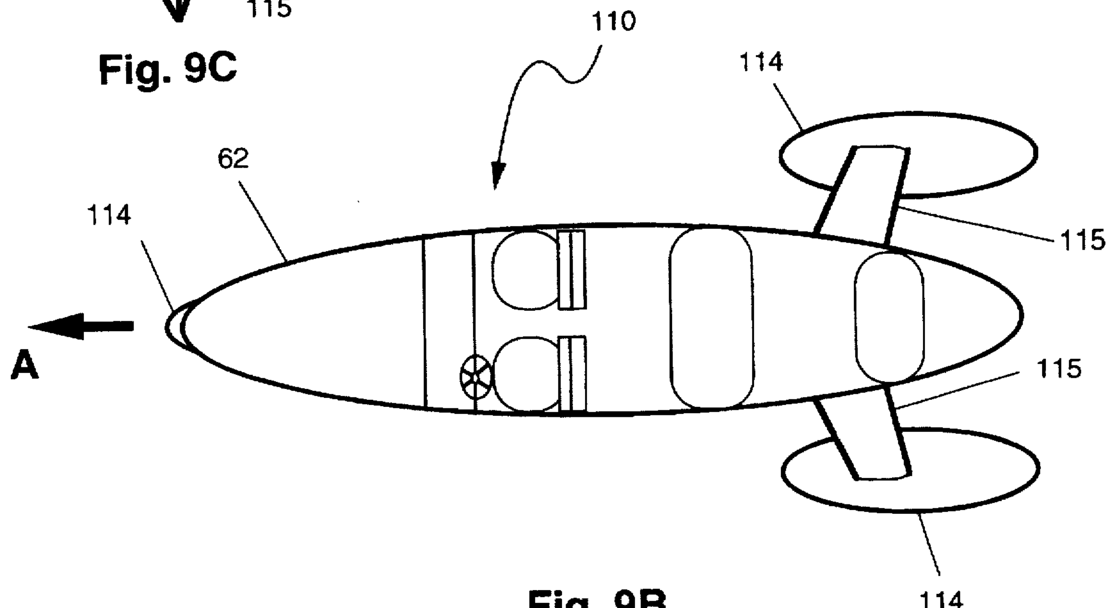

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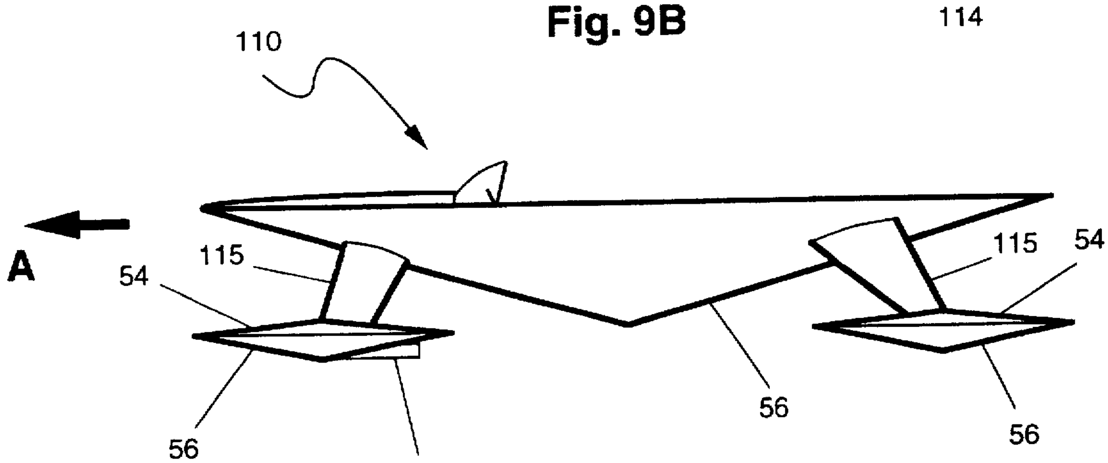

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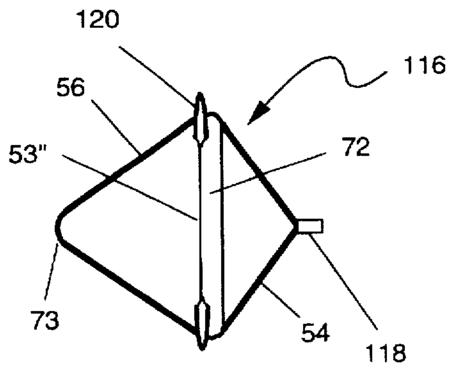

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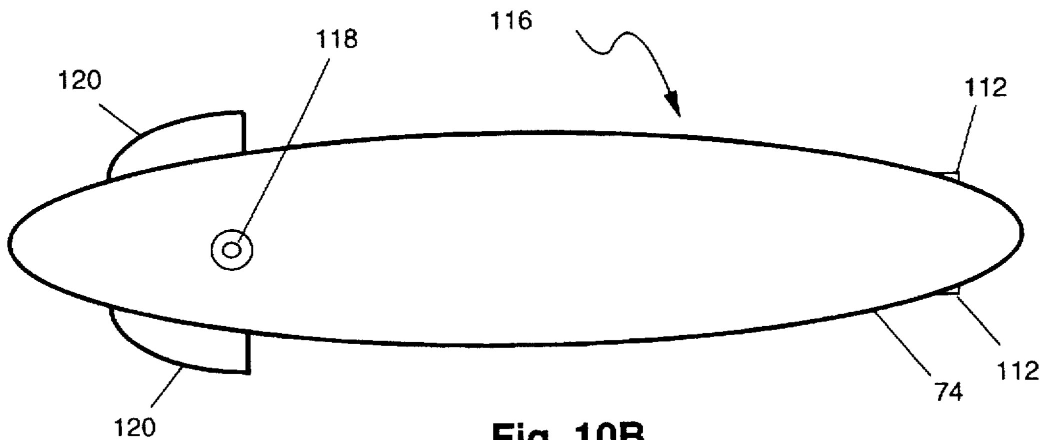

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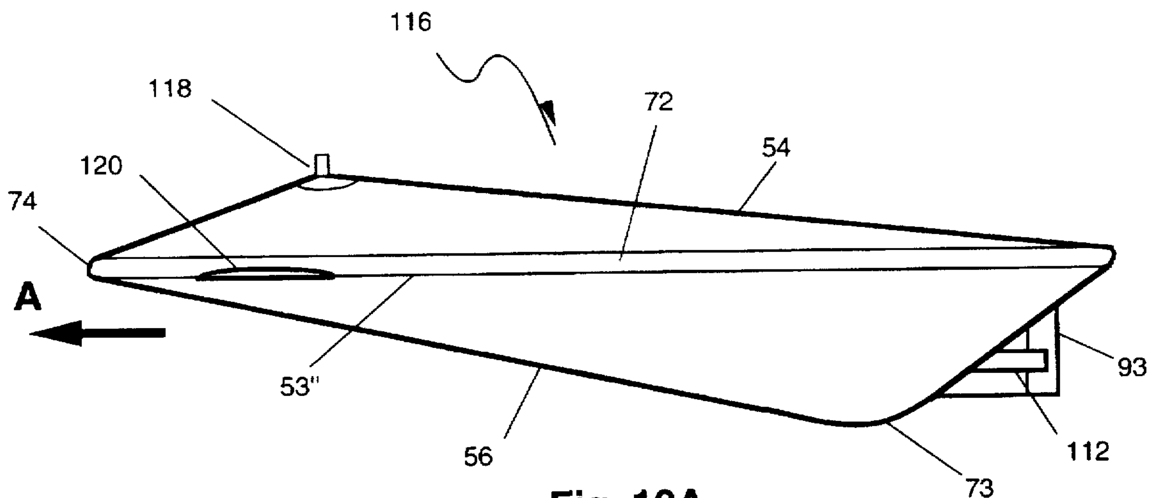

Fig. 10A

UNIVERSAL FLUID-DYNAMIC BODY FOR AIRCRAFT AND WATERCRAFT

BACKGROUND—FIELD OF INVENTION

This invention relates to air or water-borne vehicles or craft, specifically to a configuration of the vehicle's main body that provides not only passenger and cargo capacity, but also provides reduced fluid resistance.

BACKGROUND—DESCRIPTION OF PRIOR ART

Future supersonic military and commercial aircraft will be required to have high levels of lifting efficiency and minimal aerodynamic drag at subsonic, transonic, and supersonic speeds. Present philosophies for the design of aircraft vary greatly in addressing the desire to maximize performance at multiple operating conditions, but most employ some form of a traditional wing configuration. A review of existing wing design philosophies for subsonic, transonic, and supersonic flight reveals both contradictions, and similarities.

The contradictions exist mainly between the philosophies for subsonic flight and the schemes for supersonic cruise designs, where the subsonic flight includes takeoff, climb, descent, and landing operations, as well as the subsonic (low-speed) cruise design. For low-speed flight, takeoff, and landing designs, the tendency is toward a wing planform having a long span and narrow chord, where the chord is the width of the wing from the leading edge to the trailing edge and the planform is defined as the wing or vehicle outline when viewed from above. In addition wings designed for low-speed operation typically have little, if any wing sweep, such that the leading edge of the wing is generally perpendicular to the direction of flight. The traditional subsonic wing designs generally have blunt leading edges and relatively thick airfoils (cross-sectional shapes of the wings when viewed from the side). Such prior art airfoils induce a pressure distribution over the wing surface, needed to generate the required lift forces, by providing a convex upper surface having a height greater than the oppositely disposed lower surface depth. On the other hand, supersonic designs typically employ thin airfoils, sharp leading edges, and high sweep wings, such that the wing leading edge is at an acute angle to the direction of flight.

The total lift developed by a lifting airfoil, with other factors, such as angle of attack and dynamic pressures being equal, is substantially dependent on the aspect ratio of the airfoil, defined as the square of the span of the airfoil divided by the surface area. Therefore, it is apparent that a long narrow wing is capable of developing substantially greater lift-to-drag ratio than is attainable using a short broad wing of the same plan area. The use of the high-aspect ratio wing offers the advantages that the angle of attack required for landing and takeoff is at the low end of the spectrum. The takeoff and landing speeds are therefore lower than for the lower aspect ratio wings, thus permitting a relatively short takeoff and landing, as well as a low-speed climb to altitude. Furthermore, the drag due to lift is also at the low end of the spectrum, thereby providing high aerodynamic efficiency for subsonic cruise and low power requirements during takeoff and landing.

For transonic and supersonic flight however, highly swept wings are considered preferable because aerodynamic drag may be greatly reduced, and other advantages may also be obtained. For example, even during high altitude subsonic cruise, the highly swept wing configuration develops a comparatively low drag coefficient while still developing the requited lift coefficient. However, swept wing aircraft designed solely on the basis of supersonic high performance flight will obviously not perform satisfactorily for subsonic cruise, takeoff, and landing. Even present day supersonic aircraft are designed with aspect ratios higher than that considered optimum for supersonic cruising flight, to make takeoff and landing practical. These supersonic aircraft must also climb to cruise altitude at subsonic speeds to prevent shock wave ground effects and they must do this at the expense of increased fuel consumption since the relatively low aspect ratio of the wing results in increased drag due to lift while in climb.

Various attempts have been made to enable the wing configuration of an aircraft to be modified in flight to optimize both the low-speed and high-speed performance of the aircraft. At maneuvering conditions, designs for both low-speed and supersonic wings, utilizing variable-camber devices such as leading-edge and trailing-edge flaps, have succeeded fairly well. At supersonic speeds, however, leading edge flaps have accomplished only minimal benefits in performance. Devices designed to provide variable convexity to the wing contour or airfoil also have the added drawbacks of increased complexity in design, increased weight, and loss of usable volume. An alternative approach for meeting the required maneuvering conditions is developing a fixed-camber wing. Generally, these wing designs have succeeded at their designed lift conditions, but have suffered severe camber drag penalties at lower lift conditions. Techniques to mitigate some of these disadvantages by contouring three-dimensional upper and lower surfaces of the wing airfoil have been proposed-for example, in U.S. Pat. No. 5,112,120, dated May 12, 1992, to Wood et al. However, these techniques are limited to localized performance gains derived by modifying traditional airfoil technology with a significant adverse effect on manufacturing and production costs.

Further attempts have been made to enable the wing configuration of an aircraft to be modified in flight to optimize both the low-speed and high-speed performance of the aircraft. For example, turning the wing as a whole with respect to the fuselage of an aircraft, so that it can be set at a right angle to the fuselage for takeoff, landing, and low-speed flight and then pivoted as a unit so that it is skewed with one side swept forward and the other swept back at high-speeds has also been proposed in U.S. Pat. No. 3,971,535, dated Jul. 27, 1976 to Jones. Superior lift-to-drag ratios have been reported at all air speeds up to Mach 1.4 for aircraft having the skewed wing capability compared to the delta wing configuration aircraft. The straight wing operation also results in less noise and air pollution during takeoff compared to a delta wing configuration due to a takeoff power requirement reported to be only 25 percent of that needed for the delta wing design.

Although the skewed wing operation affords improved performance for aircraft required to fly at supersonic speeds, several disadvantages exist:

- a significant structural mechanism is needed to turn the wing,
- a separate fuselage section, with the corresponding contribution to aircraft weight and drag, is needed for passengers and cargo, and
- the benefits of the skewed wing performance appear to be limited to a skewed angle within the range of approximately zero to seventy degrees.

Techniques have been proposed to mitigate some of these disadvantages associated with the skewed wing aircraft. For example, in U.S. Pat. No. 4,836,470, dated Jun. 6, 1989 to Criswell, a rotatable flying wing is proposed although the wing configuration is undefined, except for the planform. Without an aerodynamically efficient wing configuration, severe performance penalties will offset any advantages of the rotatable flying wing concept. Also, American Institute of Aeronautics and Astronautics (AIAA) papers AIAA 92-4220 by Waters et at. and AIAA 92-4230 by Galloway et al. presented at the AIAA Aircraft Design Systems Meeting, 24–26 Aug. 1992, discuss structural and aerodynamic considerations for an oblique all-wing aircraft and oblique wing supersonic transport concepts. The basic performance of an oblique all-wing aircraft was reported to be excellent up to a design cruise speed of Mach 1.6. Although the oblique all-wing aircraft demonstrates improved performance compared to a typical swept-wing or delta-wing aircraft, there are significant disadvantages resulting from the present techniques employed to meld passenger and cargo space into a wing that has a traditional airfoil configuration. These conventional oblique all-wing aircraft disadvantages include:

The aerodynamic performance advantage is restricted to a maximum sweep or skewed angle of approximately 70 degrees. Some experts estimate that this sweep angle would correspond to a flight speed of Mach 2.0 as a practical upper limit.

The oblique all-wing aircraft would have to be very large, estimated to be large enough to hold 400 plus passengers, for practical operation as a passenger aircraft and to realize the performance advantage over the oblique wing aircraft that carries passengers and cargo in a conventional cylindrical fuselage.

With the wing positioned at an oblique angle on both takeoff and landing, depending upon the cockpit location, the pilot will likely experience unconventional visual cues and pilot visibility from the cockpit will be much reduced from the visibility that now exists for subsonic transport aircraft.

Structural design of the oblique all-wing aircraft will be more complex than conventional aircraft configurations and may depart significantly from traditional aircraft design practice, especially to:

a. accommodate the flight and taxi bending moments with the unique weight distributions over the wing span,

b. provide the pressurized cabin environment in a rectangular passenger section rather than the conventional cylindrical fuselage type aircraft, and

c. incorporate aircraft flight control features and satisfy the aircraft trim constraints that are unique to the oblique all-wing configuration and operating attitudes.

The relatively high aspect ratio values needed to achieve the aerodynamic performance advantages of the oblique all-wing aircraft tend to exacerbate flight stability, trim, and control concerns associated with aeroelastic effects, such as the change in lift-force distribution as the wing is deflected by the aerodynamic forces.

Many subsonic aircraft configurations have been developed to satisfy unique functional needs, including aircraft capable of vertical takeoff and landing. Helicopters provide direct lift capability but relatively poor aerodynamic efficiency at cruise speeds which are also limited to the relatively low subsonic regime. Jet aircraft, using thrust vector control of the jet exhaust to achieve vertical takeoff and landing and the tilt-rotor V-22 Osprey aircraft are examples of aircraft designed to mitigate the disadvantages of the helicopter cruise performance. However, high-speed performance improvements are incorporated at the expense of the vertical takeoff and landing performance or the aircraft weight and complexity. Other attempts to improved cruise performance of a vertical takeoff and landing aircraft include aircraft having a circular planform with rotating outer rings. The rotating outer rings incorporate vanes or blades to provide lift and the rotating rings function as a gyroscope to provide vehicle stability. Examples of these circular planform aircraft are reported in Aerospace Daily article number 22404, dated 25 Jan. 1995 and described in U.S. Pat. No. 5,064,143, dated Apr. 19, 1989, to Bucher. Gyroscopic stability is a novel feature but, without a significant improvement in aerodynamic performance, the added weight and complexity of the aircraft is difficult to justify.

Traditional winged aircraft, used on aircraft carriers, often incorporate complex and heavy mechanisms for folding the wing sections to improve storage efficiency

Satellites and spacecraft have relied chiefly upon multistage, expendable launch vehicles to achieve orbit or spaceflight. The NASA Space Transportation System (STS) Orbiter and space capsules are employed primarily where manned presence is needed in space flight and a return to earth is essential. The enormous cost of the expendable hardware, even the expendable hardware associated with the STS Orbiter, has prompted investigation of Single-Stage-To-Orbit (SSTO) launch vehicles. Materials and propulsion technology advancements are now being employed to develop SSTO design concepts. Although most SSTO vehicle configurations are based on a rocket engine thrust for launch in a vertical attitude and aerodynamic lift for landing, at least one concept relies upon rocket engine thrust for lift during both takeoff and landing. Using rocket engines to provide the lift during launch generally involves some staging to at least jettison most of the rocket engine propellant tankage that is emptied during launch. The SSTO vehicle that uses rocket engine thrust for lift during landing must carry the landing propellant through the launch, ascent, and de-orbit phases of the mission, thereby reducing the payload capacity of the vehicle. During takeoff and landing, the rocket engines cause not only high noise levels, but also create an adverse structural dynamic environment that the payload and any passengers must be capable of withstanding.

Submersible watercraft, such as submarines, are typically configured based on generally cylindrical bodies to minimize the frontal area with appendages added as needed to satisfy functional requirements such as the conning tower, propulsion systems, and diving controls. Typically the design for fluid-dynamic efficiency is incorporated after the size and shape of the submersible watercraft are established to satisfy internal capacity, configuration, and functional requirements. These performance efficiency features are often limited to generous rounding of corners and fairing of appendages to minimize the drag or fluid dynamic flow resistance as the vehicle moves through the water.

Hydrofoil watercraft are designed to float on the vehicle main body when at rest and during very low-speed operation. During transition to high-speed operation, the watercraft main body rises until the watercraft rides on the hydrofoils that are typically designed to hydroplane on the surface of the water. This surface effects operational feature tends to limit the hydroplaning to relatively smooth water surface conditions. In addition, unless the hydrofoils are retractable, adding to the weight and complexity of the watercraft, the extended hydrofoils and support struts significantly degrade watercraft performance during low-speed operation.

Objects and Advantages

Accordingly, several objects and advantages of the present invention are to improve the subsonic and supersonic aerodynamic performance of aircraft, reduce noise and air pollution, especially during the takeoff phase of high performance aircraft and spacecraft launch vehicles, and reduce the fluid-dynamic resistance of vehicles designed to operate in a water or liquid environment. Aerodynamic performance advantages include improved aircraft stability in the pitch and roll directions as well as greater lift to drag ratios throughout the operating regime. The invention provides a universal fluid-dynamic body which accommodates a wide variety of planforms, as needed to satisfy passenger or cargo functional, space or capacity, and operational requirements.

Further objects and advantages of this invention will become apparent from a consideration of the drawings and the ensuing description.

DRAWING FIGURES

FIG. 1A is a side view of a universal fluid-dynamic body showing conical upper and lower segments, in accordance with the present invention

FIG. 1B is a top view of the FIG. 1A body showing a circular planform of a baseline configuration.

FIG. 2A is a side view of a universal fluid-dynamic body showing sides of the conical upper and lower segments trimmed, thereby reducing frontal area.

FIG. 2B is a top view of the FIG. 2A body showing the circular planform of FIG. 1B trimmed to an elliptical planform and then modified to incorporate a smooth transition between the trimmed edges of the conical upper and lower segments.

FIG. 2C is a frontal elevation view of the body of FIGS. 2A and 2B showing the effects of trimming the side-walls.

FIG. 3A is a side view of a universal fluid-dynamic body in which the conical upper and lower segments intersect a common baseplane that is elliptical in planform or outline as viewed from the top.

FIG. 3B is a top view of the FIG. 3A body showing the elliptical planform that defines the common baseplane of the conical upper and lower segments.

FIG. 3C is a frontal elevation view of the body of FIGS. 3A and 3B.

FIG. 4A is a side view of a universal fluid-dynamic body in which a cylindrical section is inserted between the conical upper and lower segments and then modified to incorporate a smooth transition between the conical upper and lower segments.

FIG. 4B is a top view of the FIG. 4A body showing an elliptical planform configuration of the added cylindrical section before and after incorporating the smooth transition between the conical upper and lower segments.

FIG. 4C is a frontal elevation view of the body of FIGS. 4A and 4B.

FIG. 5A is a side view of a universal fluid-dynamic body in which the apex of the upper conical segment is positioned forward and the apex of the conical lower segment is positioned aft.

FIG. 5B is a top view of the FIG. 5A body showing an elliptical planform configuration selected to illustrate the fore and aft shift of the conical upper and lower segment apices.

FIG. 5C is a frontal elevation view of the body of FIGS. 5A and 5B.

FIG. 5D is a partial side view of the FIG. 5A body showing the effect of truncating the conical lower segment apex.

FIGS. 6A through 6C are side, top, and frontal elevation views, respectively, of a supersonic transport aircraft that embodies the universal fluid-dynamic body, in which the conical upper segment and upper section of the conical lower segment are rotated into the takeoff position.

FIGS. 6D and 6E are side and top views respectively of the FIGS. 6A through 6C supersonic aircraft, showing the option of extending the lower section and adding traditional elevator and rudder aerodynamic control systems.

FIGS. 6F through 6H are side, top, and frontal elevation views respectively of the FIGS. 6A through 6C aircraft, showing the conical upper segment and the upper section of the conical lower segment in transition between the takeoff position and fully rotated to the high-speed flight orientation.

FIGS. 6I is an isometric view of the aircraft illustrated in FIGS. 6F through 6H.

FIGS. 6J through 6L are side, top, and frontal elevation views respectively of the FIGS. 6A through 6C aircraft, showing the conical upper segment and the upper section of the conical lower segment fully rotated to the high-speed flight orientation.

FIGS. 7A through 7C are side, top, and frontal elevation views respectively of a subsonic aircraft that embodies the universal fluid-dynamic body, in which an outer ring compressor and thrust vector control system are incorporated to provide vertical takeoff and landing capability and gyroscopic stability.

FIGS. 8A through 8C are side, top, and frontal elevation views respectively of a supersonic version of the FIGS. 7A through 7C aircraft, in which a high aspect ratio planform is employed for low-speed flight and then the aircraft is rotated to the low aspect ratio planform for supersonic flight speeds.

FIGS. 9A through 9C are side, top, and frontal elevation views respectively of a hydroplane watercraft, in which universal fluid-dynamic body configurations, having generally elliptical planforms, are employed as tripod lifting bodies and a conical lower segment is used for the watercraft main body.

FIGS. 10A through 10C are side, top, and frontal elevation views respectively of a submersible watercraft in which a universal fluid-dynamic body configuration, having a generally elliptical planform and a cylindrical center section, are employed for improved fluid dynamic efficiency in a liquid environment.

Reference Numerals In Drawings	
50	universal fluid-dynamic body
52	circular planform
53	common baseplane
53'	top of cylinder
53"	bottom of cylinder
54	conical upper segment
56	conical lower segment
56'	upper section of conical lower segment
56"	lower section of conical lower segment
58	conical upper segment apex
60	conical lower segment apex
62	trimmed elliptical planform
64	new elliptical planform

-continued

Reference Numerals In Drawings	
66	second universal fluid-dynamic body
68	third universal fluid-dynamic body
70	alternate planform
71	fourth universal fluid-dynamic body
72	cylinder
73	rounded surface of truncated apex
74	rounded side-walls of cylinder
80	supersonic transport aircraft
82	truncating plane
84	air inlet
86	landing gear system
88	interface bearing
89	lower section extension
90	common vertical axis
91	traditional elevator system
92	vertical takeoff & landing aircraft
93	traditional rudder system
94	air inlet system
95	aerodynamic control surfaces
96	thrust vector control system
97	cockpit
98	compressor system
100	supersonic VTOL aircraft
110	hydroplane type watercraft
112	hydroplane watercraft propulsion system
114	tripod elements
115	support strut
116	submersible watercraft
118	conning tower
120	diving planes

SUMMARY

According to the present invention I provide a unique body configuration that improves performance efficiency and stability of vehicles operating in a fluid environment. The basic body configuration can be visualized as two cones that have a common base plane and the intersection of the two cones at the common base plane defines the planform of the vehicle. In a preferred embodiment, the height of the conical upper segment, from the tip of the apex to the base plane is approximately two-thirds the height of the conical lower segment, also from the tip of the conical lower segment apex to the common base plane. Specifically, test results indicate an aircraft or watercraft that has this unique body configuration will exhibit relatively less drag or resistance to forward motion through the air or water, resulting in lower energy requirements and less noise, especially during aircraft takeoff and climb. Test results also demonstrated inherently stable flight of this unique body configuration.

Description of Universal Fluid-dynamic Bodies-FIGS. 1A through 5C

FIGS. 1A through 5C define the baseline configuration of a universal fluid-dynamic body according to the present invention and three alternate configurations defined by modifications of the baseline to provide unique functional or performance capabilities. Each of these four configurations is described in the following sections.

Baseline Universal Fluid-Dynamic Body-FIGS. 1A and 1B

The baseline configuration is illustrated by a universal fluid-dynamic body **50**, shown in FIGS. 1A and 1B as having a circular planform **52**. Body **50** comprises a generally conical upper segment **54** and an inverted generally conical lower segment **56**. Conical upper and lower segments **54** and

56 interface and are joined at a common baseplane **53** defined by planform **52**. Height h_u of conical upper segment **54** is defined as the perpendicular distance from common baseplane **53** to a conical upper segment apex **58**. Height h_L of conical lower segment **56** is defined as the perpendicular distance from common baseplane **53** to a conical lower segment apex **60**. Segment **54** has a height hu which is generally less than height h_L of segment **56**. In the preferred embodiment, segment **54** has a height hu which is within the range of one-half to five-sixth (⅔±⅙) of height h_L of segment **56**. Segment **54** has a downward slope from apex **58** to baseplane **53** forming an angle θ_u with baseplane **53**. In the preferred embodiment, angle θ_u is within the range of 2 degrees to 10 degrees. Segment **56** has a upward slope from apex **60** to baseplane **53** forming an angle θ_L with baseplane **53**. In the preferred embodiment, angle θ_L is within the range of 3 degrees to 18 degrees.

In the generic form shown in FIGS. 1A and 1B, body **50** is suitable for application as an aircraft or a watercraft. The front and rear views of body **50** are identical to the side view shown in FIG. 1A.

As can be seen by the symmetry of the body **50**, vehicles or craft that embody this configuration are equally efficient moving in any lateral direction B, or reverse direction A', as well as forward direction A shown in FIG. 1B. However, functional design features, such as propulsion system and attitude control systems, not shown in either FIGS. 1A or 1B, will typically dictate a preferred forward direction of operation.

To accommodate the functional requirements of the desired application, a range of sizes, including height and planform area, may be selected for Body **50**. These sizes may range from miniature solid-projectiles to jumbo size aircraft capable of carrying hundreds of passengers. Conventional production methods, preferably injection or poured molding processes to manufacture large quantities or lathe turning and milling techniques for larger sizes and smaller quantities, may be used to manufacture the solid-projectile versions of body **50**. Fiberglass production techniques, currently used for surfboard production, are directly applicable to manufacture of body **50** for use as a surfboard. A conventional semi-monocoque structure design and construction techniques are suggested for larger versions of body **50** that require internal space to accommodate passengers and cargo. The semi-monocoque structure is comprised of a relatively thin outer shell with stiffeners attached as needed to aid in resisting internal pressure and external compression or collapse loads. Conventional structural design and production methods that are directly applicable to body **50** production include use of composite technology as well as aluminum skin construction, especially for the aircraft and spacecraft applications. Stringers or stiffeners, such as aluminum beam members (not shown), emanating from the region of apices **58** and **60** to a circumferential member (not shown) at the perimeter of planform **52**, provide primary support structure for the shell or skin material forming the semi-monocoque structure. Circumferential support rings (not shown), radially spaced intermittently and joined to the stringers, provide additional strength and stiffness in conjunction with the external skin covering segments **54** and **56**, to form an integrated basic structure.

Second Universal Fluid-Dynamic Body-FIGS. 2A through 2C

FIGS. 2A, 2B, and 2C, are side, top, and frontal views, respectively, of a second universal fluid-dynamic body **66** that provides a lower aspect ratio planform without affecting slope angles θ_u and θ^L of upper and lower segments **54** and **56**, respectively. To produce Body **66**, circular planform **52**, shown in FIG. **2B**, is trimmed to form an elliptical plan form **62**. Elliptical planform **62** is then modified by fairing the trimmed edges of body **66**, resulting in a new elliptical planform **64**.

Third Universal Fluid-Dynamic Body-FIGS. 3A through 3C

A universal fluid-dynamic body may be provided for alternative planforms using techniques other than trimming a circular-planform body. For example, FIGS. **3A**, **3B**, and **3C** are side, top, and end views respectively, of a third universal fluid-dynamic body **68**. Body **68** comprises a conical upper segment **54** and an inverted conical lower segment **56** that intersect and are joined at common base plane **53** defined by an alternate planform **70**. Height h_u of conical upper segment **54** is defined as the perpendicular distance from common base plane **53** to conical upper segment apex **58**. Height h_L of conical lower segment **56** is defined as the perpendicular distance from common base plane **53** to conical lower segment apex **60**. Height h_u of segment **54** is generally less than height h_L of segment **56**. In the preferred embodiment, height h_u of segment **54** is within the range of one-half to five-sixth ($\frac{2}{3}\pm\frac{1}{6}$) of height h_L of segment **56**. Due to the non-circular planform at the intersection of upper and lower segments **54** and **56**, upper and lower slopes θ_u and θ_L, respectively, vary around the perimeter of planform **70**. However, in the preferred embodiment, angle θ_u is maintained within the range of 2 degrees to 10 degrees and angle θ_L is maintained within the range of 3 degrees to 18 degrees.

Fourth Universal Fluid-Dynamic Body-FIGS. 4A through 4C

Vehicles or craft that rely primarily on buoyancy rather than fluid-dynamic lift for vertical support typically are designed to provide more usable internal volume and less external wetted surface area. This may be accomplished without significantly sacrificing major performance advantages. For example, body **68**, shown in FIGS. **3A**, **3B**, and **3C** may be further modified to create a fourth universal fluid-dynamic body **71**, shown in FIGS. **4A**, **4B**, and **4C**. This is accomplished by inserting a cylinder **72** between conical upper segment **54** and inverted conical lower segment **56**, thereby creating separate base planes **53'** and **53"** for segments **54** and **56**, respectively, and serving as the upper and lower ends, respectively, of cylinder **72**. The side walls of cylinder **72** are then hired with upper segment **54** and lower segment **56** to form a rounded side-wall **74** for improved fluid-dynamic performance and increased pressure vessel structural capability.

Conical upper and lower segment apices **58** and **60** are shown generally at the same station plane for all universal fluid-dynamic body configurations illustrated in FIGS. **1A**, **2A**, **3A**, and **4A**. However, for design or performance considerations such as,

- satisfaction of functional requirements or preferences,
- improvement of lateral stability,
- adjustment of the aerodynamic center of pressure to be more favorably aligned with the vehicle center of gravity, or
- enhancement of pressure loading as suggested in the Wood patent, supra, apices **58** and **60** may be positioned either forward or aft, either together or independently, as illustrated in FIGS. **5A**, **5B**, and **5C** for third body **68**. Likewise, either apex **58** or **60** may be truncated, as illustrated in FIG. **5D** for segment **56**, if desired to satisfy geometrical or functional preferences such as increasing ground clearance of an aircraft, without extending the height or length of the landing gear systems, not shown. A generally curved surface **73**, shown in FIG. **5D**, may be faired into the outer surface of truncated conical lower segment **56** to maintain smooth fluid-dynamic flow in the area of the truncated surface.

Vehicle Description and Operation-FIGS. 6A through 10C.

The following sections define implementation of universal fluid-dynamic body features into aircraft and watercraft as illustrated in FIGS. **6A** through **10C**. The corresponding description of operation for the preferred embodiment of the universal fluid-dynamic body is also included.

Supersonic Transport and Single-Stage-to-Orbit Aircraft-FIGS. 6A through 6L

New demands on supersonic aircraft for better economy and less noise necessitate a different concept in the design of such aircraft. A preferred embodiment of the universal fluid-dynamic body that addresses these economy and noise objectives is illustrated by a Supersonic Transport (SST) aircraft **80** in FIGS. **6A**, **6B**, and **6C**, which are side, top or planform, and frontal views, respectively. A truncating plane **82** divides segment **56** into an upper section **56'** and a lower section **56"**. Upper section **56'** and lower section **56"** are capable of being rotated relative to each other about a common vertical axis **90** that is normal to truncating plane **82**. Structural continuity between upper section **56'** and lower section **56"** is provided by interface structural devices, such as an interface bearing ring **88**, illustrated in FIG. **6B**, with control system, not shown, for rotating upper section **56'** relative to lower section **56"**. A vertical support device **86**, such as a retractable landing gear system illustrated in FIGS. **6A** and **6C**, is provided for takeoff and landing. To minimize adverse effects on the aerodynamic performance of the aircraft, a traditional propulsion system, not shown, is preferably integrated within lower section **56"**. The location of a propulsion system, such as a jet engine, is indicated by an air inlet **84** shown in FIG. **6C**.

A conventional attitude control system, not shown, such as thrust vector control or aerodynamic control surfaces **95**, are integrated into or appended to segment **54** and sections **56'** and **56"**. These provide pitch, yaw, and roll control during takeoff, flight, and landing of aircraft **80**.

An extension **89** of the aft or downstream portion of section **56"**, such as illustrated in FIGS. **6D** and **6E**, is an alternative configuration, to support a traditional elevator system **91** and a traditional rudder system **93** for additional aerodynamic control, especially during takeoff, landing, and low-speed flight. Traditional hydraulic, pneumatic, propellant, electrical, and avionics systems, cargo and passenger accommodations, and cockpit features, not shown, are added as needed to satisfy the functional requirements of aircraft **80**.

The takeoff, initial climb, and landing configuration of aircraft **80** is illustrated in FIGS. **6A**, **6B**, and **6C**. The design takes advantage of the efficient low-speed performance, reduced noise, and improved lift capability in the high-aspect ratio configuration. During takeoff, aircraft **80** travels in direction A and accelerates until airspeed is sufficient to achieve the required aerodynamic lift. The pitch attitude of aircraft **80** is then adjusted to a predetermined angle of attack for takeoff.

Following takeoff, landing gear system **86** is retracted. During climb, segment **54** and section **56'** are progressively rotated relative to section **56"**, as illustrated in FIGS. **6F**, **6G**, and **6H**, to optimize aerodynamic performance efficiency as altitude and airspeed are increased. An isometric view of aircraft **80**, with segment **54** and upper section **56'** being rotated relative to lower section **56"**, is illustrated in FIG. **6I** as aircraft **80** is in the climb phase of flight.

At high subsonic speeds, during transition from subsonic to supersonic (transonic) operation, and at supersonic and hypersonic flight speeds, segment **54** and upper section **56'** of aircraft **80** are rotated generally in line with lower section **56"**, as illustrated in FIGS. **6J**, **6K**, and **6L**, for peak performance efficiency and minimum sonic boom or shock effects. In a preferred embodiment that features added elevator **91** and rudder **93**, a retraction mechanism, not shown, is employed to fold and retract elevator system **91** and rudder **93** into upper section **56'** after upper section **56'** and segment **54** are fully rotated and locked into the high-speed flight position. As altitude and airspeed increase, aircraft **80** operates as a Single Stage To Orbit (SSTO) or spacecraft vehicle. At altitudes above the tangible atmosphere, where the air-breathing engines are ineffective, a rocket propulsion system, not shown but preferably located within the structural envelope of aircraft **80**, is used to provide the propulsive thrust.

During descent, segment **54** and upper section **56'** are progressively rotated back toward the takeoff configuration as illustrated in FIGS. **6F**, **6G**, and **6H** for descent, and then into the position shown in FIGS. **6A**, **6B**, and **6C** for the landing orientation.

Vertical Take-off and Landing Aircraft-FIGS. 7A through 8C

A Vertical Takeoff and Landing (VTOL) aircraft **92** is a preferred embodiment of the universal fluid-dynamic body for subsonic and hover type applications. FIGS. **7A**, **7B**, and **7C** are side, top or planform, and frontal views, respectively of aircraft **92**. Circular planform **52** is selected for an aircraft that is to be used predominately for low-speed and hover type operations. A cockpit **97** is situated in apex **58**, which is located in a forward position to enhance pilot visibility and improve the ram air performance of an air inlet system **94**, during forward flight. Vertical takeoff and landing are accomplished using a thrust vector control system **96** to direct exhaust flow from a single or multiple stage compressor system **98** to generate the necessary lift forces. Rotating rings of compressor system **98** also provide gyroscopic forces to augment stability control during vertical takeoff and landing. During forward flight, aerodynamic control surfaces, not shown, augment the pitch, yaw, and roll control forces of control system **96**. Before takeoff and after landing, vertical support of VTOL aircraft **92** is provided by a traditional retractable landing gear system, not shown. In forward flight operation, the vertical support is derived predominately from the aerodynamic forces acting on segments **54** and **56**, with the energy developed by the propulsion system, not shown, used almost exclusively for forward thrust, either directly or through compressor system **98** and control system **96**.

The preferred embodiment of a supersonic VTOL aircraft **100**, designed for transonic and supersonic flight speeds, employs generally elliptical planform **62** to take advantage of the large aspect ratio aerodynamic performance during low-speed flight and then rotate to the more efficient orientation, similar to SST aircraft **80**, for high-speed, transonic, and supersonic flight operation. VTOL aircraft **100** is illustrated in FIGS. **8A**, **8B**, and **8C**, which are side, top or planform, and frontal views, respectively, with flight direction arrow A indicating the low-speed direction of flight and arrow A' indicating the high-speed, transonic, and supersonic direction of flight. Operation of VTOL aircraft **100** is similar to that of VTOL aircraft **92**, except upper segment apex **58** is positioned generally in the center of planform **62** to maintain apex **58** generally on the lateral centerline as aircraft **100** rotates or turns approximately 90 degrees from the low-speed to the high-speed position. Rotation or turning of VTOL aircraft **100** is similar to the technique described above for aircraft **80** and illustrated in FIGS. **6A** through **6L**.

Hydroplane Watercraft-FIGS. 9A through 9C

The preferred embodiment of a hydro-plane type watercraft **110**, designed for operation at high-speeds on the water surface, employs generally elliptical planform **62** for the main body of watercraft **110** to take advantage of the low aspect ratio fluid-dynamic performance in the direction of travel A. Watercraft **110** is illustrated in FIGS. **9A**, **9B**, and **9C** which am side, top or planform, and frontal views, respectively. A tripod arrangement is employed to provide the hydroplane lifting forces. A tripod element **114** is joined to the lower end of a support strut **115**. The upper end of each strut **115** is joined to segment **56** of watercraft **110**. In a preferred embodiment, third universal fluid-dynamic body **68** configuration is used for tripod elements **114** to improve performance by reducing the frontal area. Tripod elements **114** lift watercraft **110** during transition to high-speed operation and then, at cruise speeds, ride on the water surface. A conventional propulsion device **112**, such as propeller or water jet system, is used to provide the translational thrust and may include a steering system, not shown, such as thrust vector control or turning of one or more of tripod elements **114** to provide directional control of watercraft **110**. The fluid-dynamic efficiency of tripod elements **114** provides improved performance for watercraft **110** during low-speed operation when tripod elements **114** are partially or completely submerged, including operation in rough water conditions. The use of conical lower segment **56** for watercraft **110** also provides lift during low-speed operation, gradually decreasing as watercraft **110** gains speed and rises to ride on the water surface.

Submersible Watercraft-FIGS. 10A through 10C

The preferred embodiment of a submersible type watercraft **116**, designed for operation primarily beneath the water surface, employs generally elliptical planform **74** for the main body to take advantage of the low aspect ratio fluid-dynamic performance in the direction of travel A. Watercraft **116** is illustrated in FIGS. **10A**, **10B**, and **10C** which are side, top or planform, and frontal views, respectively. Watercraft **116** is comprised of a combination of universal fluid-dynamic body features shown in FIGS. **4A**, **4B**, **4C**, **5A**, **5B**, and **5C**. Cylindrical segment **72** is inserted between segments **54** and **56** to increase the usable internal volume and rounded side-walls of cylinder **74** provide a fluid-dynamically efficient transition surface between segments **54** and **56**. Segment **54** is joined with segment **72** at top of cylinder **53'** and segment **56** is joined with segment **72** at bottom of cylinder 53". Apex 58 of segment 54 is positioned forward to accommodate the predetermined location of a conning tower 118. Apex 60 of segment 56 is positioned aft of watercraft 116 center to improve directional control and accommodate predetermined requirements for increased cargo height in the aft end of watercraft 116. Rounded surface of truncated apex 73 is also incorporated to provide a broader, and therefore, more stable base for watercraft 116 when resting on the bottom of the liquid operating environment. A conventional propulsion device 112, such as a propeller or water jet system, is used to provide the translational thrust and may include steering system, not shown, such as thrust vector control to provide directional control of watercraft 116. A traditional attitude control system, such as a conventional rudder system 93 and a conventional diving plane system 120, are employed to provide depth and directional control of watercraft 116.

Theory of Operation

Traditional aircraft technology considers a flow field that is predominately two-dimensional over the airfoil at a given spanwise section of the lifting wing or body. This approach focuses the aerodynamic performance design efforts on airflow in the vertical direction above and below an airfoil section of the wing or lifting body and the airflow parallel to the direction of flight. However, little effort is directed toward improving performance by inducing a portion of the fluid flow in the lateral direction, around the lifting body. I believe the improved performance efficiency of the universal fluid-dynamic body is the result of the three-dimensional flow field effects, where a portion of the fluid is allowed to flow around the upper and lower conical segments of the aircraft and watercraft, as well as over and under the body, but do not wish to be bound by this.

Summary, Ramifications, and Scope

Accordingly the reader will see that various configurations can be used for numerous aircraft, spacecraft, and watercraft types to obtain the improved performance efficiencies and environmental friendly attributes associated with this universal fluid-dynamic body. Furthermore, the universal fluid-dynamic body has the following additional advantages,

An all-wing aircraft that embodies the universal fluid-dynamic body is not constrained to an upper practical limit of 70 degrees oblique or sweep angle as indicated for oblique all-wing aircraft that are based on traditional airfoil design technology. The universal fluid-dynamic body is capable of rotating throughout a full 90 degree sweep angle range, from the high-aspect-ratio orientation for takeoff, with the aircraft planform ellipse major axis normal to the aircraft flight path, to the high-speed flight orientation in which the planform ellipse major axis is parallel to the flight path. This added sweep angle capability provides an estimated 25 percent performance advantage over delta-wing-type aircraft during takeoff. Also it provides additional performance gains during climb and cruise as the sweep angle is adjusted to optimize performance and satisfy the operating objectives, including reduced noise levels and avoiding the sonic boom problem over populated areas. The inherent configuration of the aircraft upper and lower conical segments will:

- expand the operating envelope of an oblique all-wing aircraft,
- mitigate the potential adverse aeroelastic effects of the structure,
- enable the cockpit to be located in the apex area of either the upper or lower segment to eliminate the unconventional visual cues and pilot reduced visibility associated with previously proposed oblique all-wing aircraft,
- allow the aircraft mass or weight, including passengers, cargo, and expendables, to be concentrated more toward the center of the aircraft, thereby reducing the span of the landing gear and therefore, runway width requirements, and
- simplify the application of advanced composite structure technologies in conjunction with the performance efficiency advantages, increase the feasibility of developing a true Single-Stage-To-Orbit aircraft and launch vehicle with the attendant environmental advantages, provide savings in expendable hardware, and provide an overall performance improvement using air breathing propulsion for takeoff, landing, climb, and possibly cruise.

An SSTO aircraft that embodies the universal fluid-dynamic body and uses air-breathing propulsion rather than rocket engines for takeoff will provide reduced noise levels near the launch or takeoff area. Also it will allow less robust structural design of payloads and more pleasant experience for passengers due to the relatively benign acoustic, vibration, and acceleration environment.

The universal fluid-dynamic body, when employed as a hydrofoil for a hydroplane or motorboat, is more forgiving of rough water conditions than a traditional hydrofoil. There is also less tendency for the front end of a watercraft to rise excessively (pitch-up) as the motorboat speed increases. Although submersible watercraft rely primarily on buoyancy rather than fluid-dynamic lift for vertical support, performance efficiency is improved by incorporating the features of the universal fluid-dynamic body.

Although the baseline body configuration of the present invention is defined as a conical upper segment and a conical lower segment having a common base plane, modifications of this baseline configuration are feasible without significant adverse effect on performance. For example,

- passenger, cargo, or operational requirements may be accommodated by fore or aft positioning of either upper, or lower, or both apexes of the conical segments,
- the vehicle planform may be selected to satisfy a predetermined shape,
- the planform may be trimmed after establishing the upper and lower conical segments to produce sidewalls at predetermined positions on the vehicle perimeter,
- the apices of the conical segments may be truncated,
- a cylindrical segment, with sidewalls conforming to the established planform, may be added between the upper and lower conical segments to increase internal volume without affecting the planform and minimize the effect on buoyancy, and
- traditional functional systems, such as propulsion systems, including thrust vector control devices, retractable landing gear, attitude control systems, and vehicle electrical, avionics, hydraulic and pneumatic systems may be incorporated with minimal disruption of the fluid flow field around the vehicle.

Although preferred embodiments of the invention have been described by way of example, it is understood by those skilled in the field, that additional modifications within the scope of the invention may be made to the disclosed embodiments. Operation of the universal fluid-dynamic body in the inverted orientation or flying up-side-down, such that upper segment height h_u is approximately $3/2$ the height of lower segment height h_L, is also within the scope of the present invention. Although the description above contains many specificities, these should not be construed as limiting the scope of the invention but as merely providing illustrations of some of the presently preferred embodiments. For example, planforms used in the above illustrations are all generally elliptical but a variety of planforms that maintain the generally conical upper and lower body configurations can be provided. Traditional functional systems, such as;

propeller-, jet-, and rocket-engine-type propulsion devices,

fluid-dynamic control surfaces and thrust vector control system for attitude and directional control,

landing gear systems for aircraft and SSTO reusable spacecraft, etc., as well as

state-of-the-art advances in propulsion, materials, avionics, etc., are applicable to the universal fluid-dynamic body for potentially even greater advantages. A wide variety of materials suitable for construction, including metals, woods, plastics, and composite materials such as fiberglass, carbon-fiber, and carbon-epoxy enable ease of construction using conventional fabrication techniques.

Thus the scope of the invention should be determined by the appended claims and their legal equivalents, rather than the examples given.

What is claimed is:

1. A universal fluid-dynamic aircraft or watercraft body, comprising:

(a) a generally oblique-conical upper segment having a base and having an apex, and

(b) a generally oblique-conical lower segment having a base and having an apex, said oblique-conical lower segment being inverted with respect to a common baseplane and joining said oblique-conical upper segment at said common baseplane, whereby said apex of said oblique-conical upper segment is positioned substantially above said common baseplane, and said apex of said oblique-conical lower segment is positioned substantially below said common baseplane, said apexes being offset from each other.

2. The universal fluid-dynamic body of claim **1** wherein the height of said oblique-conical upper segment is less than the height of said oblique-conical lower segment.

3. The universal fluid-dynamic body of claim **2** wherein the height of said oblique-conical upper segment is approximately two-thirds the height of said oblique-conical lower segment.

4. The universal fluid-dynamic body of claim **1** wherein a planform or outline of said body is coincident with the intersection of said oblique-conical upper segment and said oblique-conical lower segment at said common baseplane.

5. The universal fluid-dynamic body of claim **1** wherein a planform or outline of said body is circular at the longitudinal plane intersection and said oblique-conical upper segment and said oblique-conical lower segment both intersect said common baseplane at said circular planform.

6. The universal fluid-dynamic body of claim **1** wherein:

a. said planform of said body is trimmed to narrow the width of said body by removing approximately equal portions from each side of said body, and

b. said trimmed edges of said oblique-conical upper segment and of said oblique-conical lower segment are rounded to form a smooth fluid-dynamic surface joining said oblique-conical upper segment and said oblique-conical lower segment.

7. The universal fluid-dynamic body of claim **1** wherein a planform of said body is elliptical and said oblique-conical upper segment and said oblique-conical lower segment both intersect said common baseplane at said elliptical planform.

8. The universal fluid-dynamic body of claim **1** wherein:

a. said apex of said oblique-conical upper segment is truncated, and said truncated apex edges of said oblique-conical upper segment are rounded to form a smooth fluid-dynamic surface, and

b. said apex of said oblique-conical lower segment is truncated, and said truncated apex edges of said oblique-conical lower segment are rounded to form a smooth fluid-dynamic surface.

9. A universal fluid-dynamic aircraft or watercraft body, comprising:

(a) a generally oblique-conical upper segment having a base and having an apex,

(b) a generally cylindrical center segment having a lower end or base plane, a top or upper plane, and a plurality of side walls, and

(c) a generally oblique-conical lower segment having a base and having an apex, said oblique-conical lower segment being inverted with respect to a common baseplane with said cylindrical center segment and joining said base of said oblique-conical lower segment with said lower end or base plane of said cylindrical center segment, said base of said oblique-conical upper segment joined with said top or upper plane of said cylindrical center segment, whereby said apex of said oblique-conical upper segment is positioned substantially above said top or upper plane of said cylindrical center segment and said apex of said oblique-conical lower segment is positioned substantially below said lower end or base plane of said cylindrical center segment, said apexes being offset from each other, and said side walls of said cylindrical center segment being rounded to form a smooth fluid-dynamic transition surface between said oblique-conical upper segment and said oblique-conical lower segment.

10. The universal fluid-dynamic body of claim **9** wherein the height of said oblique-conical upper segment is less than the height of said oblique-conical lower segment.

11. The universal fluid-dynamic body of claim **9** wherein the height of said oblique-conical upper segment is approximately two-thirds the height of said oblique-conical lower segment.

12. The universal fluid-dynamic body of claim **9** wherein a planform of said body is coincident with said smooth fluid-dynamic transition surface between said oblique-conical upper segment and said oblique-conical lower segment.

13. The universal fluid-dynamic body of claim **9** wherein a planform of said body is circular and said oblique-conical upper segment and said oblique-conical lower segment each intersect said cylindrical center segment generally at said circular planform.

14. The universal fluid-dynamic body of claim **13** wherein:

a. said planform of said body is trimmed to narrow the width of said body by removing approximately equal portions from each side of said body, and

b. said trimmed planform edges of said oblique-conical upper segment, of said cylindrical center segment, and of said oblique-conical lower segment are rounded to form a smooth fluid-dynamic surface joining said oblique-conical upper segment and said oblique-conical lower segment.

15. The universal fluid-dynamic body of claim **9** wherein a planform of said body is elliptical and said oblique-conical upper segment and said oblique-conical lower segment each intersect said cylindrical center segment generally at said elliptical planform.

16. The universal fluid-dynamic body of claim **9** wherein:

a. said apex of said oblique-conical upper segment is truncated, and said truncated apex edges of said oblique-conical upper segment are rounded to form a smooth fluid-dynamic surface, and

b. said apex of said oblique-conical lower segment is truncated, and said truncated apex edges of said oblique-conical lower segment are rounded to form a smooth fluid-dynamic surface.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 5,730,391

DATED : March 24, 1998

INVENTOR(S) : Miller, John A., Jr. & Losey, William A.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the title page: Item [56]

, second column, under "Other Publications", change the words "Sirfoil Sections for Arrwo" in the title of NACA TN 3183 to read "Airfoil Sections for Arrow".

Column 2, Line 1; Change the words "requited lift" to read "required lift".

Column 3, Lines 47, 48 & 49; Indent Item b to the same level as Items 'a' and 'c'.

Column 8, Lines 7 & 9; Change the "height hu" to read "height h_u" (2 places).

Column 9, Line 2; Change the angle "θ^L" to read "$\theta_.$"

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 5,730,391
DATED : March 24, 1998
INVENTOR(S) : Miller, John A., Jr. & Losey, William A.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 9, Line 51; Change the words "then hired with" to read "then faired with".

Column 9, Line 67; Reposition the words "apices **58** and **60** may ..." to start on a new line rather than be a continuation of the fourth bullet item.

Column 12, Line 27; Change the words "which am" to read "which are".

Column 13, Line 64 through Column 14, Line 18; Indent the 5 sub-bullet items under the major bullet item "An all-wing ..." which starts at Column 13, Line 44.

Column 15, Line 59, Change the Claim 6 reference to "Claim 1" to read "Claim 5".

Signed and Sealed this

Twenty-third Day of June, 1998

Attest:

Bruce Lehman

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks

US005836542A

United States Patent [19]

Burns

[11] **Patent Number: 5,836,542**

[45] **Date of Patent: Nov. 17, 1998**

[54] **FLYING CRAFT AND A THRUSTER ENGINE SUITABLE FOR USE IN SUCH A CRAFT**

[76] Inventor: **David Johnston Burns**, Broomhall Castle, Menstrie, Clackmannanshire, FK11 7EA, Great Britain

[21] Appl. No.: **430,721**

[22] Filed: **Apr. 28, 1995**

[30] **Foreign Application Priority Data**

Apr. 28, 1994 [GB] United Kingdom 9408394

[51] **Int. Cl.**[6] **B64C 39/06**

[52] **U.S. Cl.** .... **244/12.2**; 244/123; 244/23 C; 244/23 B; 244/74; 60/270.1; 60/257

[58] **Field of Search** .... 244/74, 12.1, 12.2, 244/12.3, 23 R, 23 C, 23 D, 23 B, 58, 36, 15, 62, 53 R; 60/270.1, 257, 258

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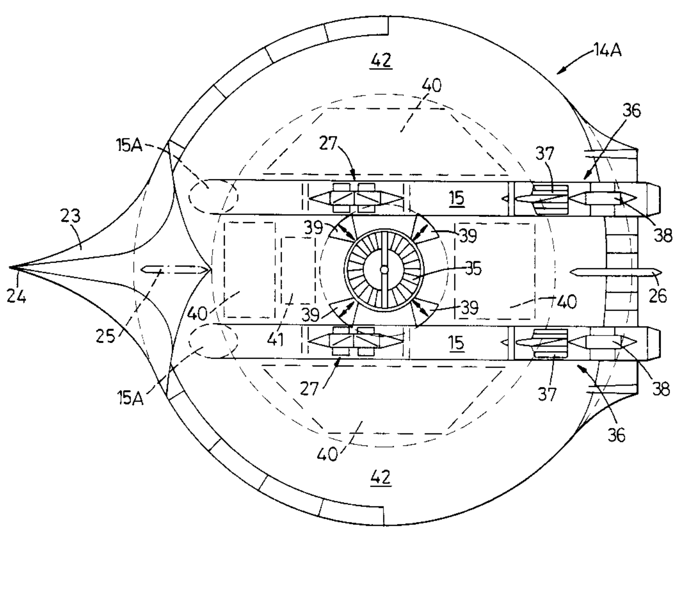
Primary Examiner—Galen L. Barefoot
Attorney, Agent, or Firm—Reid & Priest LLP

[57] **ABSTRACT**

A flying craft **(14)** has a dish shaped body **(18, 20, 21)** with a convex upper surface **(18)** to provide lift. Engine means **(1)** in the form of a jet or rocket engine is housed in the body at the rear, while a duct **(15)** extends through the body from an air opening **(15A)** at the front of the craft **(14)** so as to direct air to the engine means **(1)** for example to serve as cooling and/or combustion air for the engine means. Additional thruster jets **(16A, 16B)** can be located on the bottom of the body for directional control. In a further embodiment (FIG. **12**), an electric motor driven fan **(37)** is located in the duct **(15)** to form a ducted fan propulsion and unit for forward, slightly descending, movement of the craft **(14A)**, while a more powerful jet or rocket engine **(35)** is located vertically in the craft to effect vertical ascent of the craft to an elevation where forward motion by the ducted fan propulsion unit can commence. A turbine fan driven alternator **(27)** can also be located in the ducting **(15)**. A suitable rocket engine is also described (FIGS. **1** and **6**).

6 Claims, 16 Drawing Sheets



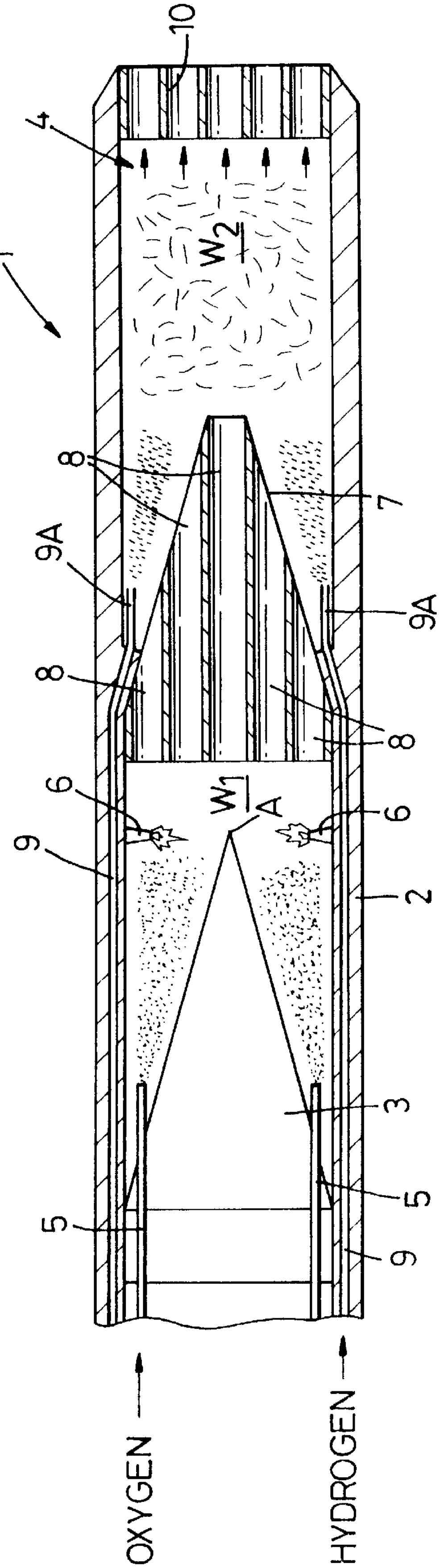


Fig. 1

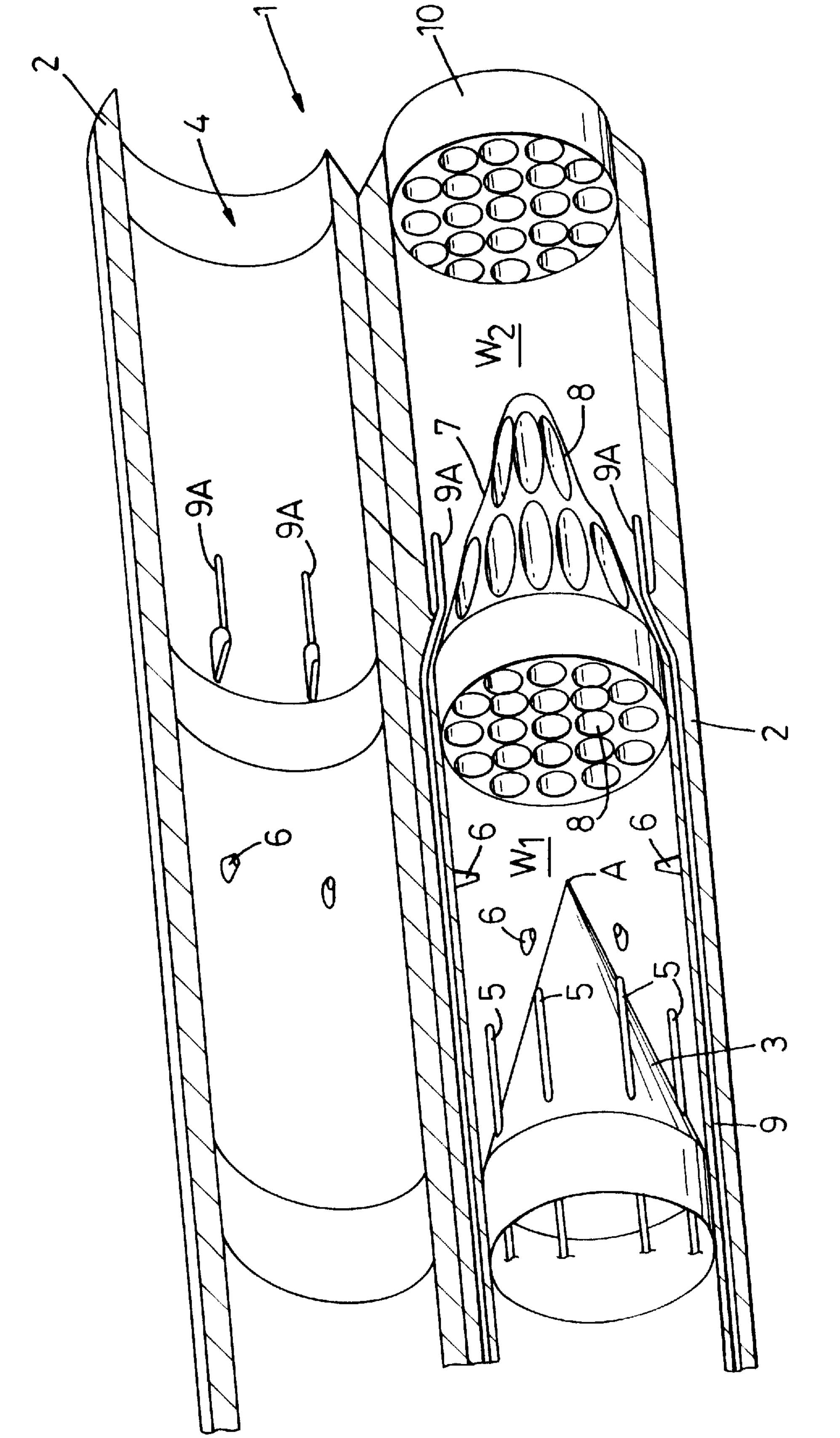


Fig. 2

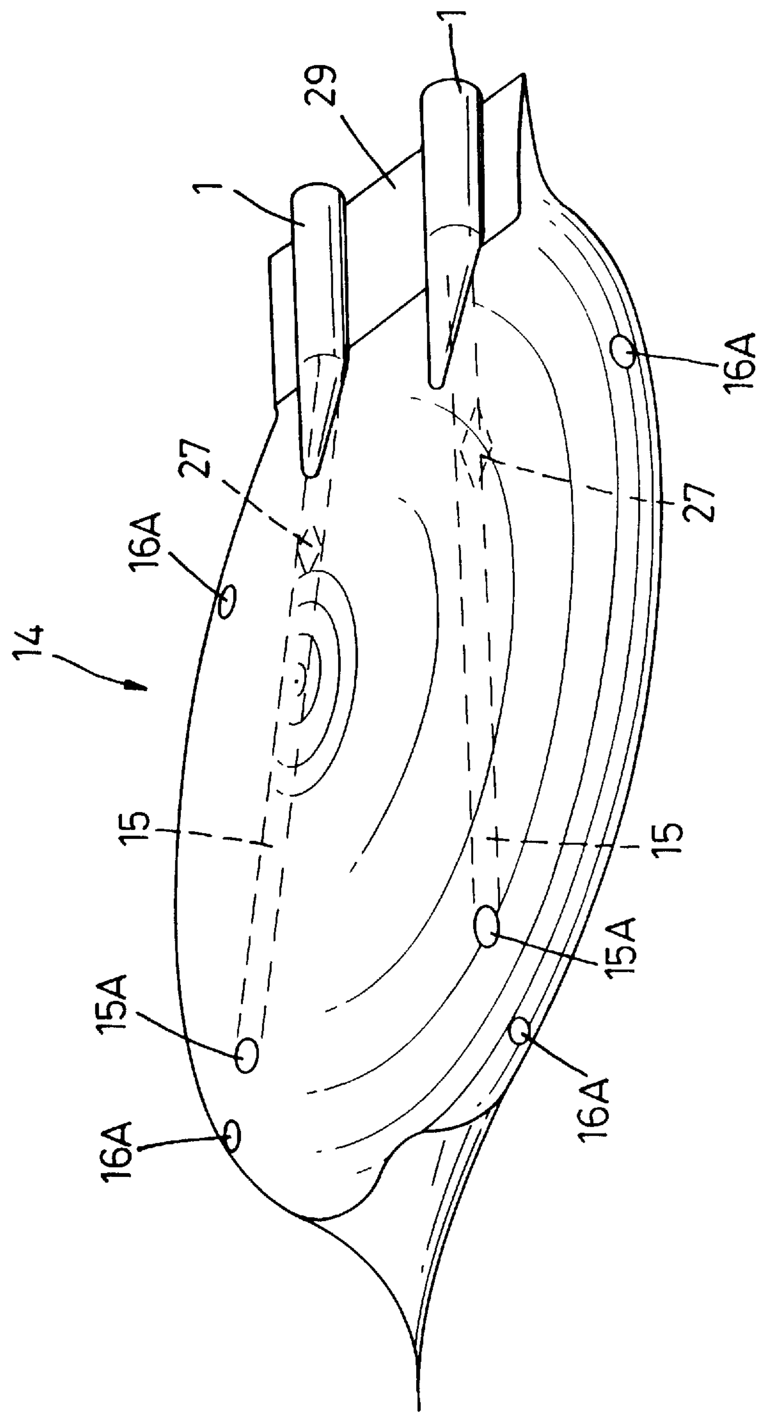


Fig. 3

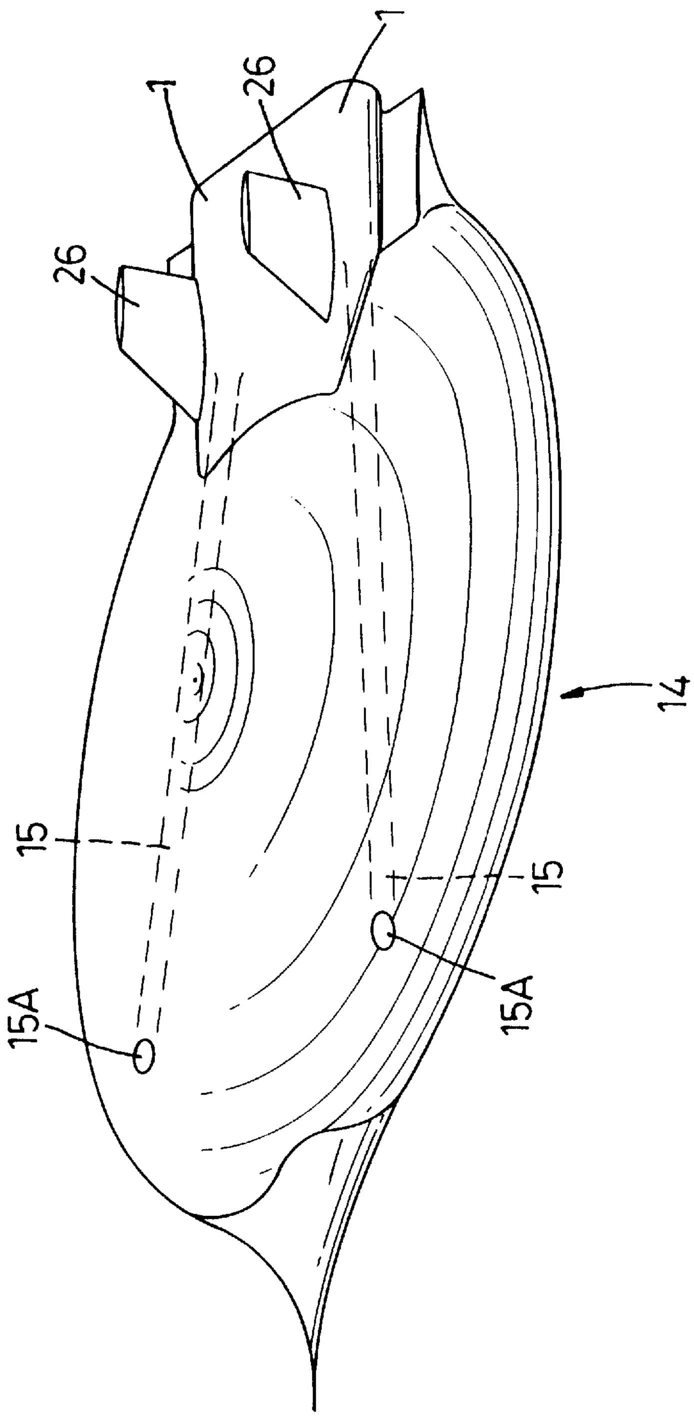


Fig. 4

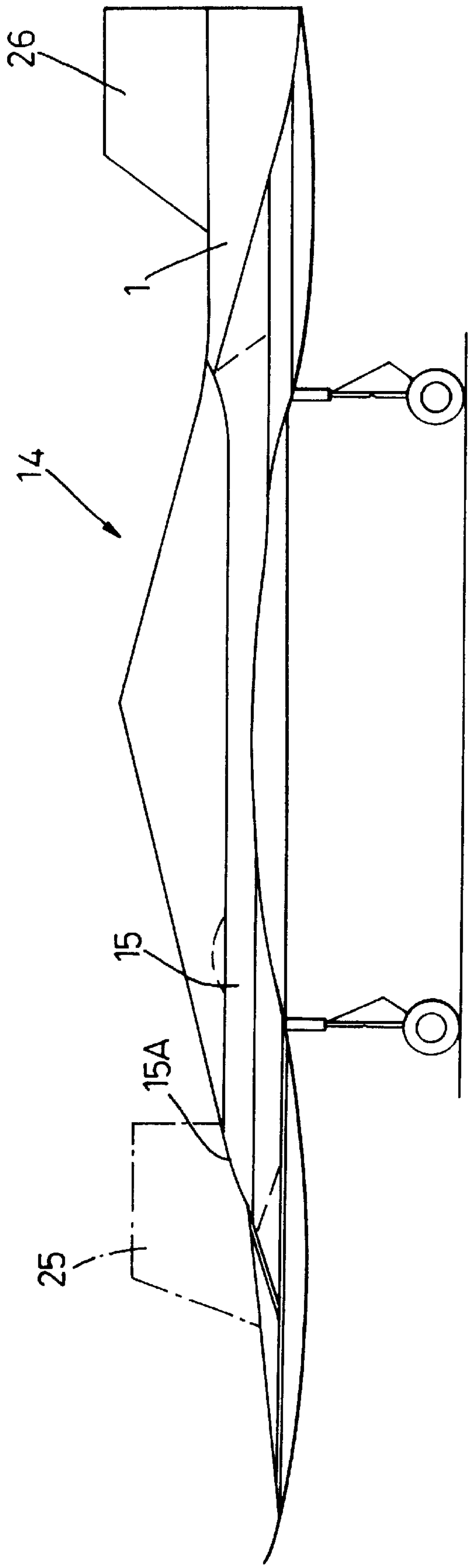


Fig. 5

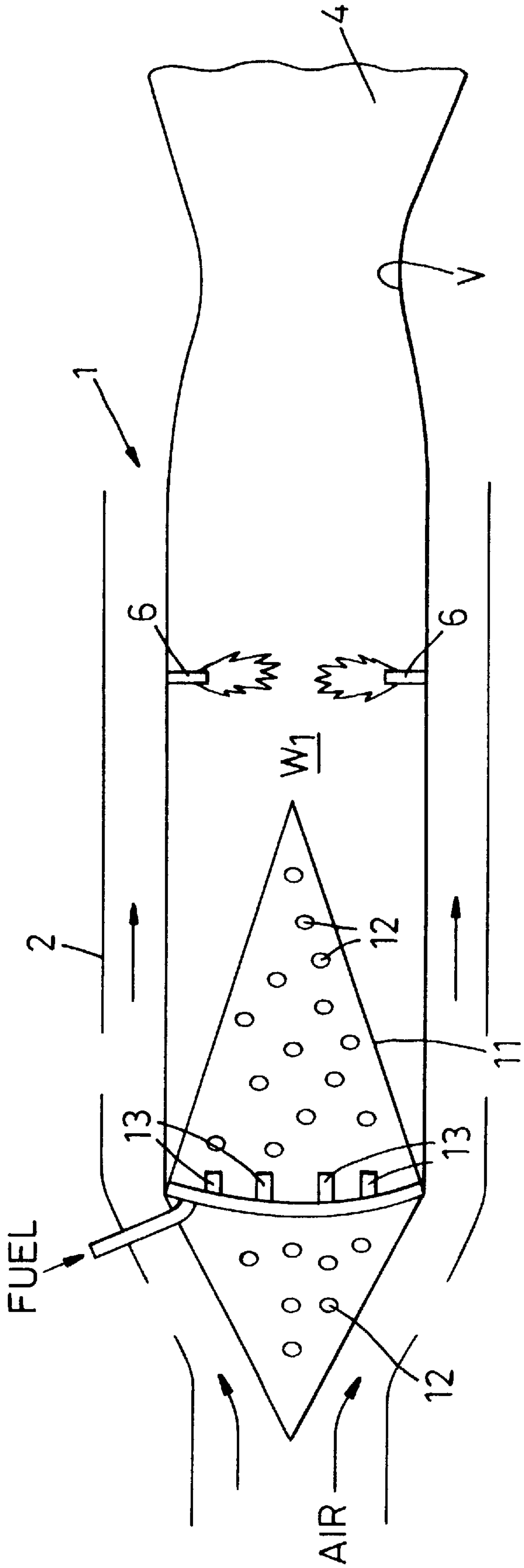


Fig. 6

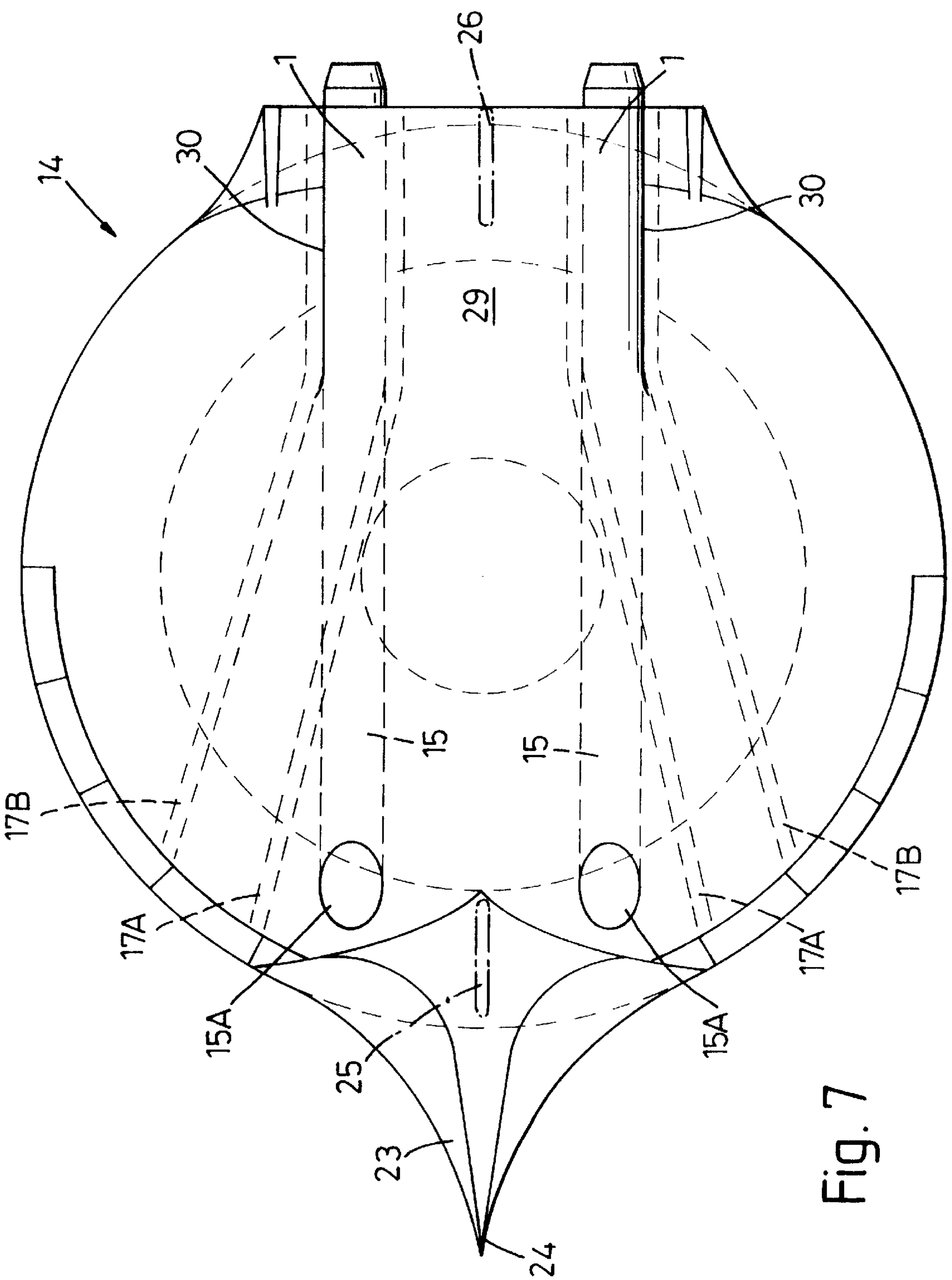
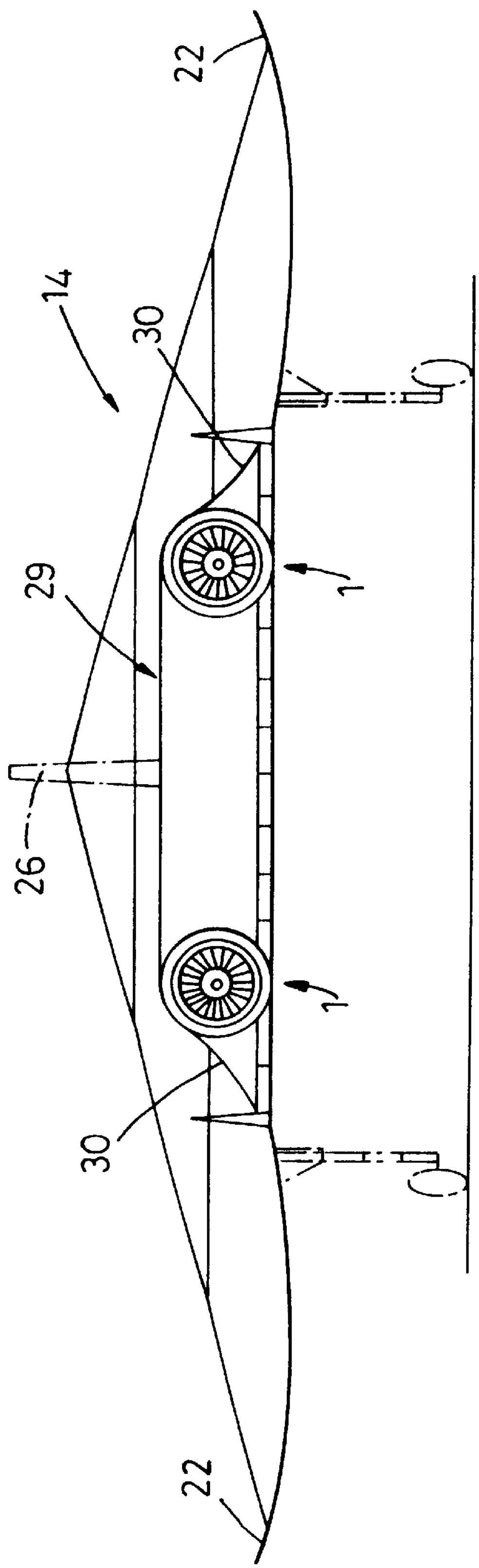
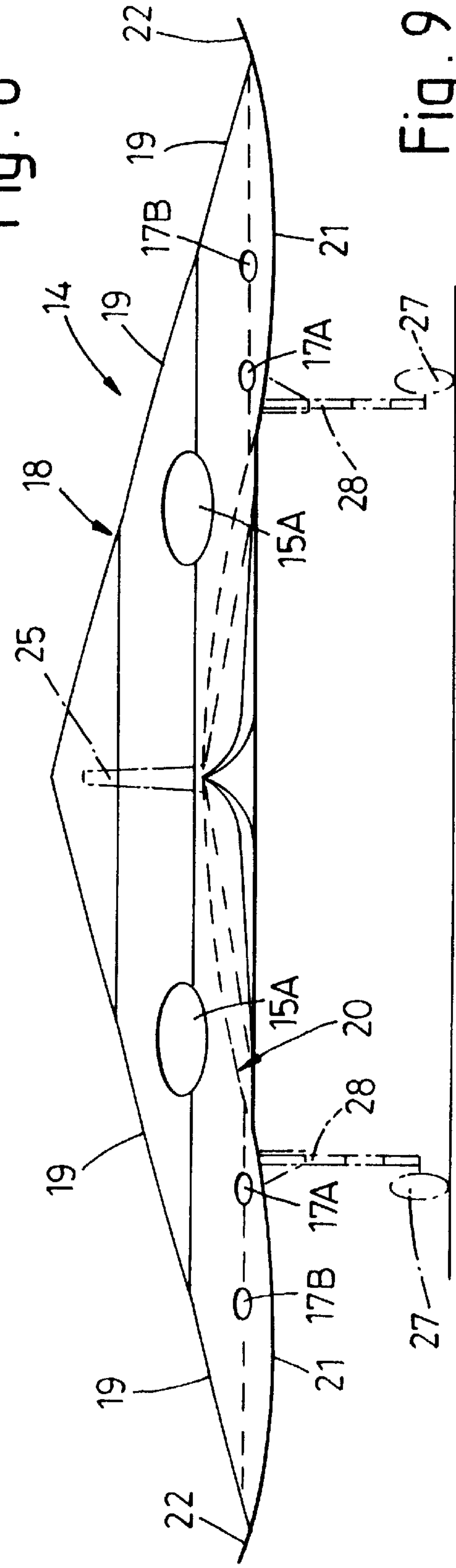


Fig. 7


22
14
30
29
1
26
1
30
22
Fig. 8


22
19
17B
21
14
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17A
27
28
18
15A
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15A
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28
19
17A
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17B
19
21
22
Fig. 9

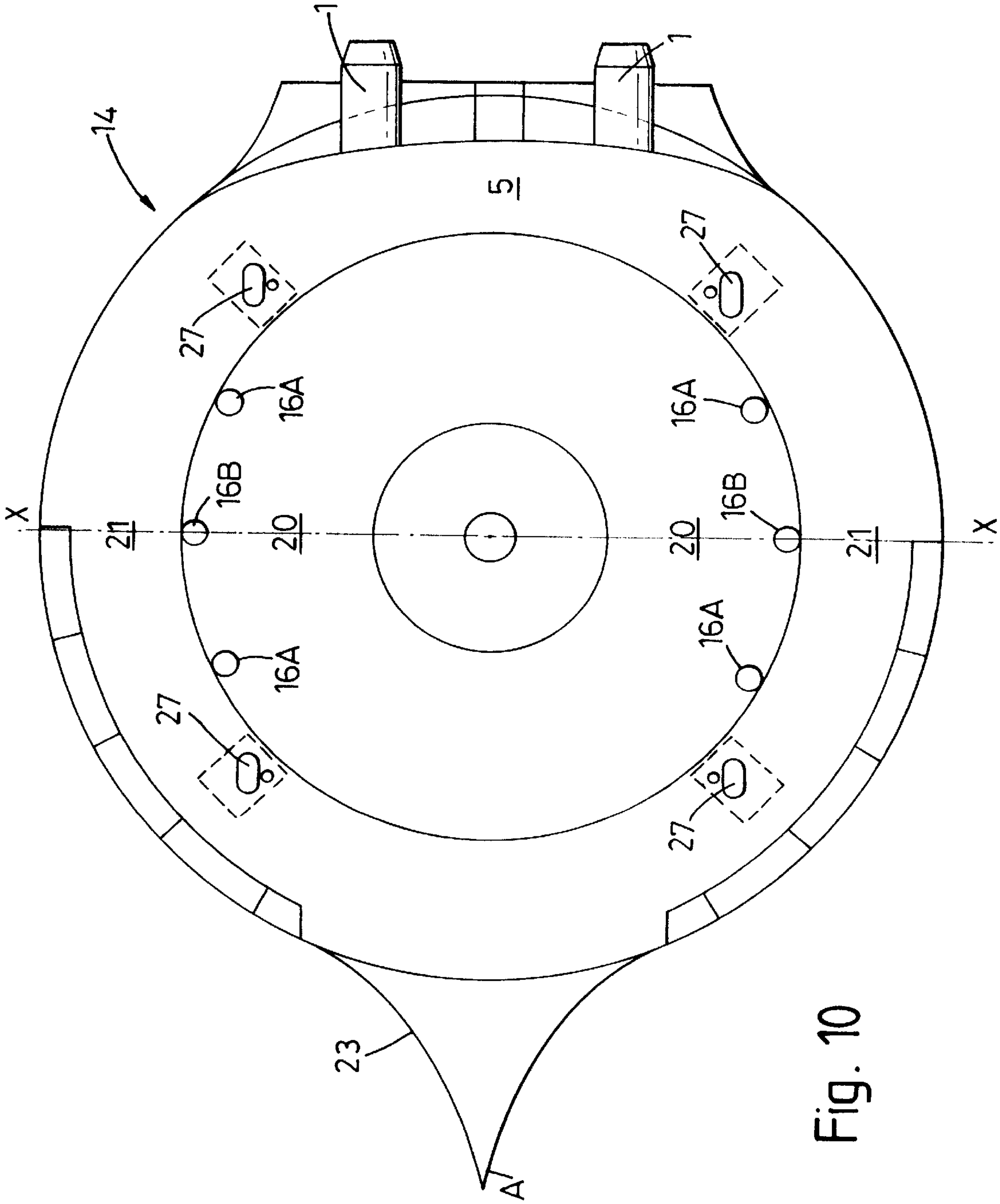
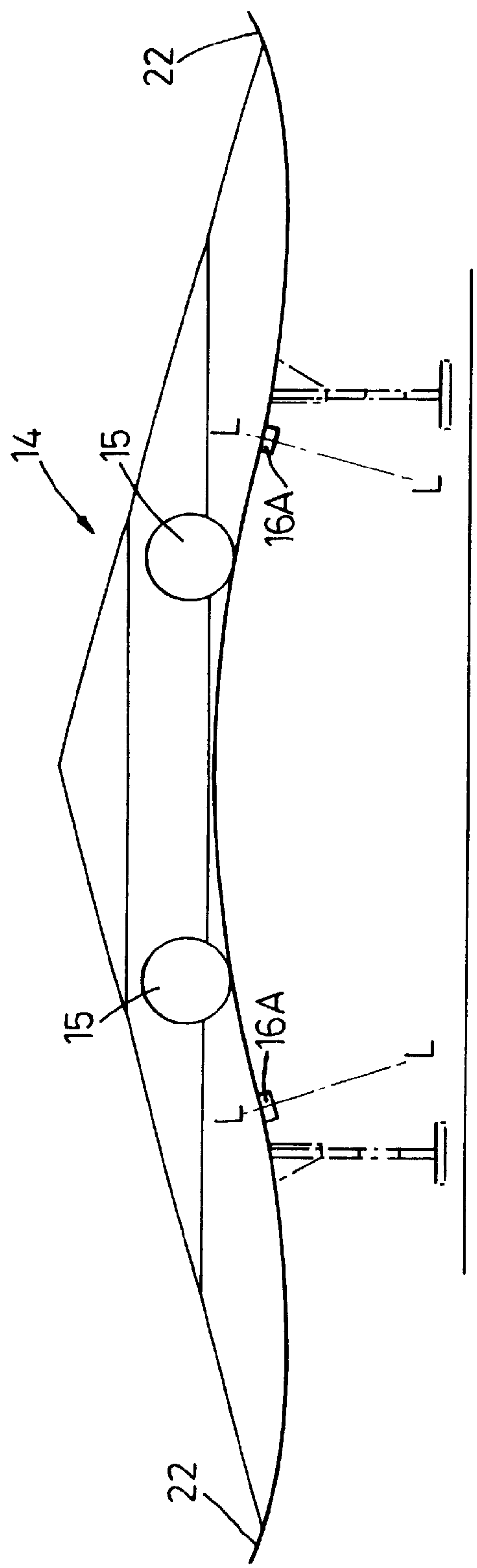


Fig. 10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16A
16A
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22
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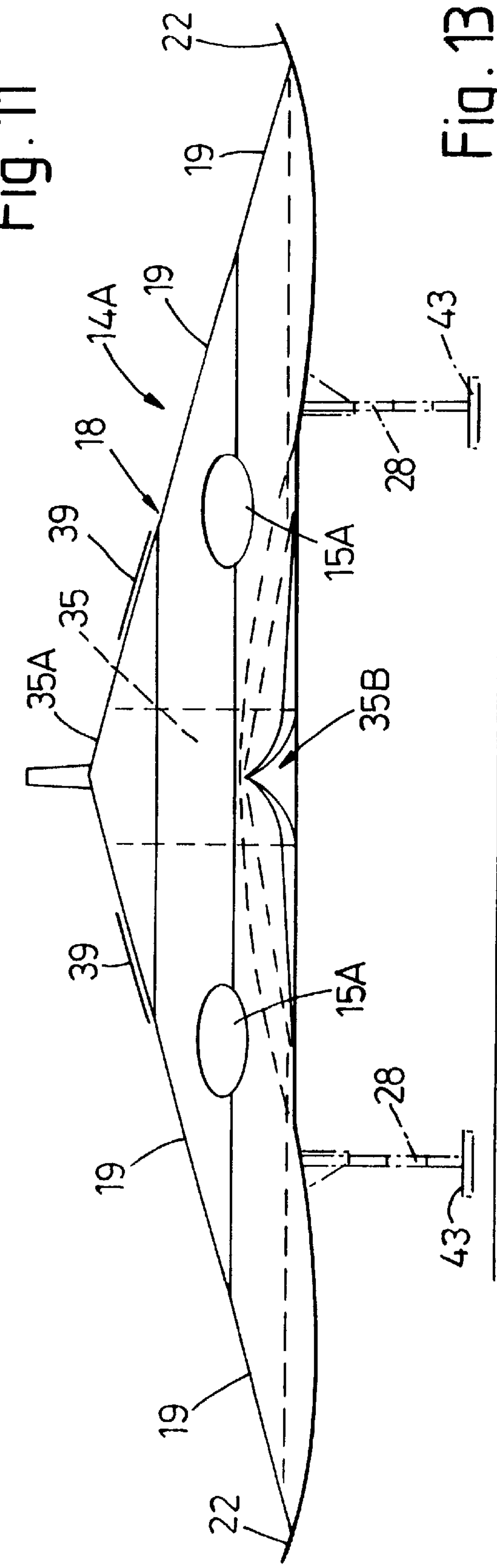
L
L

Fig. 11


14A
15A
15A
18
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35
35A
35B
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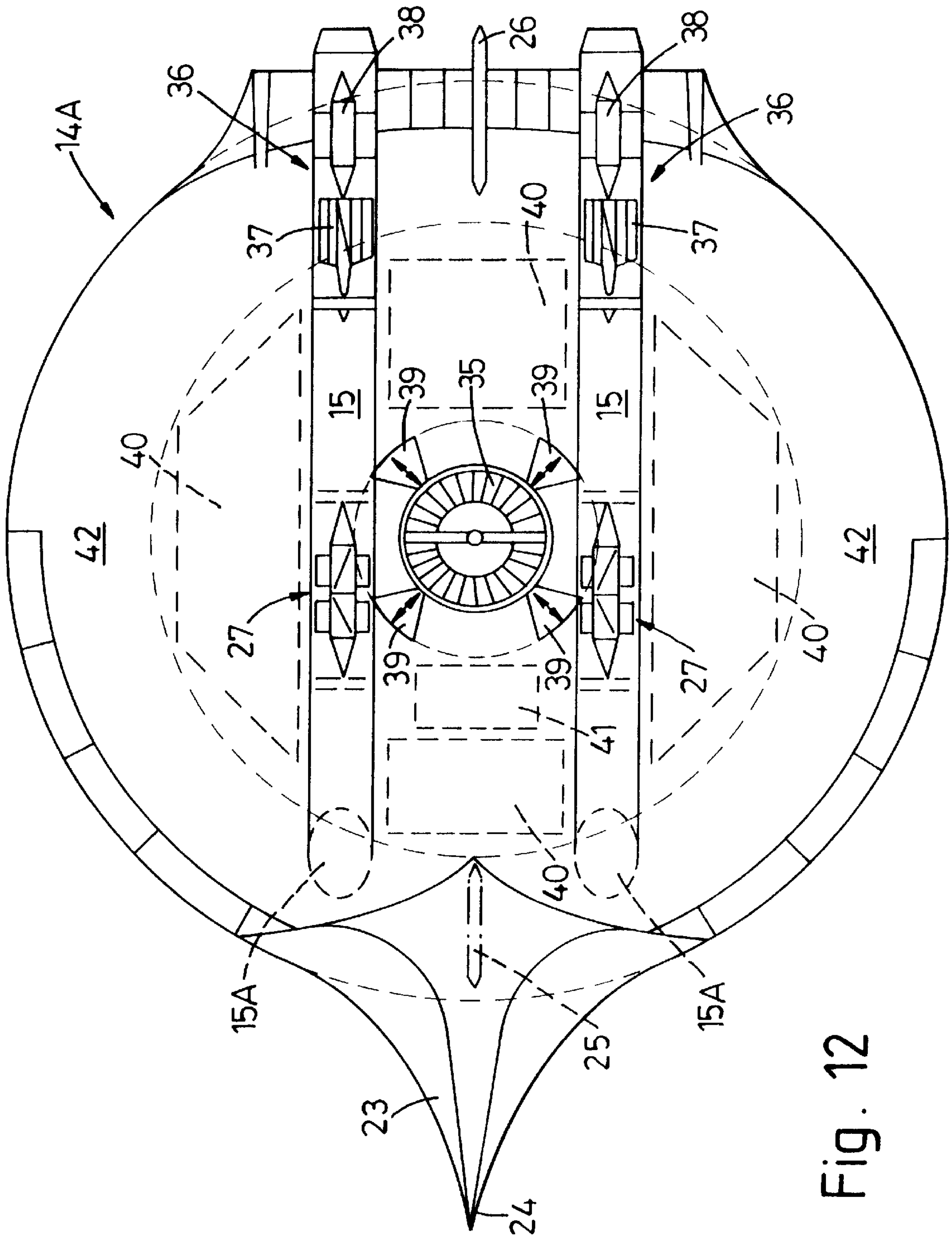
Fig. 13


14A
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15A
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15A
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Fig. 12

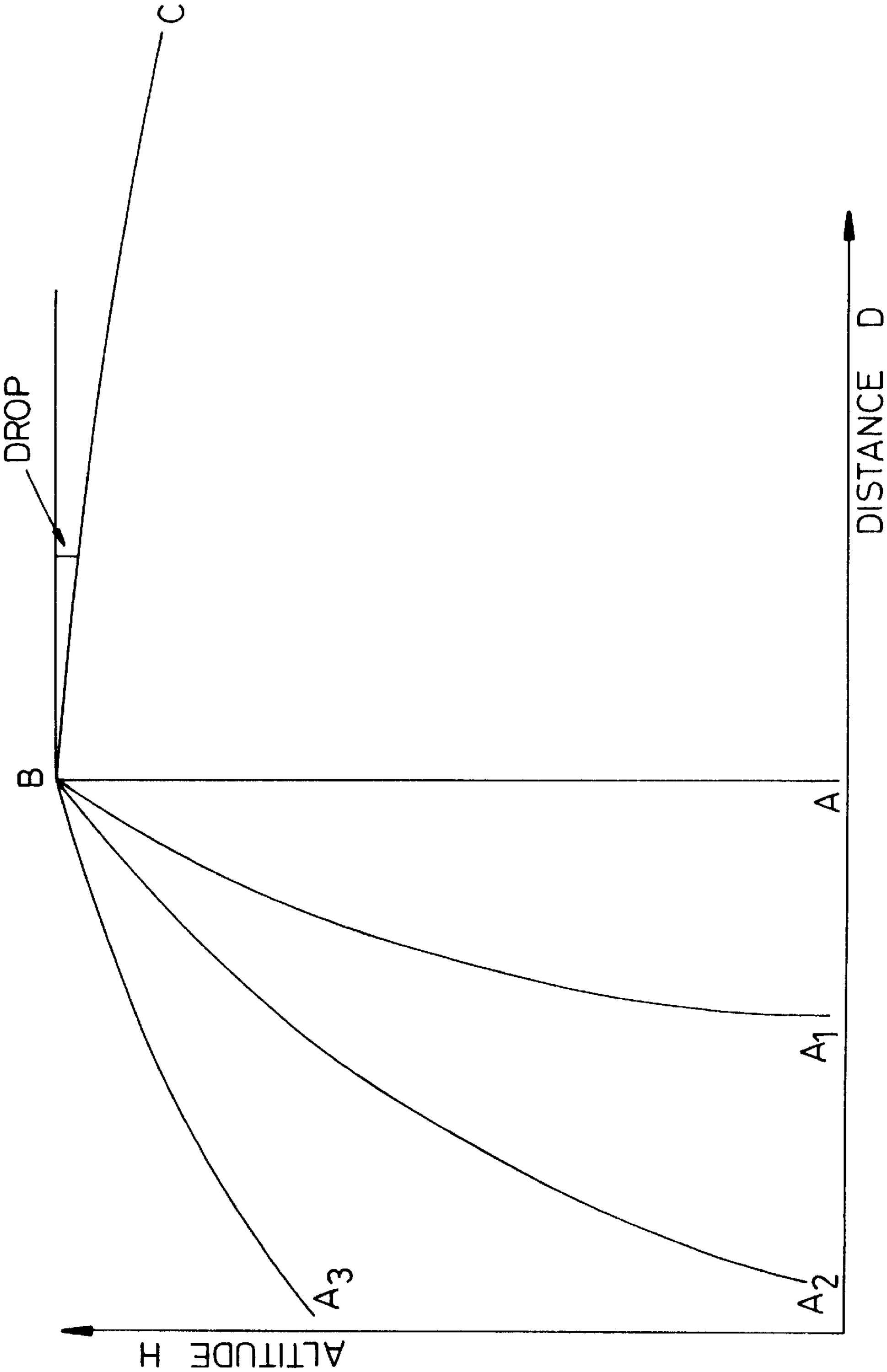


Fig. 14

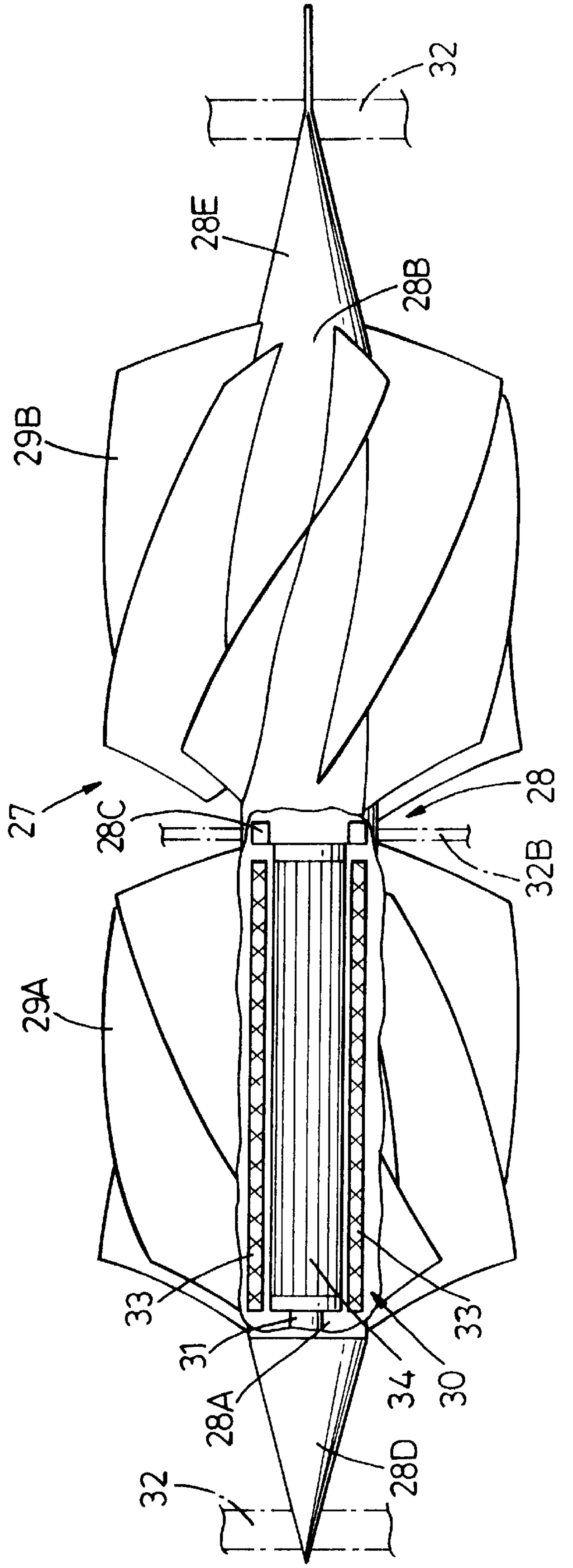
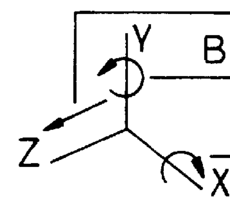


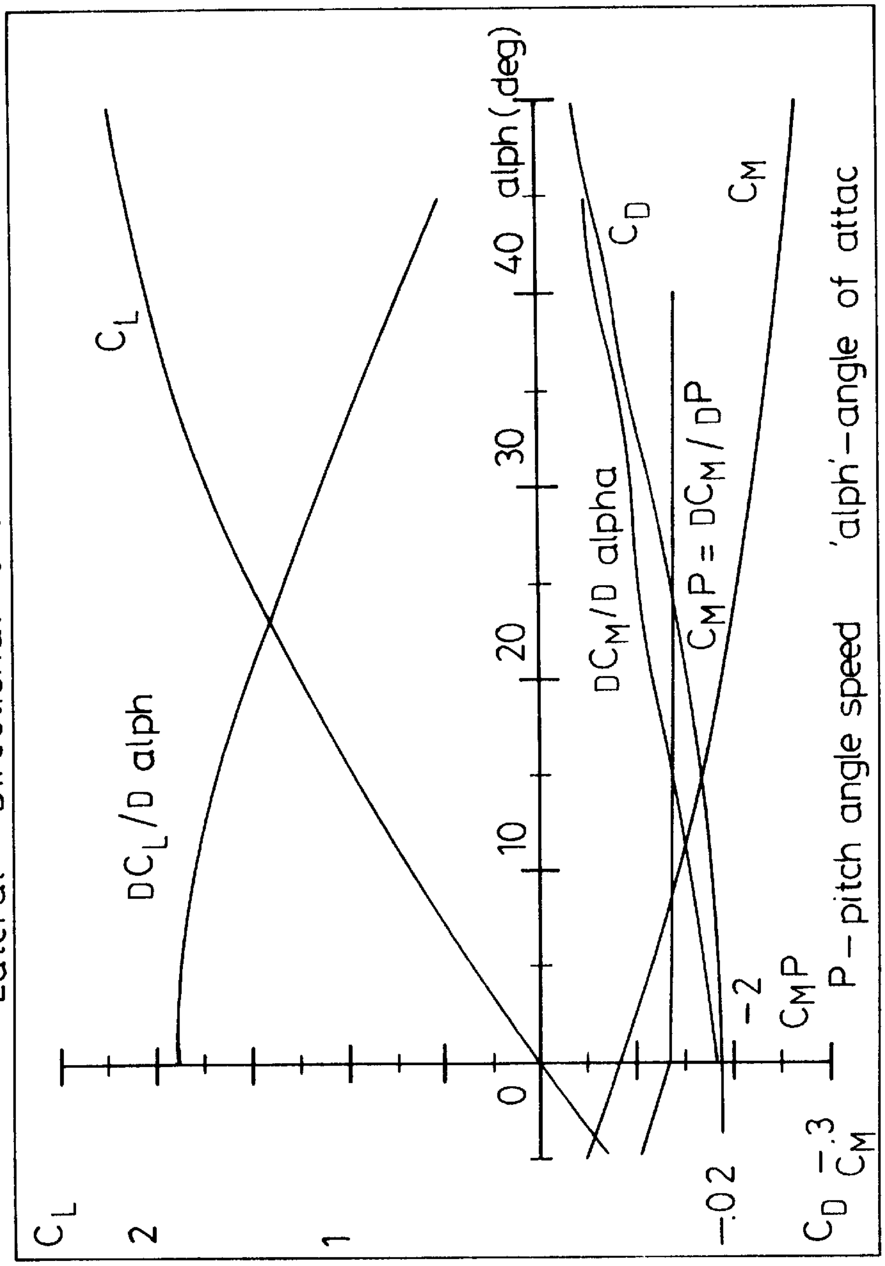
Fig. 15

Test aircraft 2nd design

Coefficients	Values	Commentary
lateral force/ rudder angle	-0.05	 Y, Z, X — lateral force; B-cource angle; cource moment & rotative speed N; rolling moment & rotative speed R; Coordonnate sistem
cource moment/ rudder angle	-0.0403	
roll moment/ alter on angle	-0.0722	
dC_l /dB	-0.154	Stability derivatives in Lateral — Directional moving [Fig. 4]
dM_n/dB	-0.095	
dM_r/dB	-0.108	
dC_l / dN	-0.096	Nota bene 1. controllability not enough 2. stability aperlodical
dM_n/ dN	-0.709	
dM_r / dR	-0.943	

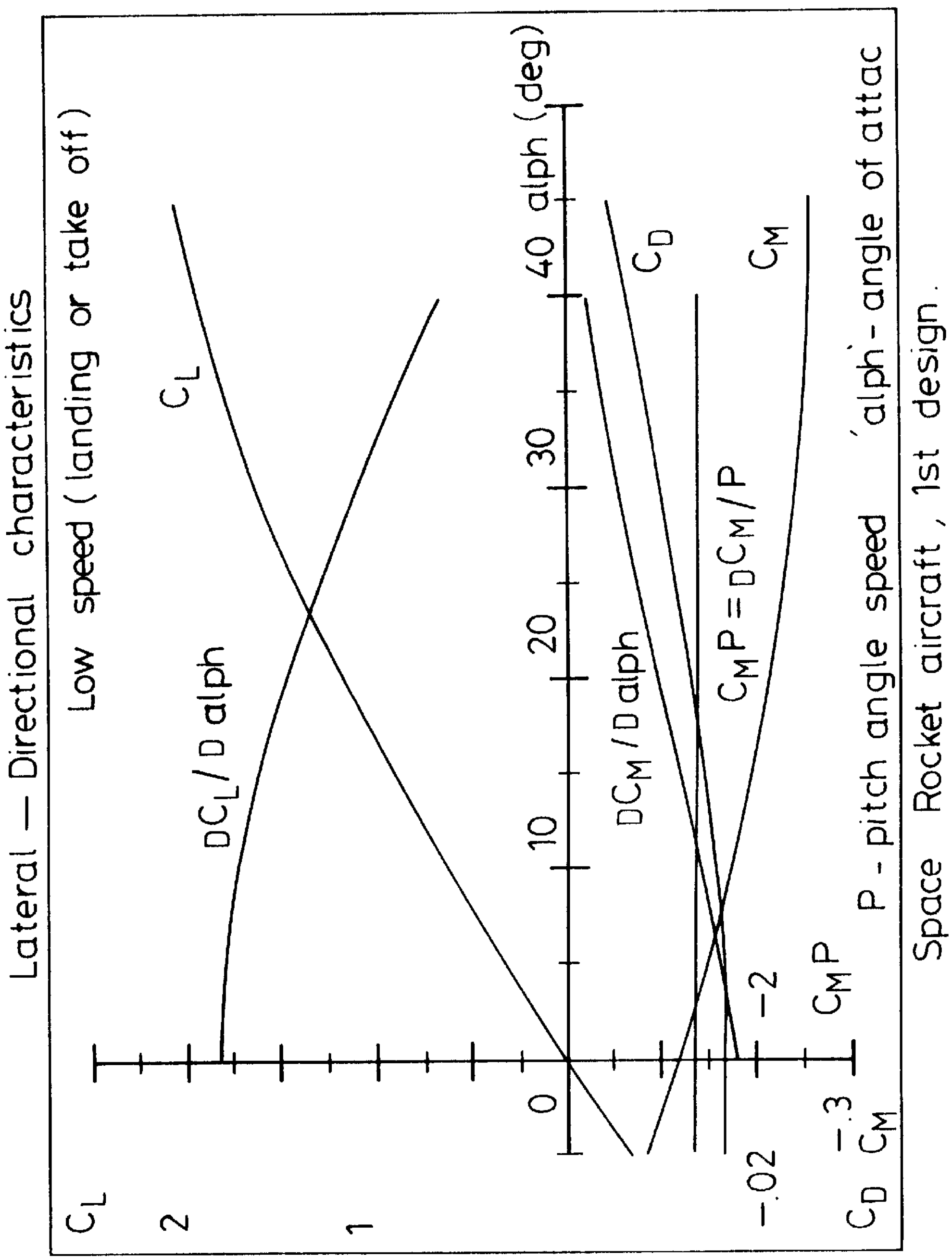
Stability roots: roll damping -2.366 cource damping -0.209 -0.0345

Fig. 16



Test aircraft, 1st design.

Fig. 17



Lateral — Directional characteristics
Low speed (landing or take off)
C_L
DC_L / D alph
DC_M / D alph
C_D
C_M
$C_M P = {}_D C_M / P$
$C_M P$
P - pitch angle speed
'alph' - angle of attac
Space Rocket aircraft , 1st design .
alph (deg)
0
10
20
30
40
C_L
2
1
-.02
C_D
-.3
C_M
-2

Fig. 18

FLYING CRAFT AND A THRUSTER ENGINE SUITABLE FOR USE IN SUCH A CRAFT

The present invention relates to a flying craft and to a thruster engine which can be used to power the craft. More especially thrust in the engine is obtained by a high velocity gas jet, and in particular the engine can be of the rocket-type.

Dish-form flying craft are known and have recognised benefits in an ability to fly at particularly high speeds due to their low drag factor. They are also capable of carrying a larger number of passengers in comparison with comparable conventional (winged) aircraft. An example of such a dished flying craft is described in GB Patent specification 2 227 469 B. It is an object of the present invention to povide improvements in such a flying craft.

Also, rocket engines are well established and are especially beneficial for use in oxygen-free outer space. The rocket engine operates by burning a propellant fuel or fuels in a combustion chamber to produce via a rear nozzle a high velocity gas flow, providing the driving thrust for the engine. A common propellant is a liquid-propellant such as for example liquid-oxygen or liquid hydrogen, and rocket engines utilising a bipropellant system, i.e. two combustibles, are also known.

It is a further object of the present invention to provide a liquid-propellant rocket engine of improved performance for use in a flying craft.

According to a first aspect of the present invention, a flying craft includes a thruster engine, said thruster engine comprising means for housing adjacent first and second work zones, said casing means having a rear first delivery means for introducing a first propellant fuel into said work zone combustion in said first and second work zone, said first delivery means comprising:

(a) a first conical member having a surface and an apex, said apex facing said first work zone.

(b) a second conical member coaxial with said first conical member;

(c) duct means in said surface of said first conical member for the through flow of said first propellant fuel into said first work zone; and

(d) conduit means for directing burning fuel from said work zone to said second work zone, said conduit means being formed on said second conical body, and

second delivery means for directing a second medium to said second work zone for admixture with the burning fuel, the burning fuel and the medium being discharged from said rear of said casing means to constitute a thrust jet for said engine.

The present invention is also a flying craft comprising a generally dished form body providing a lift characteristic, and having a front end and a rear end, said body further having a domed shaped upper surface and a lower surface, and an air inlet located in said front part of the domed upper surface, a vertically disposed first engine means located substantially at the center of said dish shaped body to provide a vertical thrust for vertically propelling said flying craft to an elevated position, second engine means for providing propulsion power which is only sufficient to cause a forward motion of the flying craft with a slight descending path from an elevated position attained by means of the first engine means, the second engine means comprising electrically powered propulsion means for use in providing a horizontal thrust for propelling said flying craft in a forward direction from said elevated position, said electrically powered propulsion means comprising propulsion turbines and electrical drive means for driving the propulsion turbines, and air ducting located on either side of said first engine means and extending within said body from said air inlet to said rear end of said body, each of said ductings housing a said propulsion turbine whereby propulsion air is supplied to said turbine through the ducting.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings wherein:

FIG. **1** shows a sectional elevation of a rocket engine according to the present invention;

FIG. **2** shows a pictorial view of the engine of FIG. **1** with the casing "open" to better illustrate the internal components and internal arrangement;

FIG. **3** shows a pictorial view of a dished form aircraft embodying the present invention;

FIGS. **4** & **5** show a further such aircraft according to further embodiments; FIG. **5** being a sectional elevation.

FIG. **6** shows a modified engine in accordance with the present invention;

FIG. **7** is a plan view of the flying craft;

FIG. **8** is a rear view of the craft of FIG. **7**;

FIG. **9** is a front view of the craft;

FIG. **10** is a bottom view of the craft showing the auxiliary thruster/booster jets;

FIG. **11** is an elevational view through X—X in FIG. **10**;

FIG. **12** is a plan view of a flying craft according to another embodiment of the present invention;

FIG. **13** is a front view of the flying craft of FIG. **12**;

FIG. **14** is a graph showing a possible flight path achievable by the craft of FIG. **12**;

FIG. **15** shows a part sectioned elevation of a contra-rotating double-fan turbine generator usable in the invention;

FIGS. **16** to **18** are performance graphs of the aircraft.

Referring firstly to FIGS. **1** and **2**, a rocket engine comprises a casing **2** preferably of a glazed finished ceramic lined form defining two internal work zones W_1, W_2. A conical member **3** is located at the inlet of the first zone W_1, with its apex A located toward the rear discharge end **4** of the casing **2** and carries liquid-oxygen feed pipes **5** for discharge into the zone W_1. A suitable storage tank (not shown) will supply to the pipes **5**. The liquid-oxygen is combusted in the zone W_1, defining a combustion chamber, by means of igniter devices **6**. At the entry to the work zone W_2, there is provided a further conical member **7** with its apex towards the end **4**, and a plurality of axial ducts **8** are present in the member **7** for through-flow of the burning or combusted oxygen from the zone W_1, to the zone W_2. Conduits **9**, shown in this example embedded in the casing **2** feed a second medium, in this case liquid-hydrogen, to the work zone W_2, the hydrogen being discharged via nozzles **9A** at the periphery of the conical member **7**. Consequently the burning oxygen mixes with the hydrogen in the work zone W_2 to produce very high temperature burning gases resulting in a high velocity thruster jet discharging at the rear end of the casing **2** via a multi-orificed nozzle device **10**.

The liquid hydrogen will be stored in a suitable storage tank (not shown).

FIG. **6** shows a further engine wherein atmospheric air is supplied for the combustion process, and the casing **2** houses a double conical member **11** including through-openings **12** for flow of the air to the combustion zone W_1 provided with igniters **6**. Combustible fuel is pumped to the zone W_1, via nozzles **13**. The rear **4** of the casing **2** constitutes a ventor throat V. The air also serves to cool the engine by flowing along the outer surface of the zone W_1 as shown.

FIGS. **3** and **4** show dish-shaped aircraft **14** essentially as shown in GB patent specification 2 227 469 B. The aircraft **14** can be provided with engines **1** in accordance with either FIG. **1** or FIG. **6**. Further, vent ducts **15** extend internally within the aircraft-fuselage to pass cooling medium i.e. air around the periphery of the engines for cooling of the engines and this air could also serve as combustion air for the engine. In particular the front end **15**A of the vent duct **15** opens externally the top surface of the fuselage. Consequently air can enter the ducts on top of the craft and be passed around the outside of the engine **1**, on forward movement of the craft **1**, to cool the engines. This arrangement can also serve to pressurise fuel delivering to the engines, and similarly air can be pumped to the engines from the ducts **15**. Booster jets **16**A may also be provided. The engines **1** can be located almost wholly within the aircraft fuselage as shown in FIG. **5**, so that the aircraft **14** can enjoy an extremely low drag factor e.g. 0.02 or even less.

FIGS. **7** to **9** show further views of the flying craft **14**, in particular the straight main ducts **15** through the fuselage are present, extending from openings **15**A at the front portion of the craft **14** to the engines **1** at the rear of the craft **14** to provide cooling air for example surrounding the engines and/or combustion air for the engines **1**. Further ducts **17**A, **17**B could be present alternatively or additionally again extending through the fuselage to provide air for the engine **1**, the ducts **17**A, **17**B which can be of smaller diameter than the ducts **15** this time having their front opening at the leading edge of the flying craft **14**. Pumping means could be present for increased air flow through the various ducts **15**, **17**A/B.

Considering now the aerodynamic form of the craft **14**. The flying craft **14** has a domed upper surface **18** of continuous sheeting forming a series of annular portions **19** each of a gently bowed form in the radial direction but maintaining an upper surface which is smoothly contoured.

To provide the slender body form the domed upper surface **18** can have a gently rising gradient for example in the order of 16%. The underside is also smoothly contoured and comprises a central concave wall **20** and a second surface **21** surrounding the wall **20**: in a preferred embodiment the wall **21** is of convex form as shown. The edge of the dish comprises an upturned flange **22** (as seen in FIGS. **8**/**9**), while a streamlined proboscis **23** is located at the front of the craft and includes an upturned tip **24**. The proboscis **23** serves to prevent undesirable yawing of the flying craft in flight and encourages longitudinal stability. In addition a fin **25**, **26** could be provided at the front and/or the rear for directional stability or controlability. A retractable undercarriage including wheels **27** carried by hydraulic struts **28** facilitates clear landing and take-off of the flying craft. The top **18** and bottom **20**/**21** walls of the flying craft can be carried by a suitable internal support structure (not shown).

The flying craft **14** is constructed from suitable material for example aluminium or titanium, especially the latter where very high altitude or space flight is intended. Further, an appropriate coating may be applied to the surface skins, for example carbon fibre paint, particularly to enable the flying craft to withstand heat at very high speed flight (e.g. 4 to 10 MKS per hour).

The shape of the flying craft dish will result in a very low drag characteristic enabling the craft to cut through the air with ease. Also, although designed for high speed operation, flying craft **14** nevertheless will be able to descend smoothly and conveniently on landing on a runway.

The two spaced engines **1** can be seen in FIG. **8** and these are essentially located within the fuselage to encourage the presence of a low drag factor for the flying craft: thus a fuselage wall portion **29** extends between the engines **1** and blends into the top surface **18** towards the domed central portion, while the outer sides of the engines **1** are smoothly faired into the fuselage at **30**. The front openings **15**A for the ducts **15** to the engines **1** can be seen in FIG. **9**. Turning of the craft could be achieved by a rudder **25**, **26**, but alternatively this turning could be achieved by controller operation of the engines **1** i.e. by increasing the thrust of one engine relative to the other. Also a rear flap could be present for air craft climbing or descent.

Directional control of the flying craft **14** can also be obtained by means of the thruster jets **16**A/**16**B shown in FIGS. **10** and **11**. Thus the jets **16**A are arranged in pairs on either side of the fuselage symmetry line x—x, so that operation of the front pair raises the nose of the craft **15** for ascent while operation of the rear pair lowers the nose for craft descent. Further, banking of the craft **14** can be achieved by operation of the jets alone at the port or starboard side appropriately and the further thruster/booster jets **16**B at the central line L—L can be used in this operation. The downward angle of the jets can be selected appropriately and it would be possible to provide variable discharge nozzles at any of the jets **16**A, **16**B to change a jet direction, for more sensitive directional control. Air could be provided for the jet producing devices of jets **16**A, **16**B from any of the air ducts **15**, **17**A/B.

The air flow in the ducts **15** can also serve to drive a double fan turbine as described in the applicants GB Patent Application No 9 507 976.0 (Publication No), filed 19 Apr. 1995 and U.S. Ser. No. 08/425,056 filed Apr. 19, 1995 concerning electrical generating apparatus, so as to produce electrical energy for electrical energy supply requirements of the aircraft.

FIG. **15** shows an example of this double fan turbine in greater detail. Thus turbine/alternator **27** comprises a fan drum assembly **28** carrying two sets of fan blades **29**A, **29**B. Each fan blade set **29**A, **29**B is carried by its separate hub portion **28**A, **28**B so that the fan sets **29**A, **29**B can rotate separately from each other, the drum **28** including a stationary central ring portion **28**C which can support the hub portions **28**A, **28**B. The blades of each fan set **29**A, **29**B, are of elongate form with an axial length greater than the radial dimension and arranged helically on the respective hub portions so that the fan sets **29**A, **29**B are of opposite hand. Consequently wind flow over the fan sets **29**A, **29**B by the flow say in ducts **15** caused the fan sets to rotate in opposite (contra) directions. The front hub **28**A includes a cone **28**D with its apex forward encouraging a smooth air-flow from the duct **15** onto the turbine fan while the rear hub has a similar conical portion **28**E at the rear. The fan and the alternator advantageously constitute a rotary unit defining an electrical generator. Thus, the alternator **30** comprises a central shaft **31** preferably of hollow form connected to the hub portion **28**B with the hub portion **28**A surrounding the shaft **31**. The fan assembly can be carried by suitable supports **32** front and rear, while a radial support **32**B for example in the form of rods can be provided at the central portion **28**C. Both the supports **32** will be linked to stationary parts of the hub cones.

Wire coils **33** are provided on the under side of hub potion **28**A to constitute the armature component of the alternator while the rotary shaft **31** carries the induction coils **34** constituting the induction component of the alternator. Exciting current to the coils for electromagnetic field production and electrical power taken off from the alternator can be achieved by appropriate means.

FIGS. **16** and **17** show possible performance criteria provided by the aircraft **14** (for atmospheric operation) while FIG. **18** shows a performance graph similar to FIG. **17** for the aircraft **14** as intended for use in outer space i.e. as a space craft. The low drag factor C_D will be noted.

The thruster jets **16**A, **16**B could function to give a certain vertical take-off characteristic to the flying craft **14**, and also permit a controlled vertical descent of the craft. The embodiments shown in FIGS. **12** and **13** develops this characteristic but uses a single engine **35** (or a plurality of engines) arranged vertically and of much greater power for take-off and ascent of the craft **14**A essentially vertically. The flying craft **14**A of FIG. **12** in fact is provided with two separate propulsion modes, namely the engine **35** for vertical motion and electrical propulsion means **36** for forward (substantially horizontal) movement. Each propulsion means **36** is located in a respective air duct **15**, which can be of different diameter than previously, and in essence comprises a ducted fan propulsion means, having a turbine fan **37** coupled to an electric drive motor **38** (which may be provided with a further cooling fan). The engine **35** is shown as a jet engine having an upper air inlet **35**A and a lower jet discharge **35**B. Movable shutter or segment portions **39** are located on the top of the craft **14**A to move over and close the air inlet **35**A and provide complete surface continuity on the top of the craft when the craft operates in the second electric propulsion mode. Similar or other closure means could be provided for the discharge **35**B. Instead of a jet engine **35** it would of course be possible to utilise a rocket engine, especially one of the rocket engines described previously. Zones **40** in the flying craft **14**A will serve as storage spaces e.g. for power batteries for the electric motors **38** and other electrical items and/or passenger accommodation spaces. The pilot and other crew members can be located in cockpit space **41**, while fuel for engine **35** can be stored in peripherial spaces **42**. Thruster engines as before (**16**A/B) could be installed for control of the movement of the craft **14**A.

Wind driven turbine alternators **27** as described previously are installed in the ducts **15** for the production of electrical power, for supply for example to the power batteries of the electric motors **38**.

Referring to FIG. **14**, in the proposed operation of the flying craft **14**A take-off (A–B) is effected by the first power mode i.e. engine **35** and the engine power is such as to lift the craft **14**A substantially vertically as can be seen by path A–B. The altitude B reached should be very substantial e.g. possibly greater than 60,000 ft and even as high as 90,000 ft for example. When the desired height (B) is attained, the engine **35** is shut-down and the inlet **35**A (and outlet **35**B) are closed by the shutters **39**, and drive power is transferred i.e. to the second mode i.e. to electrical propulsion means **36** for movement of the craft in path B–C. The second power mode **36** will of course have very limited power compared to the engine **35** but it is intended to have a substantially soaring motion in the path B–C with very gradual descent. Forward speed attainable by the power mode **36** will be quite low e.g. 200 or 300 m.p.h., but the relatively quiet fan motors **37**/**38** will enable the dish-shaped craft **14**A to move forward in a silent stealth like manner.

The descent can be very gradual, say 1 mile drop for every 100 mile advance, so that the range may be quite reasonable e.g. about 1800 miles from an altitude of 90,000 ft although the battery capacity will affect this range. If an increase in range is desired during forward movement, then there could be intermediate operation of the engine **35** to gain altitude to provide an increased range. A certain directional control can be achieved by varying the operation of the motors **38** to give unbalanced thrusts. The motors **38** may drive the fans **37** at speeds greater than 10,000 r.p.m. and up to 20,000 r.p.m. or more. The engine **35** can provide for controlled vertical descent.

The craft **14**A may use simple skids **43** in its undercarriage instead of wheels. As will be seen in FIG. **12**, the periphery of the fuselage is now downwardly carried instead of having the previous flange **22** to reduce resistance to vertical movement. Also, the first power mode could be arranged so that the take-off and ascent path is not completely vertical as shown by alternative paths A_1B and A_2B and this will enable a less powerful engine(s) to be used. Further, use of the first power mode could extend into the second path to give an initial boost to the motion in this path for a short distance.

Modifications are of course possible in all the embodiments. In particular rocket engines may be replaced by jet engines or vice versa. In the emodiment of FIG. **12**, the primary engine (**35**) could be released and ejected from the flying craft when the desired altitude (B) is attained: the engine could be fitted with parachutes for descent to the ground.

I claim:

1. A flying craft including a thruster engine, said thruster engine comprising:

casing means for housing adjacent first and second work zones, said casing means having a rear;

first delivery means for introducing a first propellant fuel into said first work zone for combustion in said first and second work zones, said first delivery means comprising:

(a) a first conical member having a surface and an apex, said apex facing said first work zone;

(b) a second conical member coaxial with said first conical member;

(c) duct means in said surface of said first conical member for the through-flow of said first propellant fuel into said first work zone; and

(d) conduit means for directing burning fuel from said first work zone to said second work zone, said conduit means being formed on said second conical body; and

second delivery means for directing a second medium to said second work zone for admixture with the burning fuel, the burning fuel and the medium being discharged from said rear of said casing means to constitute a thrust jet for said engine.

2. The flying craft according to claim **1**, wherein said first propellant fuel is liquid-oxygen and said second medium is liquid-hydrogen.

3. The flying craft according to claim **1**, further comprising a nozzle device at said rear of said casing means.

4. A flying craft as claimed in claim **1**, wherein:

the flying craft has a fuselage body of generally dished form with a domed upper surface, said fuselage body having a rear and said thruster engine being located at the rear of the fuselage body,

the fuselage body has a front inlet on said upper surface, and

the flying craft additionally includes an air duct extending through the fuselage body from the front inlet on said upper surface to said thruster engine to provide cooling air for said engine.

5. A flying craft as claimed in claim **4**, wherein said flying craft additionally includes electrical apparatus in the form of a turbine electricity generator in said air duct, said turbine electricity generator including a plurality of electricity-producing components and a plurality of separate vaned members set for contra-rotation by impingement with air passing in the air duct, each of said vaned members being coupled to a respective one of said electricity-producing components of the turbine electricity generator.

6. A flying craft comprising:

a generally dished form body providing a lift characteristic, and having a front end and a rear end, said body further having a domed shaped upper surface and a lower surface, said domed shaped upper surface having a front part and an air inlet located in said front part of said domed upper surface;

vertically disposed first engine means located substantially at the center of said dish shaped body for providing a vertical thrust for vertically propelling said flying craft to an elevated position; and

second engine means for providing propulsion power which is only sufficient to cause a forward motion of the flying craft with a slight descending path from an elevated position attained by means of the first engine means, said second engine means comprising electrically powered propulsion means for providing a horizontal thrust for propelling said flying craft in a forward direction from said elevated position, said electrically powered propulsion means comprising propulsion turbines, electrical drive means for driving said propulsion turbines, and air ductings located on either side of said first engine means and extending within said body from said air inlet to said rear end of said body, each of said ductings housing a said propulsion turbine whereby propulsion air is supplied to said propulsion turbine through the ducting.

* * * * *

US005836543A

United States Patent [19]

Kunkel et al.

[11] **Patent Number: 5,836,543**

[45] **Date of Patent: Nov. 17, 1998**

[54] **DISCUS-SHAPED AERODYNE VEHICLE FOR EXTREMELY HIGH VELOCITIES**

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[73] Assignee: **Klaus Kunkel**, Ratingen, Germany

[21] Appl. No.: **666,581**

[22] PCT Filed: **Oct. 16, 1995**

[86] PCT No.: **PCT/DE95/01430**

§ 371 Date: **Aug. 1, 1996**

§ 102(e) Date: **Aug. 1, 1996**

[87] PCT Pub. No.: **WO96/14504**

PCT Pub. Date: **May 17, 1996**

[30] **Foreign Application Priority Data**

Nov. 2, 1994 [DE] Germany 44 39 073.4

[51] **Int. Cl.**^{6} **B64C 15/12**; B64C 30/00

[52] **U.S. Cl.** .... **244/12.2**; 244/12.3; 244/12.4; 244/23 B; 244/23 C

[58] **Field of Search** .... 244/6, 7 R, 12.1, 244/12.2, 12.3, 12.4, 23 B, 23 C, 74; 60/39.461, 205

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Primary Examiner—William Grant

Attorney, Agent, or Firm—Herbert Dubno

[57] **ABSTRACT**

A discus-shaped aircraft is provided with a peripheral jet arrangement for generating lift and, in the bottom of the aircraft, at least one rocket engine supplied with silicon hydride and compressed air and operated under conditions in which the silicon hydride is reacted with nitrogen of the compressed air to form silicon nitride while the nitrogen of the silicon hydride compounds reacts with oxygen to form H_2O.

14 Claims, 2 Drawing Sheets

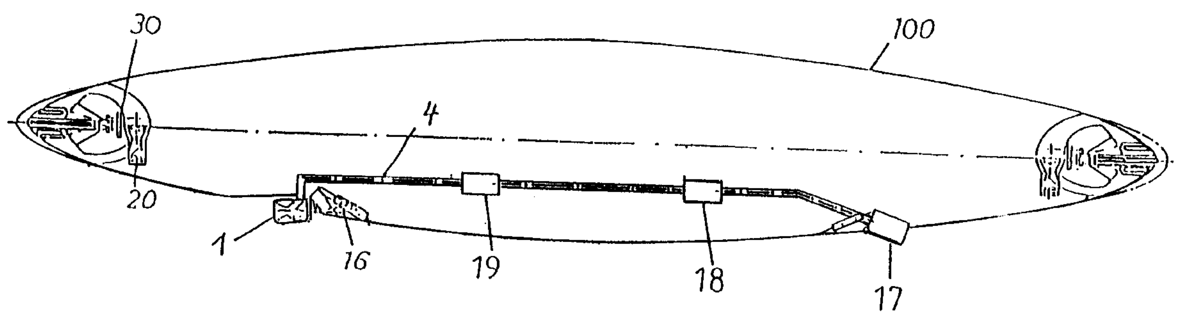
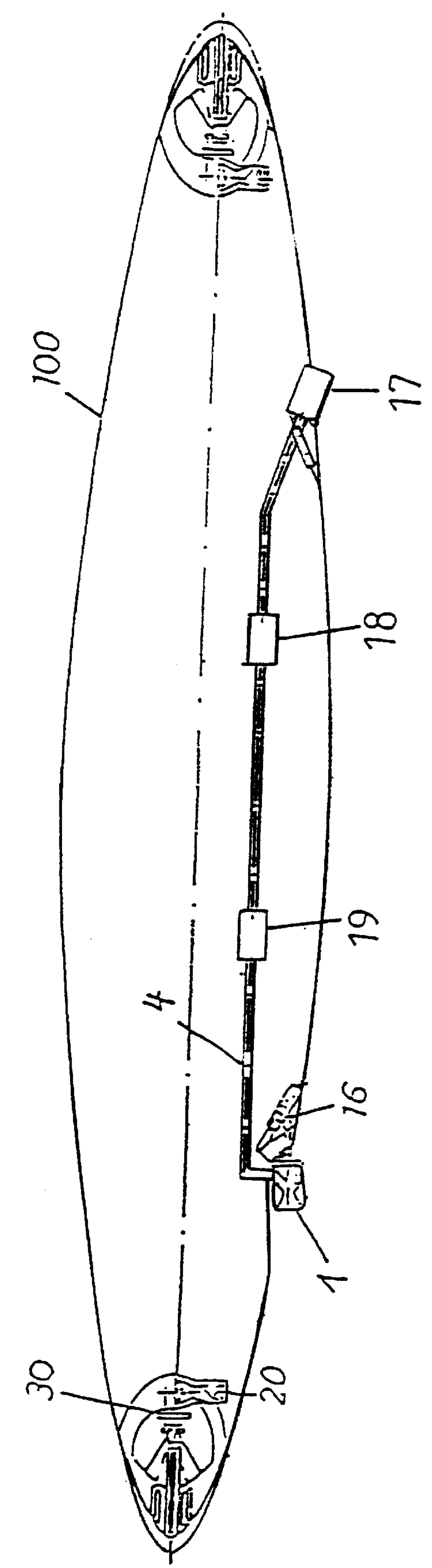


FIG. 1



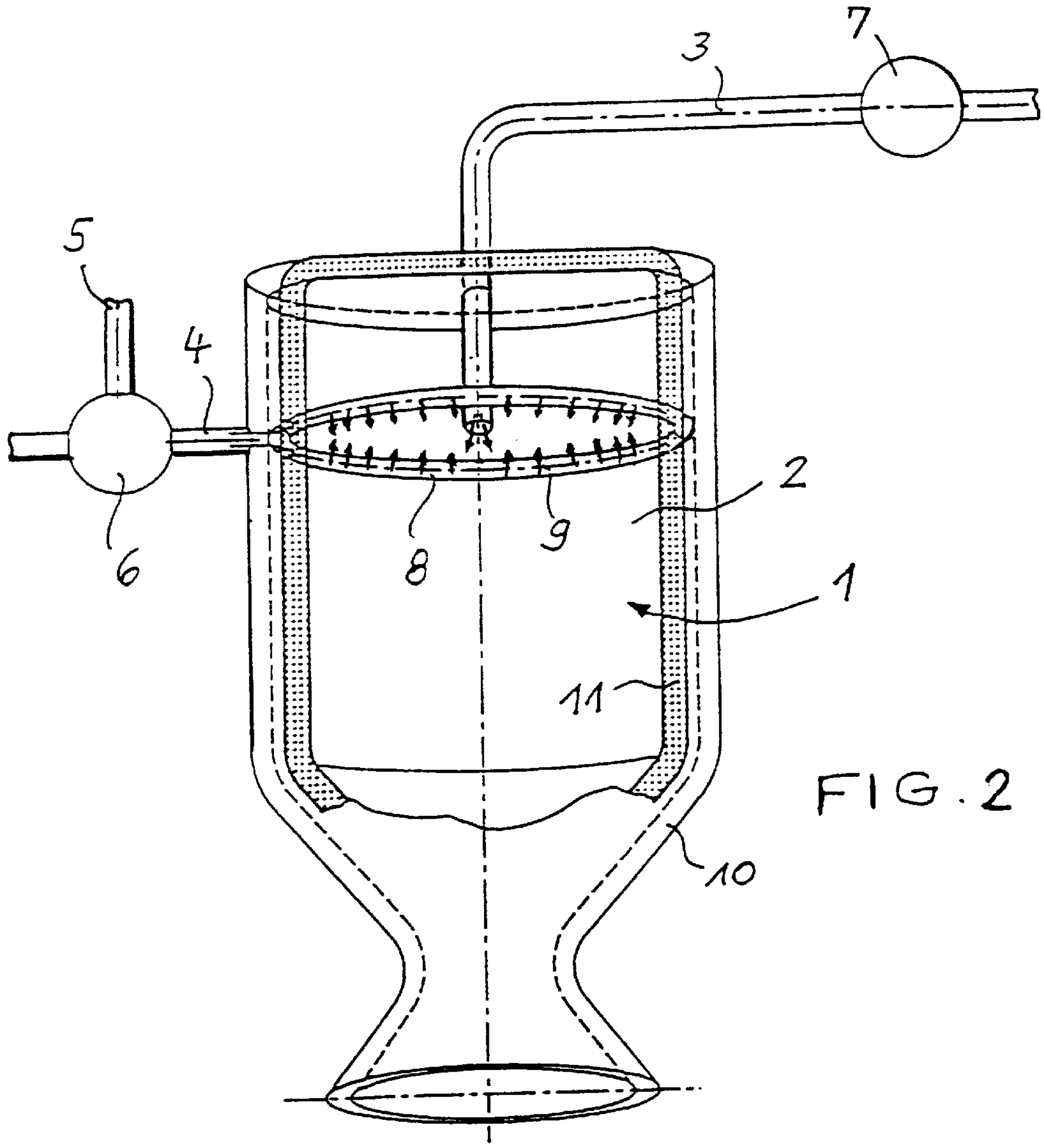


FIG. 2

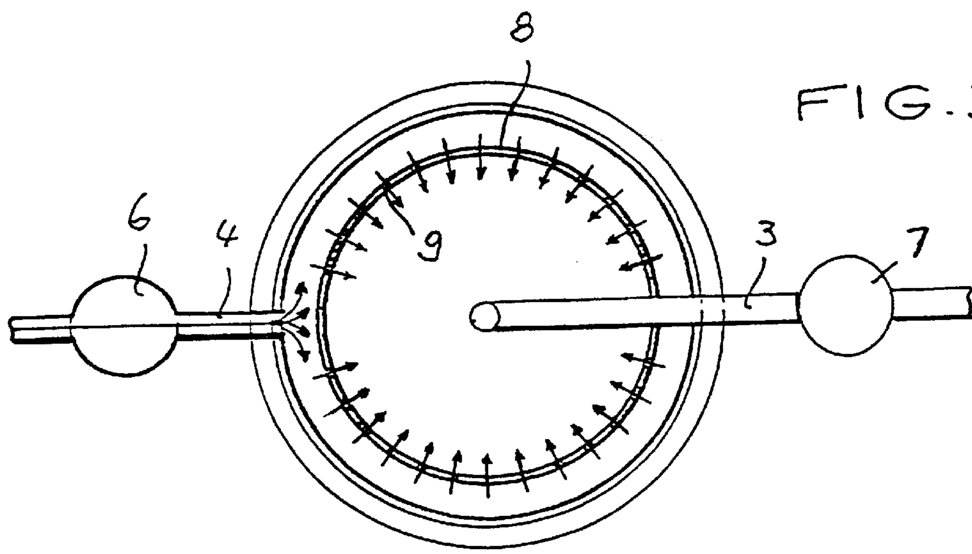


FIG. 3

DISCUS-SHAPED AERODYNE VEHICLE FOR EXTREMELY HIGH VELOCITIES

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a national stage of PCT/DE95/01430 filed 16 Oct. 1995 and based, in turn, on German national application P4439073.4 of 2 Nov. 1994 under the International Convention.

FIELD OF THE INVENTION

The present invention relates to a discus-shaped aerodyne for extremely high velocities and extreme altitudes, the aerodyne having an outer casing generating buoyancy when horizontally flying through a gas atmosphere, a jet arrangement located in a peripheral region of the aerodyne and serving for the generation of a vertical movement and at least one rocket engine for the combustion of silicon hydride compounds for the generation of a horizontal movement of the aerodyne.

BACKGROUND OF THE INVENTION

In order to fly long distances, long-distance aircraft flying in the supersonic range must travel for a long time. Supersonic aircrafts with a very high fuel consumption, as for instance the Concorde, must have intermediate stops to supplement their fuel stock. Accordingly, there is a need for a long-distance aircraft which can be economically operated and with which a great number of passengers or a large quantity of freight can be transported.

An aerodyne of the above-described kind which is designed as spacecraft is known from German patent 42 15 835. The known aerodyne has three drive means. In the start phase it operates as a helicopter by using jets acting on two oppositely driven rings through gear means. The rings have adjustable blades and operate as turbine blade rings. The aerodyne is kept in suspension by this drive.

In this phase the aerodyne is accelerated by means of at least one rocket drive adapted to be swung out from a bottom area of the discus-shaped outer casing and oriented laterally obliquely. When this second drive is effective the helicopter drive can be switched off and the casing of the turbine blade rings can be pulled in so that the aerodyne is occluded with respect to the outside air. The aerodyne is adapted to be lifted to the upper level of the stratosphere with this rocket drive.

Furthermore, the known aerodyne includes at least one main thruster centrally located with respect to the discus-shaped outer casing and adapted to move the spacecraft through the vacuum space.

The main thruster and the rocket drive are formed in such a manner that they can be driven by a silane oil of the chemical formula Si_5H_{12} to Si_9H_{20} as rocket propellant.

In the cited publication (see U.S. Pat. No. 5,730,390 based on application Ser. No. 08/353,355) liquid oxygen is mentioned as oxidizing agent for the combustion of the silane oils in the two rocket engines, namely the rocket drive and the main thruster, wherein liquid chlorine or fluorine are also cited. This liquid oxidizing agent has to be carried along within the aerodyne. However, this fact practically excludes the use of such an aerodyne for aviation and makes the same only suited as spacecraft, as has also been described in German patent 42 15 835. That is, the large amount of oxidizing agents carried along does not make such aerodynes suitable for the transport of freight or passengers for long-distance flights.

OBJECT OF THE INVENTION

It is the object of the invention to provide an aerodyne of the cited kind which is suitable for flights within the terrestric area with a high load capacity and especially high velocities.

SUMMARY OF THE INVENTION

This object is attained in a discus-shaped aerodyne, according to the invention by providing at least one rocket drive in the form of a nitrogen burner in which the silicon hydride compounds are burned with atmospheric nitrogen at high temperatures in the presence of atmospheric oxygen as oxidizing agent for the hydrogen of the silicon hydride compounds.

Preferably, silane oils, having the chemical formula Si_5H_{12} to Si_9H_{20}, are burned in the nitrogen burner.

Accordingly, with the inventive solution the rocket drive providing for the horizontal movement of the discus-shaped aerodyne is formed as a nitrogen burner in which the silicon hydride compounds, especially silane oils, are burned together with the nitrogen of the atmosphere. This has the advantage that the aerodyne need not carry along a special oxydizing agent, as for instance liquid oxygen, for the silicon hydride compounds since the atmosphere of the earth contains nitrogen (N_2) in a proportion of about 80%. Accordingly, air, especially compressed air, is introduced into the combustion chamber of the rocket drive and is caused to be reacted with the silicon hydride compounds.

When burning silicon hydride compounds, especially silane oils, with compressed air the oxygen portion reacts with the hydrogen of the silane chain in accordance with the equation

$$4H+O_2=2H_2O.$$

In this hydrogen-oxygen-combustion, temperatures of about 3000° C. are reached. This temperature is sufficient to crack the N_2 molecules which are present in the supply of the compressed air. According to the equation

$$4N+3Si=Si_3N_4$$

the nitrogen radicals now attack the free silicon atoms with extreme vehemence. Silicon nitride is formed which has a molecular weight of 117 and thus is nearly three times as heavy as carbon dioxide. Accordingly, the repulsion effect is significant as compared with earlier systems.

Of course, the cited reaction occurs only with correspondingly high temperatures. In the air silane oils, after ignition, burn only to develop red-brown amorphous silicon monoxide since the combustion mixture does not contain enough oxygen because of the rapidity of the combustion. No reaction with nitrogen takes place since nitrogen does not form free radicals under these conditions.

Compared with conventional jets which can only use about 20% of the atmosphere for the combustion, important advantages are obtained since the combustion can be based not only on the 20% of the atmosphere representing the O_2 content but also on the additional about 80% N_2 content. The silicon nitride (Si_3N_4), predominantly formed by the reaction of radicals with silicon, has a substantially higher molecular weight than the carbon dioxide developing with the jets of the prior art, whereby an especially high efficiency of the drive means is reached since, according to the kinetic energy equation, not only the velocity but also the mass of the gases is of importance.

According to a feature of the invention, in addition to air, nitrogen compounds or nitrogen-oxygen compounds are introduced into the combustion chamber. This is especially advantageous if in great altitudes (with decreasing density of the atmosphere) an effective nitrogen combustion or hydrogen combustion is to be maintained. Preferably, such compounds are introduced which contain not only nitrogen but also oxygen in order to ensure both reactions, these compounds can be N_2O_4 or nitric acid HNO_3. Furthermore, the invention does not exclude that nitrogen itself or corresponding oxidizing agents are carried along within the aerodyne in order to initiate or maintain the corresponding reactions. However, preferably, the nitrogen and oxygen of the air are used.

Preferably, the reaction is caused to run at a temperature above 1400° C. since below this value a combustion of the silicon hydride compounds, especially of the silane oils, with nitrogen can be realized only in a difficult manner or not at all. Preferably, one operates with increased temperatures of 2500°–3000° C. which are generated during the hydrogen-oxygen combustion resulting from the reaction of the oxygen portion of the atmosphere of the earth with the hydrogen portion of the silane chains of the silicon hydride compounds.

Accordingly, compared with the prior art the inventive aerodyne has, in addition to a jet arrangement serving for the generation of a vertical movement of the aerodyne, i.e. for the start and landing, only one rocket drive unit comprising at least one rocket engine formed as nitrogen burner. The previously described main thruster with the above-cited prior art is omitted since the inventive aerodyne is formed as true aerodyne for the terrestric area, i.e. for the range of the atmosphere of the earth, and does not represent a spacecraft. The rocket drive unit including the at least one rocket engine provides for the principal movement (horizontal movement) of the aerodyne, wherein an especially high efficiency of the drive means can be achieved (high accelerations, high velocities and high payloads of the aerodyne with comparable low consumption of energy since the nitrogen required for the combustion can be taken from the air of the atmosphere) with the combustion of the silicon hydride compounds, especially silane oils, with nitrogen according to the invention. Furthermore, the aerodyne is especially compatible with regard to environmental aspects since silicon nitride is generated by the combustion of the silicon hydride compounds (silane oils) with nitrogen and has a dust-like consistency and is non-toxic.

The nitrogen burner includes a combustion chamber, a supply line for the silicon hydride compounds leading into the combustion chamber and a supply line for compressed air supplying the nitrogen for the combustion of the silicon hydride compounds and the oxygen for the combustion of the hydrogen of the silicon hydride compounds. The air supply line leads to at least one air inlet opening at the outer casing of the aerodyne, wherein corresponding compression means are arranged therebetween. Preferably, the supply line for the silicon hydride compounds is connected to a source of silane oils which are carried along as fuel in a corresponding storage room of the aerodyne. The silane oils are liquid and adapted to be pumped.

Preferably, the combustion chamber is formed in such a manner that the compressed air is annularly introduced into the combustion chamber while the silane oil is introduced into the combustion chamber approximately centrally. Preferably, the fuel supply for the combustion chamber is realized automatically in response to the pressure and the temperature of the combustion chamber.

The casing of the combustion chamber is designed for correspondingly high pressures and temperatures. Appropriately, it includes a cooling jacket. The inner chamber can be protected by a ceramic or noble metal lining. Furthermore, the casing of the combustion chamber can preferably consist at least partly of titanium.

If not enough O_2 (from the air) is present for the combustion in order to burn all the H atoms of the silicon hydride compounds and to reach a sufficiently high temperature for the cracking of the N_2 molecule, additional oxygen has to be introduced into the combustion chamber, preferably, as nitric oxide. The additional oxygen has the effect of an "ignition medium" for the following N reaction.

The rocket drive used in the inventive aerodyne presents a mixture of a jet and of a known liquid rocket drive. According to the invention the advantages of both known systems are combined with one another. The inventive engine operates according to the repulsion principle, i.e. is comparable with a rocket engine and utilizes the high efficiency of the same, however, uses the nitrogen present in the atmosphere for the combustion of the silicon hydride compounds so that no specific oxidizing agent has to be carried along within the aerodyne. Furthermore, compared with a conventional jet engine it has the advantage that no mechanical elements in the combustion chamber are necessary.

Appropriately, the at least one rocket engine is disposed in the bottom area of the discus-shaped outer casing of the aerodyne. Preferably, it is adapted to be swung out from the bottom portion of the outer casing so that it is oriented laterally obliquely in order to enable a propulsion of the aerodyne in horizontal direction. Furthermore, the aerodyne has at least one air inlet opening preferably in the bottom aera of the discus-shaped outer casing. From there the air, if necessary after relaxation, is introduced into the combustion chamber of the rocket engine through compression means. Preferably, the air inlet opening is formed as air box adapted to be swung out from the bottom area and operating laterally obliquely.

The aerodyne operates in such a manner that it starts and lands by means of jet arrangements (helicopter engine) disposed in the peripherial area of the aerodyne. After lifting-off it is laterally accelerated with the at least one rocket engine. From a velocity of about 300 km/h the turbine blade rings of the helicopter engine can be switched off since the discus-shaped aerodyne is borne by the atmosphere on account of its buoyancy. By acceleration with the rocket engine to about 5000 km/h the discus-shaped aerodyne gains height by itself, to an altitude of 50 km there is still enough air for the rocket engine at this velocity. This process can continue up to an altitude of at least 80 km at about 8000 km/h. Here, the air is so rare that the resistance of the air is very small. The aerodyne flies with this cruising speed through the beginning of space with a throttled rocket engine which, if necessary, can be supplied with energy-rich liquid nitrogen-oxygen compounds. At a certain point of time the rocket engine can be completely switched off since the high velocity is still sufficient for a long cruising distance inspite of the incipient retardation. The increase of retardation and the reinforced lower side of the aerodyne, preferably reinforced with ceramic, allow a landing manoeuvre as with starting with turbines turned on again.

BRIEF DESCRIPTION OF THE DRAWING

The above and other objects, features, and advantages will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. **1** is a diagrammatic elevational view of a discus-shaped aerodyne for extreme velocities;

FIG. **2** is a diagrammatic cross section of a rocket engine of the aerodyne in an elevational view (broken away); and

FIG. **3** is a horizontal section through FIG. **2**.

SPECIFIC DESCRIPTION

The discus-shaped aerodyne **100** shown in FIG. **1** has, apart from its main drive means, substantially the same design as the aerodyne described in the above-cited German patent 42 15 835. Accordingly, details which are not contained in the present specification can be taken from the cited publication.

The aerodyne **100** shown in FIG. **1** has a discus-shaped outer casing which is formed in such a manner that buoyancy is generated when the discus-shaped vehicle travels obliquely through a gaseous medium.

In the peripheral region of the aerodyne a plurality of jets, preferably four, offset with respect to one another by 90°, respectively, are provided which, through corresponding transmissions **30**, drive in opposite senses two rings guided along the whole periphery of the aerodyne. Angularly adjustable rotor blades are fastened on the rings. These rotor blades, as impellers, form two blade rings with which a downwardly directed air stream can be generated.

Further details with regard to the construction and the function of the jets can be taken from the above-cited German patent 42 15 835 and hence the jets need not be separately discussed here.

A rocket drive **1** is provided in the region of the lower surface of the discus-shaped aerodyne. This rocket drive is shown in detail in FIGS. **2** and **3**. After the opening of a corresponding flap by means of a hydraulic cylinder **16**, the rocket drive can be turned into a downwardly inclined position. This rocket drive is provided with a steerable suspension in order to enable the steering of the whole spacecraft. As occasion demands, a plurality of such rocket drives **1** can be provided on the lower surface of the aircraft.

The rocket drive **1** includes a combustion chamber **2** shown in FIGS. **2** and **3** which is supplied with silane oils as fuel and with compressed air for burning the fuel. The supply of air is schematicly indicated in FIG. **1**. A supply line **4** opens into the combustion chamber **2** of the rocket drive. The air is taken from the atmosphere surrounding the aerodyne by means of an air inlet opening, here shown as an air capturing box **17** which is provided at the lower side of the aerodyne in a tiltable manner. The tilting of the air capturing box **17** is realized by means of a suitable hydraulic cylinder. From here the inflowing air is fed through the line **4** into an air relaxation means **18** and from there into a compression means **19**. Both of these means are only schematically indicated. The strongly compressed air is fed from the compression means **19** into the combustion chamber **2** of the rocket drive.

The exact design of the rocket drive is shown in FIGS. **2** and **3**. Here, the rocket drive is shown in a vertical position. Normally, it has a horizontal or inclined position at the lower side of the aerodyne.

The rocket drive includes a combustion chamber **2** the casing **11** of which consists of a suitable high temperature-resistent material, for instance metal or ceramics. Preferably, the casing consists at least partly of titanium. It is surrounded by a suitable cooling jacket **10**.

Moreover, the combustion chamber is formed as the combustion chamber of a known rocket drive and has at its lower end in the figure an outlet opening provided with a corresponding restriction for increasing the velocity of the combustion gases.

The supply line **4** for the compressed air, which is compressed by the compressor schematicly shown at **6**, opens into the combustion chamber. The supply line **4** feeds the compressed air into a ring **8** disposed within the combustion chamber and provided with a plurality of inwardly directed nozzle outlet openings **9** by means of which the compressed air is introduced into the interior of the combustion chamber. Furthermore, a supply line **3** for silane oils, which are introduced into the combustion chamber by means of a pump **7**, opens into the combustion chamber into the interior of the ring **8**. The introduction can be realized by suitable injection means (not shown).

The oxygen portion of the compressed air reacts with the hydrogen of the silane chain for the formation of H_2O. With the corresponding hydrogen-oxygen combustion sufficiently high temperatures are reached to crack the N_2 molecule. Now, the free nitrogen radicals attack the free silicon atoms whereby the desired combustion with nitrogen is generated. Si_3N_4 is formed. If sufficient air is not present, additional nitrogen-oxygen compounds, as for instance NO_2 or HNO_3, can be supplied to the combustion chamber, as schematically shown by the line **5**.

Tetrafluorohydrazine is another preferred compound which supplies not only the required nitrogen but also the required oxidizing agent, namely fluorine.

FIG. **3** shows a horizontal section through the combustion chamber of FIG. **2**.

The inventive aerodyne operates in the following manner:

With the aerodyne being in the rest position on foot rests which are not shown, at first the jets **20** are operated. Through the transmissions **30** the two rings with the corresponding blade rings are thereby oppositely rotated, whereby a downwardly directed air stream is generated. In this manner the aerodyne is lifted off the ground in the manner of a helicopter.

While the spacecraft is soaring over the ground the rocket drive **1** excentrically arranged in the bottom area of the outer casing of the aerodyne is turned into the position shown in FIG. **1** by means of the hydraulic cylinder **16** and is taken into operation. The aerodyne is laterally accelerated by means of this rocket drive. Still before reaching sonic speed the rotor blades of the blade rings can be positioned horizontally since now the aerodynamic shape of the outer casing **1** supplies the necessary buoyancy with increasing velocity. The jets **20** are switched off at a velocity of about 1000 km/h and a flight height of about 5 km. The afterrunning of the blade rings stabilizes the aerodyne.

Now, the aerodyne can be accelerated to a velocity of about 6000 km/h by means of the rocket drive **15**. The atmospheric pressure substantially exponentially decreasing with increasing flight height is compensated by the increasingly higher velocity of the aerodyne so that a flight height of about 50 km can be reached in this manner by oblique flight.

For the landing of the aerodyne the rocket drive **1** is switched off and tilted back. Also the corresponding air boxes are tilted back. Then, the jets **20** are switched on again so that the aerodyne can carry out a smooth downward movement in vertical direction.

Accordingly, long-distance flights in great altitudes (at least 80 km) with great velocities (about 8000 km/h) can be carried out with the inventive aerodyne. In this area the air is so rare that the air resistance is extremely low. However, still enough air is present for the required combustion. In this area the aerodyne can fly through the beginning of space with throttled rocket engines which, if necessary, are supplied with energy-rich liquid nitrogen-oxygen compounds. At a certain point of time the rocket engines can be completely switched off since the high velocity is still sufficient for a long cruising distance in spite of the later beginning retardation. The increasing retardation against the lower side of the aerodyne which is armored with ceramics allows a landing manoeuvre with the turbines switched on again.

Accordingly, very high velocities with very high altitudes can be reached wherein, the aircraft can travel without any drive by utilization a sailing effect. A point landing is possible because of the turbine drive so that the aerodyne has a very large range of application.

We claim:

1. A discus-shaped aerodyne for extremely high velocities and extreme altitudes comprising:

a discus-shaped outer casing configured to generate buoyancy upon horizontal travel through a gas atmosphere;

a jet arrangement disposed along a peripheral area of the casing for the generation of lift;

at least one rocket drive on said casing for reaction of silicon hydride compounds for the generation of horizontal movement of the aerodyne and including a nitrogen burner in which the silicon hydride compounds are burned with atmospheric nitrogen at increased temperatures in the presence of atmospheric oxygen as an oxidizing agent for hydrogen of the silicon hydride compounds; and

means for feeding said silicon hydride compounds and atmospheric air to said burner.

2. The aerodyne according to claim **1** wherein the rocket drive burns silane oils.

3. The aerodyne according to claim **2** wherein said means for feeding supplies silane oils of the chemical formula Si_5H_{12} to Si_9H_{20} to said burner.

4. The aerodyne according to claim **1**, further comprising means for feeding to the rocket drive nitrogen compounds for the combustion in addition to atmospheric nitrogen.

5. The aerodyne according to claim **1** wherein the rocket drive includes a combustion chamber, a supply line for the silicon hydride compounds leading into the combustion chamber, and a supply line for the atmospheric nitrogen and the atmospheric oxygen leading into the combustion chamber.

6. The aerodyne according to claim **5** wherein the supply line for the atmospheric nitrogen and the atmospheric oxygen is connected to a source of compressed air.

7. The aerodyne according to claim **5**, further comprising means for introducing the compressed air annularly into the combustion chamber.

8. The aerodyne according to claim **5**, further comprising a cooling jacket for said combustion chamber.

9. The aerodyne according to claim **8** wherein said combustion chamber has a casing consisting at least partially of titanium.

10. The aerodyne according to claim **5**, further comprising means for controlling introduction of the silicon hydride compounds, the compressed air and nitrogen compounds into the combustion chamber automatically in response to the pressure and the temperature of the combustion chamber.

11. The aerodyne according to claim **5** wherein said rocket drive is disposed in a bottom region of the discus-shaped casing.

12. The aerodyne according to claim **11**, further comprising means for mounting said rocket drive to be swung out from the bottom area of the outer casing so that said rocket drive acts laterally obliquely.

13. The aerodyne according to claim **12**, further comprising at least one air inlet opening in the bottom area of the discus-shaped outer casing.

14. The aerodyne according to claim **13** wherein the air inlet opening is formed as an air box adapted to be swung out from the bottom area and acting laterally obliquely.

* * * * *

US005881970A

United States Patent [19]

Whitesides

[11] **Patent Number: 5,881,970**

[45] **Date of Patent: Mar. 16, 1999**

[54] **LEVITY AIRCRAFT DESIGN**

[76] Inventor: **Carl Wayne Whitesides**, 18975 Symeron Rd., Apple Valley, Calif. 92307

[21] Appl. No.: **434,981**

[22] Filed: **May 4, 1995**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 54,017, Apr. 29, 1993, abandoned.

[51] **Int. Cl.**[6] **B64C 29/04**; B64C 15/02; B64B 01/36

[52] **U.S. Cl.** .... **244/23 C**; 244/23 D; 244/12.2; 244/52

[58] **Field of Search** .... 244/23 R, 23 C, 244/52, 12.2, 12.5, 73 B, 23 D

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Primary Examiner—Verna Lissi Mojica

[57] **ABSTRACT**

An aircraft with automated means to transport. Spherical or one of its segments, without airfoils for lift or guidance. Means for flight are housed within the aircraft. The outermost sureface is configured to disrupt the air-flow, over its surfaces, in flight. This, to reduce skin-friction and drag coefficients, and mollify heat build-up on the skins outer surfaces as speeds increase to and beyond mach 1. The weight of gas per unit volume, with temperature variations, is the means to reduce the gross-weight and adjust for temperature and weight changes during flight. Propulsion, within the propulsion component, is provided by turbojet engines. They are secured within an inner compression pod and an outer combustion pod. The compression pod and the attached vertical-air-duct, rotate through three hundred sixty degrees, as the means for directional guidance and direct thrust. Augmented power-thrust-tubes extend outward from the combustion pod to the mid-horizontal circumference of the aircraft. Control baffles, on each thrust-tube, check, deflect and regulate the engines' thrust to control the motivity of the aircraft. Struts retract for flight and are extended for landing. These electro-hydraulic struts, level, raise and lower the aircraft for direct ground level support operations. The aircraft has the means to maintain a horizontal flight attitude. For flight aptness the aircraft has an internal, mechanical and scientific means, for vertical ascent and vertical descent without horizontal motivity, to hover and maintain a position and altitude. And during horizontal flight, climb and descend, and perform heading changes. These flight means are all performed in the aircrafts' horizontal attitude.

14 Claims, 5 Drawing Sheets

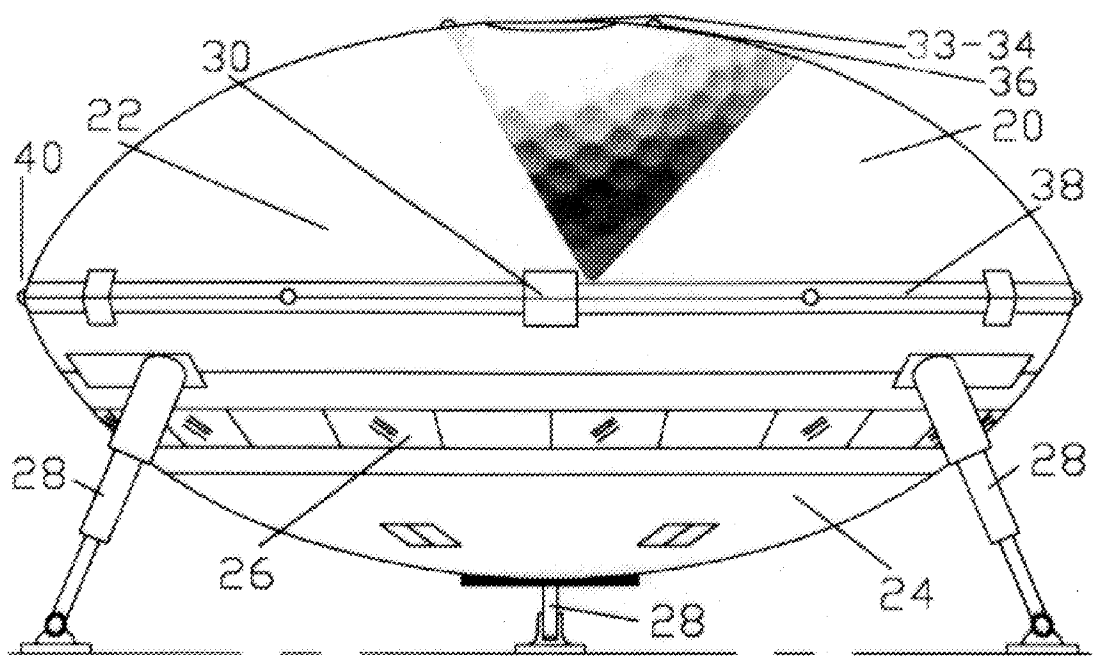
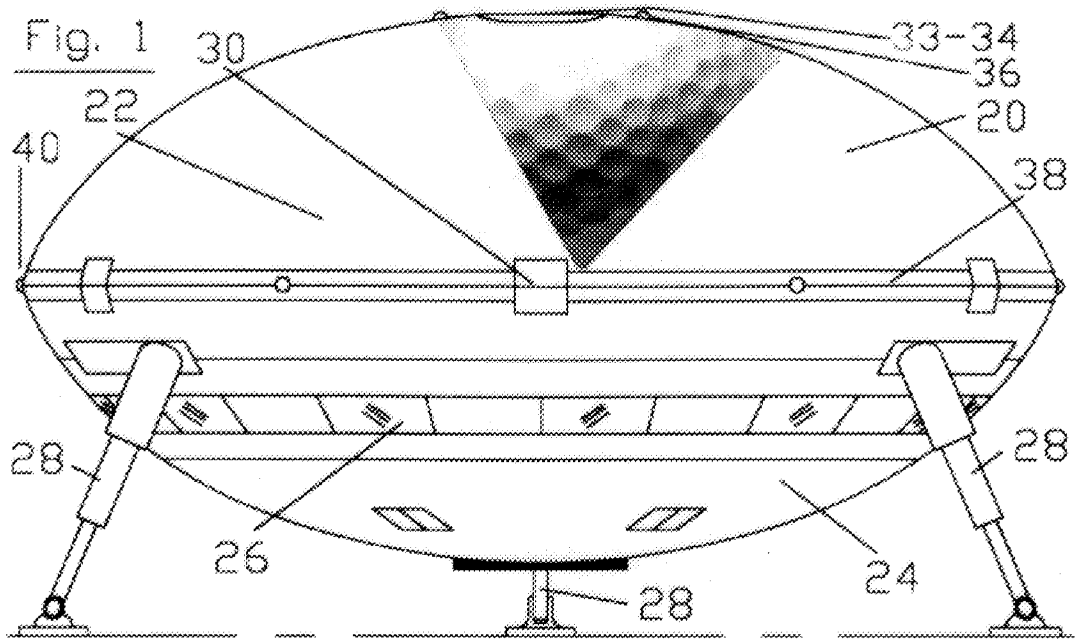


Fig. 1



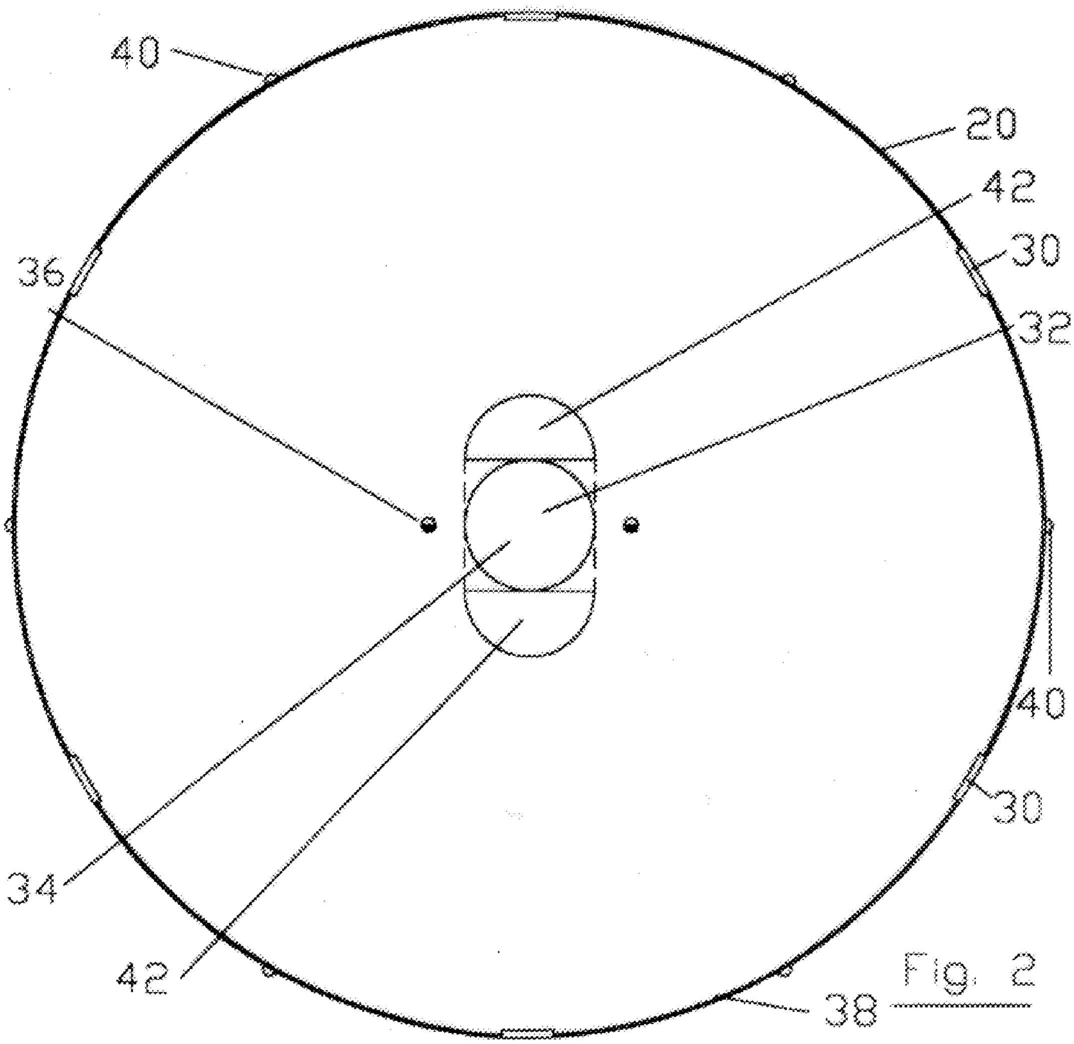
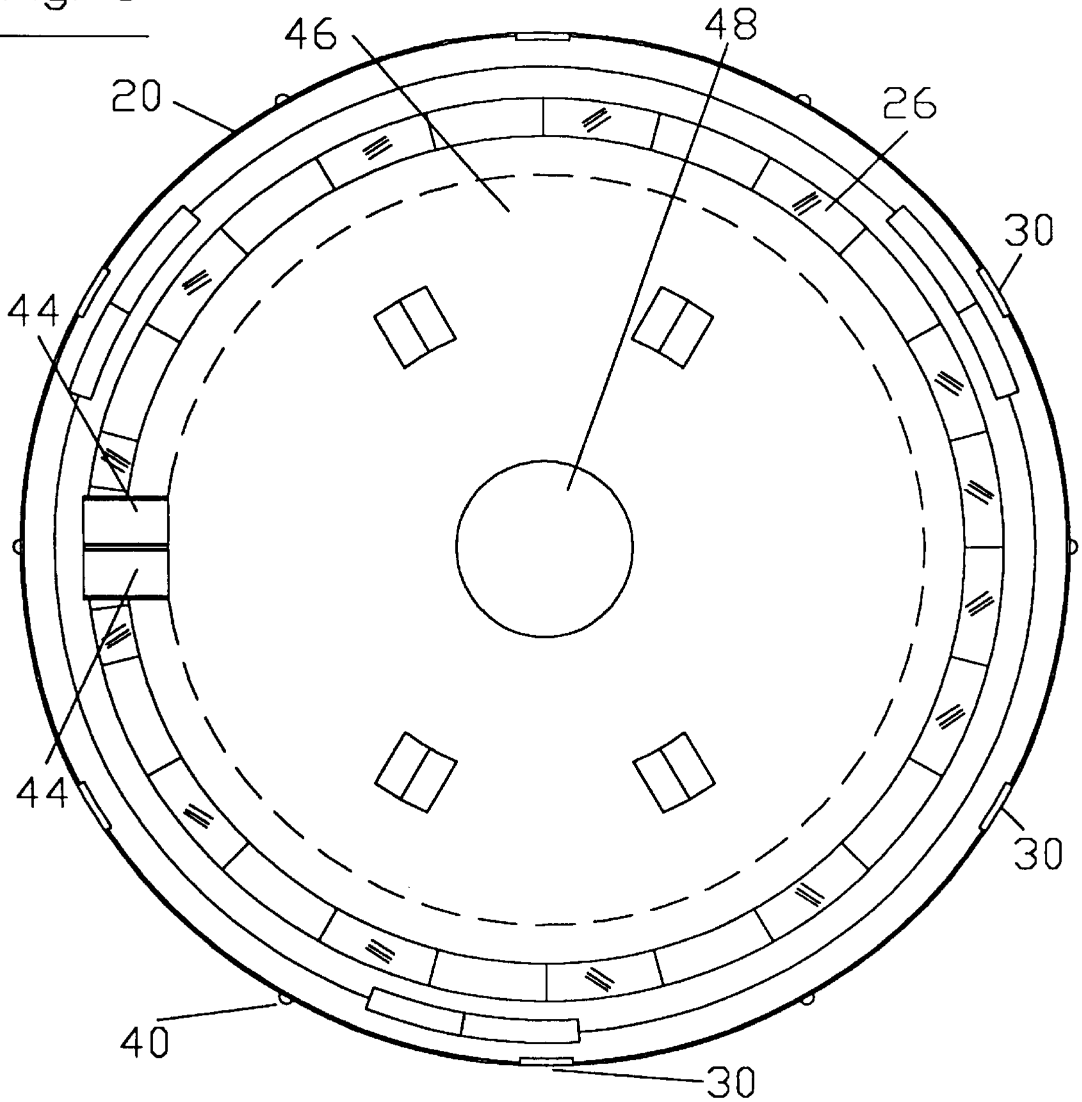


Fig. 2

Fig. 3



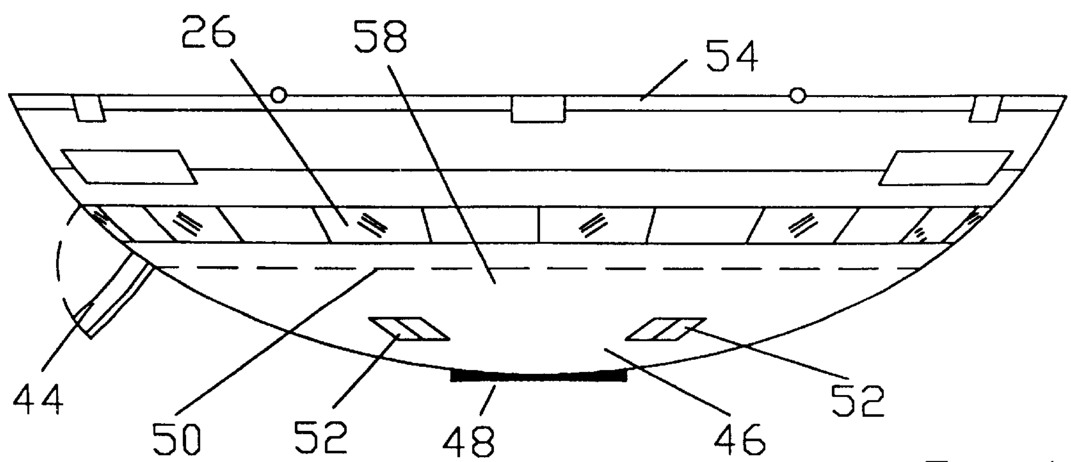
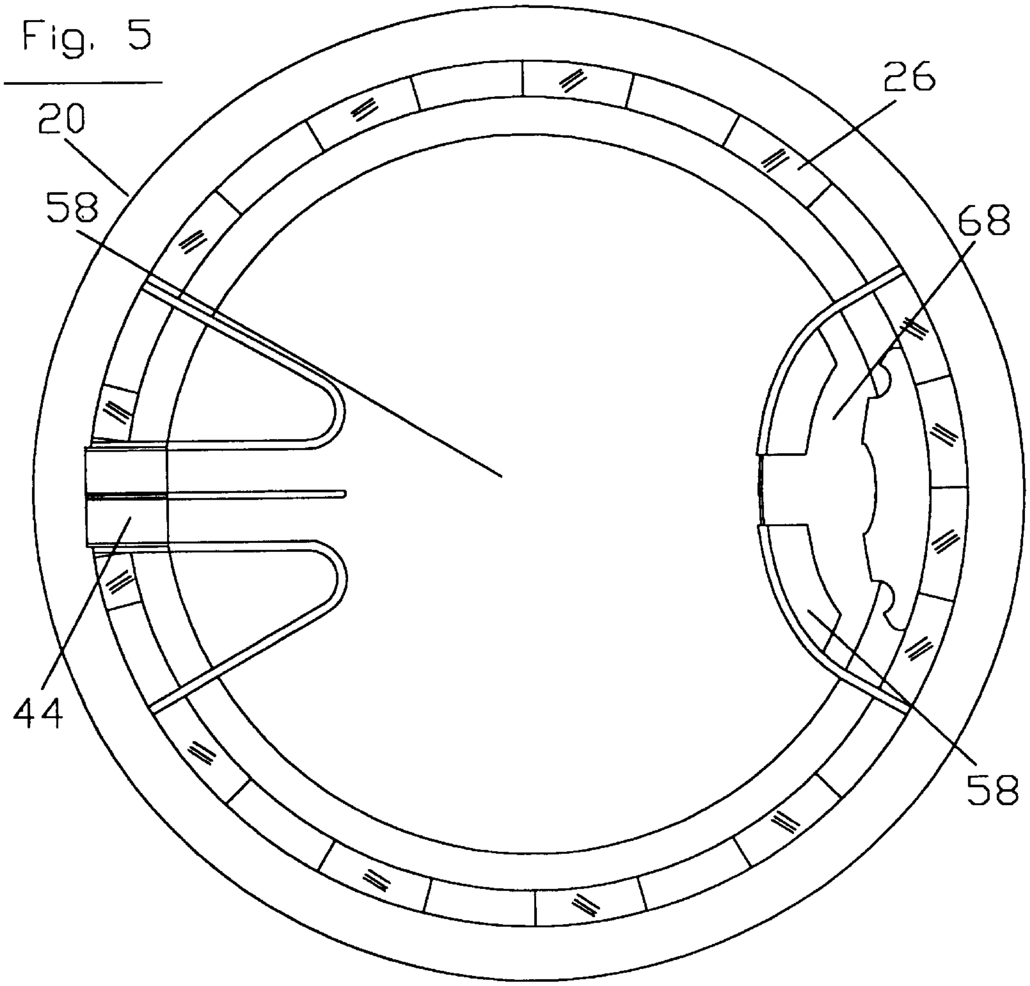


Fig. 4

Fig. 5



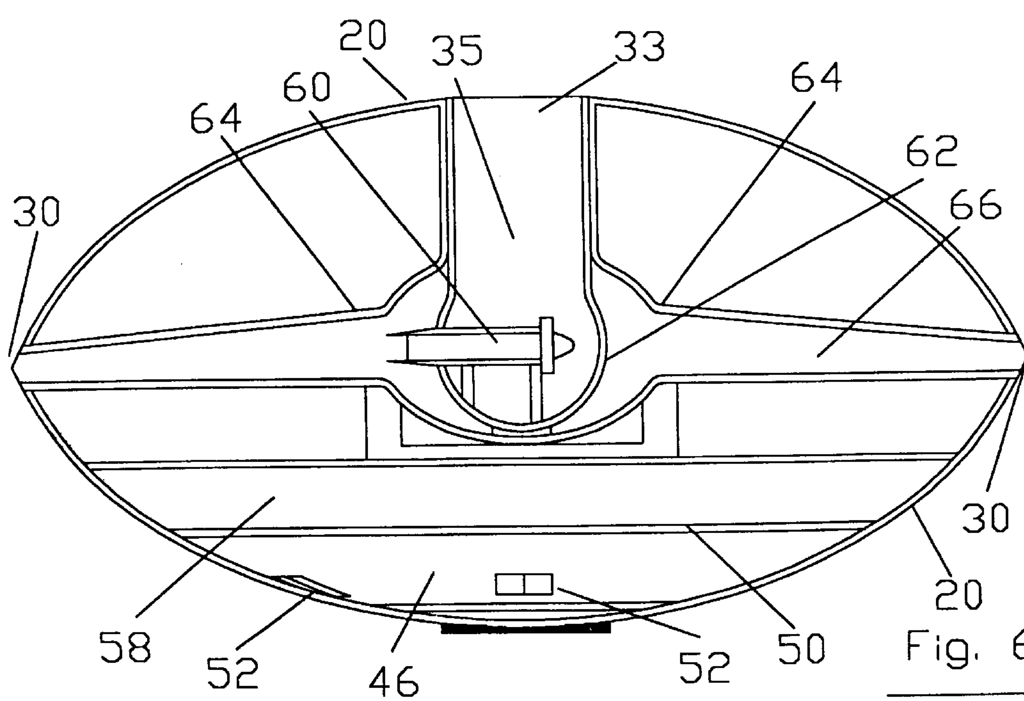
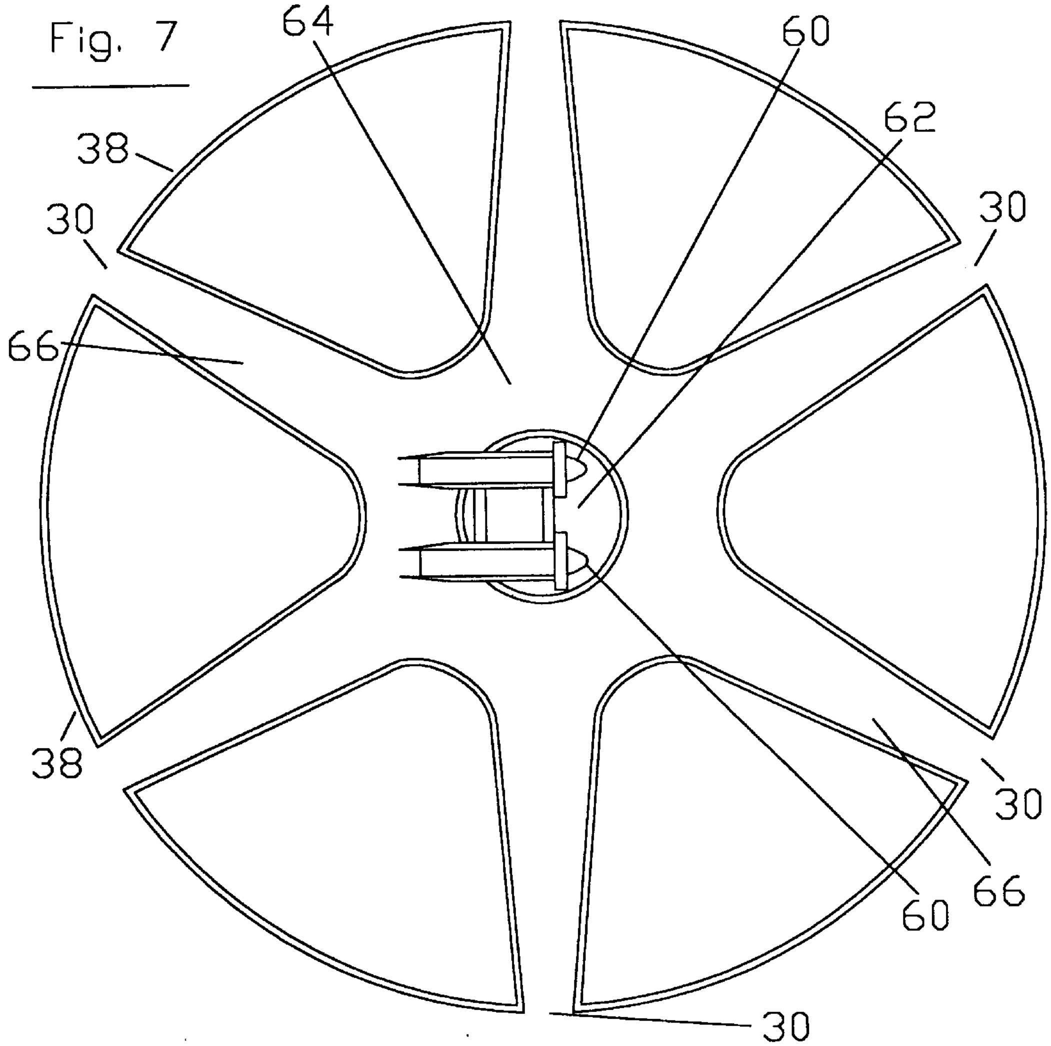


Fig. 6

Fig. 7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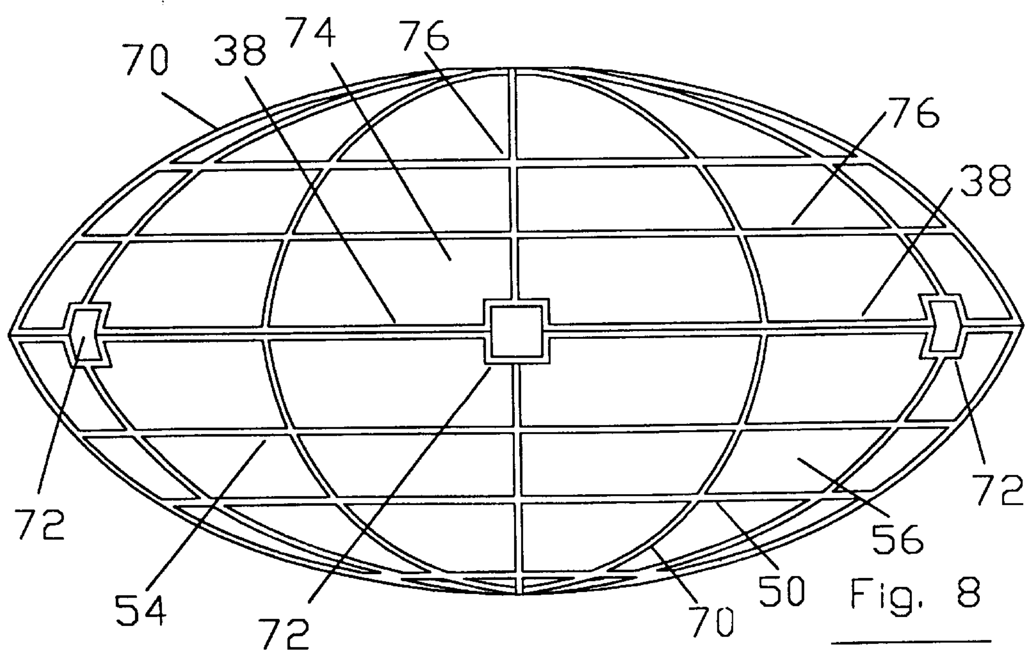
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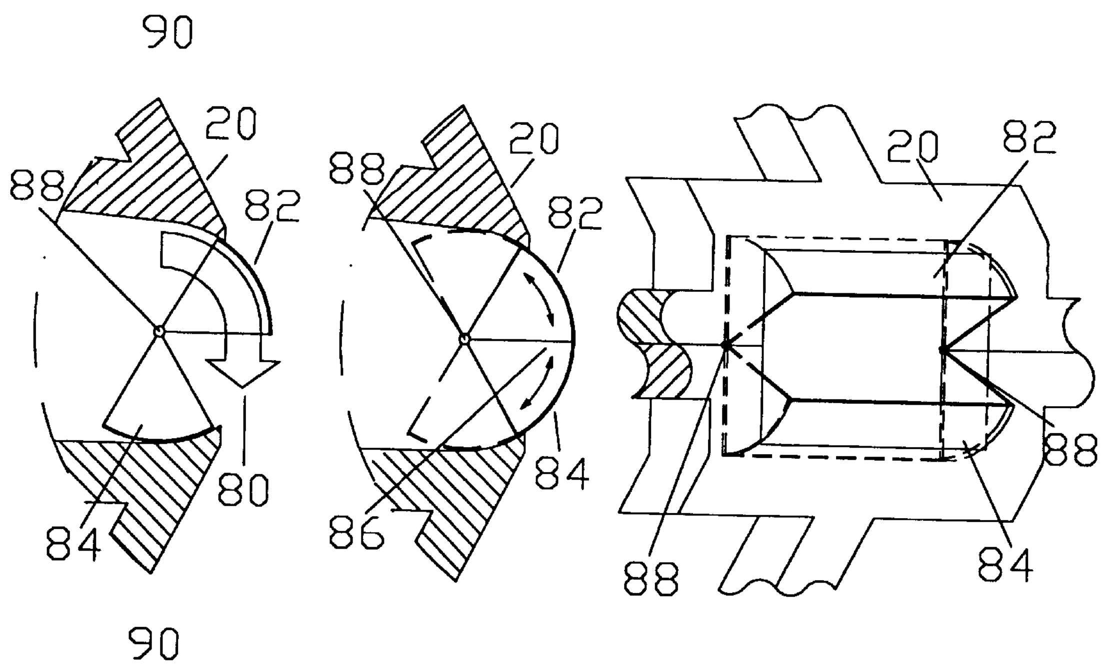
Fig. 8

Fig. 9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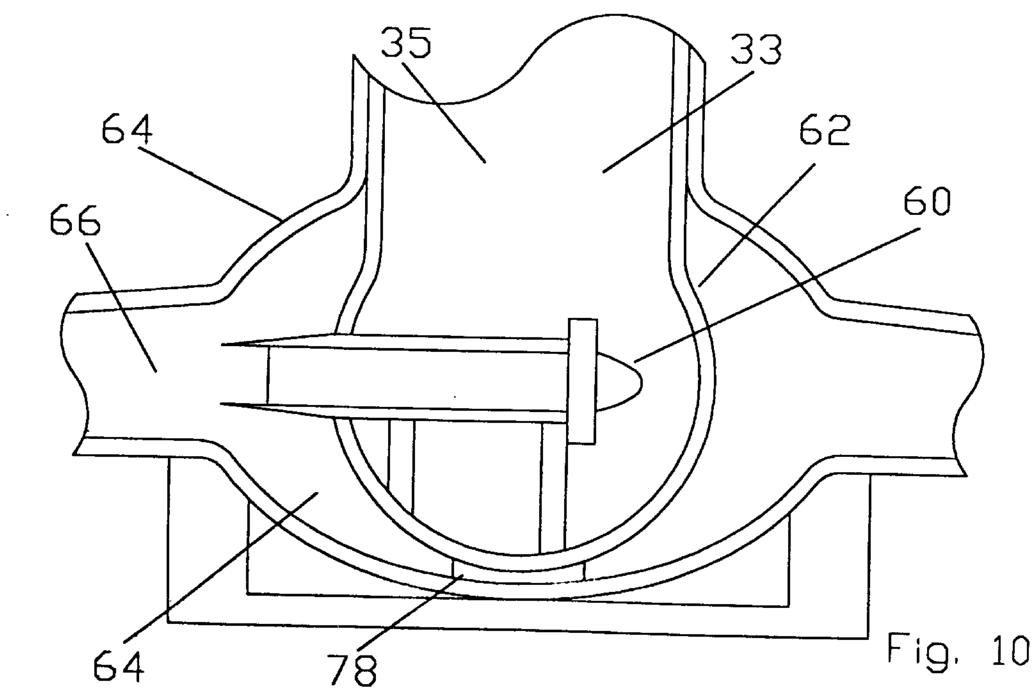
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Fig. 10

LEVITY AIRCRAFT DESIGN

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation in part submitted by the inventor Carl Wayne Whitesides serial number 08/054,017 filed Apr. 29, 1993 now abandoned.

Enclosed was the return receipt (photo-copy) that the PTO received the CPI Feb. 15, 1995 and because it was incomplete or deficient it was not officially filed but was "deposited". The PTO did not send me a letter stating the deficiency in the application or tell me to promptly remedy it.

The next communication I received from the PTO was "Notice of Abandonment" dated Feb. 15, 1995 of the original application 08/054,017 filed Apr. 29, 1993. This abandonment notice can avoid possible DP if this CIP is treated as a new application and is allowable.

I have the filing receipt for the CIP dated Aug. 25, 1994 by the PTO therewith my CIP application is officially "patent pending".

Statement as to Rights to invention made under Federally sponsored research and development: No agency funds or other considerations were involved in making or on the conception of the invention. That I made and conceived this invention on my own time using only my own facilities, equipment, materials, funds, information and services.

BACKGROUND OF THE INVENTION

Description of the Prior Art

Human advances in the art of flight is the product of machines. Machines are devices for accomplishing a task. They usually involve some activity of motion that is performed by working parts.

In general, aircraft gain motivate and fly using articles of manufacture. Different kinds of aircraft have different capabilities, and different user purposes require different capabilities. Certain capabilities exclude others, so that every design is a collection of compromises.

By official designation there are four categories of aircraft; lighter-than-air, gliders, rotor-craft, and airplanes. Aerodynamics and structural considerations for all these categories of aircraft, with the exception of lighter-than-air machines depend upon airfoil's for lift.

Lift required to raise and fly an aircraft is the product of aerodynamics that mathematically resolve the effects of lift, drag, thrust, and weight. By definition, lift forces act perpendicular to the relative wind. Drag forces act in parallel to the relative wind. Thrust forces usually act in parallel to the line of flight. Weight always acts in the direction of gravity. To simplify, for this exercise, an airfoil is any surface that is designed to obtain lift from the air through which it moves.

Ranges of speeds that must be considered is divided into four speed categories. These are denoted successfully as; subsonic, transonic, supersonic, and hypersonic. Each denote a speed range, within which aerodynamic design problems differ and require different resolutions. Aerodynamic designed airfoils for each denoted speed range are ingredients of both engineering and compromises, when fabricating machines for flight.

The earliest desires of man to fly in machines were thwarted by the lack of sufficient means of propulsion. Engine thrust to weight ratios have been developed, and the art of engine propulsion has now exceeded the art of airfoil design and usefulness. And we can now ask; do we need airfoils to fly?. As these powerful engines are developed and become available, many aircraft fabricated parts have to be changed and additional fabricated parts added, to aircraft, to compensate and overcome unsafe flight characteristics. There is increased air-friction and air-pressure, vortex anomaly and sound wave encounters, as airspeeds increase to mach I and beyond. Some of the aircraft fabricated parts that are used for lift and guidance are; propellers, rotor-blades, ailerons, rudders, elevators, wing-flaps, spoilers, trim-tabs. All these are attached and coupled by mechanical and electronic means to control their functions from within a control center.

Aircraft flight control systems generally operate and control aircraft around two axes; the vertical axis for horizontal control, and the horizontal axis for vertical control. Coordinated movements of these control surfaces are required to effect smooth flight maneuvers, through the air. To guide an aircraft, in flight, they are maneuvered into unusual attitudes. An unusual attitude is a change from the horizontal plane perpendicular to the earth's gravitational pull. These unusual attitude changes, increase stress upon the aircraft's structure the flight crews, as well as the passengers and effect the safety of the aircraft.

The gross weight of an aircraft is a means to determine the engine propulsion that is require for its motivity. As the gross weights of aircraft's increase engine propulsion increases are required to lift and fly these machines. At some point, in aircraft development, weight limits and propulsion requirements go beyond the economic feasibility to lift and fly these machines. This invention addresses these disadvantages and compromises, by introducing an alternative means for machine flight.

This invention is a powered-heavier-than-air machine. That can ascend and descend vertically under precision control without the need for airfoil designs, for lift or guidance. After the successful use of internal combustion engines in aircraft, another thirty years were required to solve the problems of controlling rotor-craft as a zero horizontal speed take-off and vertical landing machine. The rotor-craft uses airfoil designed rotor-blades to provide lift and guidance.

This invention addresses a multitude of means to change the way we fly, and introduces a machine for flight that will solve many current aviation problems as we move aviation into a more meaningful future. All flight movements such as vertical ascent and descent are continually being considered for development in many forms and shapes of machines for flight. The uses of airfoil flight seems to be the main direction for these developments, as opposed to the elimination of airfoils for lift and guidance. Aircraft using airfoils for lift and guidance have excessive weight problems to overcome, as well as the elimination of external structures attached to the main fuselages of these airplanes.

A means to lower an aircraft to ground level for ground support services would be an advantage. Some military aircraft require little terminal ground support means. However; flight crew personnel fly with the aircraft and are trained to provide ground and flight support needs. Commercial aircraft operators use motorized ground support machines, in conjunction with especially designed terminal settings, to fulfill these commercial transport needs.

The flight and ground functions of this invention, with automatic means to transport will reduce air terminal congestion and many other problems. It will move air commerce into additional locations, away from the present terminals, located near major cities. This flying machine will support the expanding world population and fulfill their needs, as opposed to the economic and social inconveniences, of fixing an old inadequate system of transport, by air.

This aircraft with automated means to transport eliminates the use of airfoil designs for lift and guidance. It replaces the need for airfoils, that are replaced with engine propulsion means within this new aircraft design.

Objects and Advantages

Accordingly, besides the objects and advantages of these different kinds of aircraft, they have different purposes that require different capabilities. Certain capabilities exclude others so that every design is a collection of compromises. Each aerodynamic airfoil design differs and requires different resolutions. To reduce these compromises and resolutions, several objects and advantages of the present invention are:

(a) to provide a structure for the spherical aircraft design by assembling the major design components;

(b) to provide a lift component to regulate the lifting force, within the lift component, to oppose the force of gravity,

(c) to provide a propulsion component with turbojet engines secured within an inner compression pod and an outer combustion pod;

(d) to provide a pressurized transport component that forms the bottom portion of the spherical aircraft that contains windows, doors, and a flight control center,

(e) to provide the means to reduce the gross weight of the aircraft by the elimination of airfoil components for lift and guidance;

(f) to provide an outer surface designed and configured to disrupt the air-flow over its surface during flight;

(g) to provide the means to fly, maintaining a horizontal attitude perpendicular to the earth's center of gravity while performing all patterns;

(h) to provide an internal guidance means to change headings, ascend and descend vertically and eliminate attitude changes that deviate from the horizontal attitude;

(I) to provide struts with a wheel-less means for landing, that retract for flight and extend for landing, these located on the underside of the spherical aircraft;

(j) to provide electro-hydraulic landing struts to raise, lower, and change the posture of the aircraft while in the landing configuration, on the ground.

(k) to provide a means to lower the aircraft to the ground level to on-load or off-load personnel and cargo, by the means of the electro-hydraulic struts;

(l) to provide the means to change the red and green navigation lights to indicate the direction of flight, the spherical aircraft has neither a built-in front nor back and can move in any compass-card direction by rotation of the internal engines thrust;

(m) to provide internal lift within the lift component plus propulsion from the propulsion component, these two means eliminate loss of altitude during wind shear encounters, that changes the air-flow over the airfoils and eliminates the lift factor;

(n) to provide a means to perform preventative and major maintenance, by detaching the transport component from the air-frame, thus gaining access into the interior where the major components are located.

Further objects and advantages of the lift component is to decrease and regulate the gross-weight of the aircraft, prior to lift-off for flight, then continue to control this factor during flight. As a result; an increase in the payload, an increase in speed and range of a flight, a reduction in engines size and propulsion requirements, and reduced fuel consumption. Still further objects and advantages will become apparent from the ensuing descriptions and drawings.

SUMMARY OF THE INVENTION

The elimination of airfoil designs for lift and guidance; a means to decrease and regulate the gross-weight, of the aircraft, prior to lift-off for a flight and maintained during flight; an outer skin design to disrupt the air-flow during flights; to maintain a horizontal attitude during all flight requirements; an internal flight control means that eliminates unusual flight attitudes; to hover over a fixed position; perform vertical ascents and descents; during flight to proceed, stop, and fly in any compass-card direction using internal means for control and guidance; a decrease in engine size and propulsion requirements; a decrease in fuel consumption; an increase in useful-load capacities; an increase in flight ranges and speed; a means to lower, raise, and level the airframe to adjust to a variety of operational requirements; a means to detach the transport component in order to gain access into its interior, for maintenance.

It being understood that the invention is not restricted to the details of the illustrated art work and described embodiments but it is susceptible to modification and adaptations.

The file of the patent contains at least one drawing executed in cold.

FIG. **1** shows a spherical levity aircraft design sitting on the ground with some visible embodiments and detail of the exterior.

FIG. **2** shows a top view of a spherical levity aircraft design with some exterior embodiments and detail.

FIG. **3** shows a bottom view of a spherical levity aircraft design with some external embodiments and detail.

FIG. **4** shows a side elevation view of the bottom half of a spherical levity aircraft design and the lower half of a propulsion component atop the transport component with exterior embodiments and detail.

FIG. **5** shows a top horizontal cut-away of a passenger area within a transport component depicting the area for a user design.

FIG. **6** shows a vertical cut-away of a spherical levity aircraft design showing components and their relative positions, as viewed from top to bottom; a lift component, a propulsion component containing engines, two pods, and a vertical air-duct, and horizontal thrust tubes, a passenger area and a cargo area.

FIG. **7** shows a horizontal cut-away of a propulsion component that is located in that portion of FIG. **6** with embodiments and detail.

FIG. **8** shows a side elevation of a spherical levity aircraft design that demonstrates oblique spherical triangular spars assembled to form the horizontal circumference spar with embodiments and detail.

FIG. **9** shows three cut-away expanded baffle views, detailing from left to right; a side view deflecting engine thrust, a side view closed to stop engine thrust quarter front view as positioned within the horizontal spar with embodiments and detail.

FIG. **10** shows an expanded vertical cut-away within the propulsion component showing engines as they are located within the inner and outer containment pods with embodiment and detail.

DETAILED DESCRIPTION

Definition of spherical, is having the form of a sphere or one of its segments. The levity aircraft design is spherical or one of its segments. It has no airfoils or external moving parts, configured to its exterior and used for lift or guidance. The landing struts extend and retract. The propulsion to fly and operate the spherical aircraft's turbojet engines. These are located internally and contained within an inner compression pod and an outer combustion pod, and these contained within the propulsion component.

There are three major design components with internal sub-components. The three major components are; a lift component, a propulsion component with engines and the means to extend the propulsion for flight, and a pressurized transport component that contains a flight control center. Some of the sub-components are; a master flight attitude gyro, auto-pilot, computers, instrument panels, flight controls, communication and engineer consoles. The spherical aircraft is designed and crafted with titanium and heat resistant metals. And heat resistant carbon composite materials or their equivalents.

The turbojet engines provide two sources of energy. Compressed bleed-air from the compression pod, and propulsion thrust from the combustion pod. The lift component gets hot bleed-air from the engine's high-pressure-tap, within the compression pod. The bleed-air is diluted with ambient air and ducted into the lift component where it is contained and controlled for temperature and pressure. The pressure is controlled with pressure-relief valves. The hot air, contained within the lift component, produces a vertical lifting force that opposes the force of gravity. The lift factor is controlled with a continuous mixture of heated and ambient air. A computer sensor controlling this factor, measures the differential air temperatures using the ambient air temperature and the heated air temperature within the lift component. The controlled lift factor, decreases the gross-weight of the aircraft prior to lift-off and during a flight. This weight reduction is new in the art to which this invention pertains.

A gross-weight reduction mollifies the size of the engines and the propulsion required to fly and operate the aircraft. In present airplanes, that use airfoils for lift, eighty percent of the engine's propulsion energy is expended to overcome lift, weight, and drag. Thus twenty percent remains for flight propulsion. In this invention, lift, weight, and drag are reduced to allow less energy to overcome these three factors and increase the amount of propulsion energy available for flight propulsion.

The propulsion engines, the vertical air-duct, the augmented power tubes, and the flight control baffles, are additions and extensions that are fabricated into the propulsion component. The propulsion component center, is located at the horizontal center of the spherical aircraft and below the vertical center for proper weight distribution. The vertical air-intake duct that is attached to the compressor pod, is the means of ambient air source needed to operate the engines. The vertical tube extends upward to the top of the horizontal center of the spherical aircraft. The compression pod and the vertical air-duct rotate through three hundred sixty degrees, clockwise or counter-clockwise. This rotation is controlled within the flight control center and provides the internal means for flight guidance. Rotating the engines, eliminates the need to turn the aircraft when changing directions. Thus . . . turn the engines for direction changes and not the aircraft. The spherical aircraft can proceed in any compass-card direction, without turning, as there is neither front nor rear configured into the design. The engines can be rotated to provide direct thrust for controlled flight. Aircraft flight configurations changes are not required to climb and descend during controlled flight. A flight configuration change is required for; vertical ascent, vertical descent, hovering, horizontal airframe rotation either clock-wise or counter clock-wise. Again, all maneuvers are executed, maintaining the horizontal flight attitude.

The power thrust tubes that duct the engine thrust are extended from the outer enclosure, called the combustion pod that is outside but not attached to the compression pod. The combustion pod enclosure contains and directs engines' turbojet thrust, that exits through the augmented power thrust tubes. These tubes extend to the mid-circumference spar of the spherical aircraft. Each tube has an augmented (after-burner). At the exit end of each power thrust tube is a thrust control baffle. These baffles are controlled by servo wheels, these move the baffle control gates with signals from the master gyro computer and the auto-pilot. These baffles check, deflect, and regulate the thrust that exits from the power thrust tubes. This controlled energy provides the motivity for operating and flying the spherical aircraft.

For flight in a cruise configuration, the air-intake-duct and the engines' compressor pod are rotated, horizontally, to provide optimum thrust and airspeed in the direction of flight. The control baffles maintain attitude, altitude, stabilization, and directional control of the aircraft during a flight. In the direct thrust configuration, the aircraft easily reaches speeds up to mach I and beyond.

The thrust, from the engines, through the power thrust tubes is controlled at the circumference of the aircraft by the control baffles. These baffles are made from titanium and operate individually to maintain the envelope of flight. The baffles can operate from fully closed to fully open. They each function from a fully closed position to sixty degrees each side of their horizontal center. By deflecting and regulating the engines' thrust, the baffles are controlled to stabilize the aircrafts' horizontal attitude, perpendicular to the earth's' gravitational pull. These baffles deflect the thrust and move the aircraft to ascend and descend at a controlled rate, correcting for wind-drift. Rotating the aircraft at a controlled rate clock-wise or counter clock-wise. Fly on course with the capability to climb or descend. Hover at an assigned fix while maintaining altitude and attitude. In all flight configurations the aircraft is controlled with mechanical and scientific exactness using the means defined within this invention.

The spherical aircraft is equipped with red and green navigation lights that denotes flight direction. A computer makes their adjustments according to the flight direction. The aircraft has strobe lights, on top and on the bottom as well as landing lights for night operations.

Wheel-less, break-less landing struts are located at the bottom of the aircraft, near the lower circumference. These struts are configured into the skeletal main frame spars and are not configured as part of the pressurized transport component. The operation of the landing struts are controlled from the flight control center. They can be used to level the airframe after landing if the ground is not level. The struts can be activated to lower the airframe to ground level for the convenience for loading or un-loading passengers or air cargo.

The pressurized transport component is the bottom portion of the spherical aircraft. It can be removed from the aircraft, when it is on the ground, to provide access into the interior of the aircraft. This allows access to conduct engine changes, maintenance, repairs, and safety inspections. The pressurized component has windows to provide visibility from within the passenger compartment. An airstair door and ramp provides a means for entering and exiting the transport component.

The spherical aircraft can be engineered and configured to meet specific weight-lifting and speed requirements, without changing the operational characteristics. This is accomplished by changing the horizontal circumference diameter, or the vertical diameter or both, and still be spherical within this inventors definition of spherical. Engines' propulsions can be increased or decreased to meet these specific configuration requirements.

The motivity of the spherical aircraft **20** is controlled from the flight control center **58–68** located within the pressurized component **56**. A flight control center **58–68** fully equipped to provide a flight crew with control pedestals **58–68** that operate the controls of the aircraft **20**. A flight control center **58–68** equipped with flight crew seating locations. The aircraft **20** does not require feet controls. A command pilots' pedestal **58–68** that has engines' **60** control levers and automatic-pilot controls **58–68** with manual over-rides to manage a cybernetic complex of electronic parts **58–68**. Flight instrument panels **58 68**, communication panels **58–68**, engineers' panel **58–68**, communication equipment control panel **58–68**, therein the engineers panel and pedestal **58–68** to monitor the functions of the entire spherical aircraft **20**.

A flight crew, in place, to perform the required procedures to prepare the aircraft **20** for flight. A flight computer **58–68** communicates the flight requirements in response to the flight crews' input. The items considered before flight is, the gross-weight of the aircraft, pre-measured by computerized scale system that weighs each item as it is ingress into the aircraft **20**. These total weights, the weights of the fuel and crew, are fed into the master flight computers **58–68**. This gross-weight, and the ambient air temperature **33–35** are the computer functions that provide a resultant temperature factor for the lift component **22**. The resultant temperature factor provides lift and reduces the gross-weight of the aircraft **20**, prior to a vertical lift-off flight.

When all flight parameters are met, including the vertical altitude and the direction of the flight, the flight crew starts the engines **60**. After receiving a clearance for lift-off, the aircraft **20** begins a vertical ascent.

The thrust **62–64** from the turbojet engines **60**, exits at the augmented power thrust tubes **60-66-30** outlets that are equally spaced at the outer circumference **38** of the spherical aircraft **20**. The control baffles **30** direct the thrust forces **82–84**, with signal inputs from the flight control center **58–68**. The baffles **30** interact to keep the aircraft **20** in a horizontal attitude while in flight. At full engine **60** thrust **82–84**, with augment thrust **66–67**, if needed, the control baffles **30** direct the thrust **82–84** downward **80**. The downward thrust **80** places a vertical pressure upon the aircraft **20** and the aircraft **20** is forced upward at a controlled rate of ascent. The aircraft's **20** flight movements are detected by the master gyro and compass that provides information to the flight control center **58–68**. These electronic signals are sent to the control baffles **30** to correct for wind-drift as the aircraft **20** ascends to altitude.

Upon reaching flight altitude the flight crew **58–68** changes the aircraft **20** to the enroute flight configuration. The aircraft **20** flight heading is signaled and the engine pod **62** and the vertical air intake tube **33–35** rotate to provide direct thrust **80** for the direction of flight. The control baffles **30** are continually activating to keep the aircraft **20** in the horizontal flight attitude as well as changing altitudes during the flight. Direction changes can be made by rotating the engines **60** to effect the desired course.

Upon reaching its destination, the aircraft **20** reduces its speed until it is hovering over a ground fix. At this point the aircraft **20** configuration is changed for descent. To descend, the force of gravity is mollified by the control baffles **30** and the engines **60**, to descend vertically at a controlled rate. The landing struts **28** are extended and the engines **60** thrust **80** is used to effect a soft landing. These types of approaches and landings can be made in weather that is zero visibility and or icing conditions. After landing firmly upon the ground, the thrust **80** from the engines **60** is directed upward to hold the aircraft firmly upon the ground. Then the aircraft **20** is leveled by the electro-hydraulic landing struts **28**. The engines **60** are shut down and the lift component **22** temperatures are returned to the normal ambient air temperature. At this point the aircraft **20** can be lowered to ground level by activating the electro-hydraulic landing struts **28**. The aircraft **20** is now ready for un-loading its passengers **44** and the cargo **52** and is ready for ground servicing. During the un-loading and loading the computer scales record the total weights taken off and brought aboard.

Color video monitoring devices **58–68** within the flight control center **58–68** monitor activities around the aircraft **20**. Adverse weather, especially related to wind shear is not an adverse condition for this type of aircraft **20**. The spherical aircraft **20** can depart and land vertically, thus ice and snow on runways is not a major problem. Poor visibility and fog conditions do not prevent flight operations and de-icing on the ground and iceing in flight is eliminated because of the heated lift component **22**. Navigation systems are now in place that can pin-point the aircraft's positioning in any location to effect safe, and cost effective commercial air transport.

The disrupted air-flow over the outside of the aircraft is a change in concept from airplanes that use airfoils for lift and are not needed for this aircraft. Thus there is a great reduction in the aircraft's' basic weight. Another advantage is that the exterior is designed to disrupt the airflow over its sureface **20**. This decreases the skin-friction and drag coefficients as the air passes around the aircraft **20** during a flight and has less, rough-air effects in flight, on the aircraft **20**. And like a golfball, can move through the air with better air penitration and directional properties.

The propulsion thruster tubes **66** and the flight control baffles **30-82-84-88** have control authority to keep the spherical aircraft **20** in horizontal flight, correcting for wind and weather conditions. To ascend and descend vertically with controlled precision. To change directions without effecting, an unusual attitude. Come to a full stop and hover maintaining its position and altitude and from a hovering position, change the configuration of the aircraft **20** then fly and reach speeds to mach I and beyond.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to the several drawings the art-work depicts a spherical levity aircraft design generally characterized by the reference number **20**. As shown in FIG. **1**, **2** and **3**,the aircraft is spherical, by definition. The entire exterior sureface **20** is configured to disrupt the ambient air-flow over its sureface, during flight. The disrupted air-flow reduces skin-friction and drag, and like a golf-ball has improved air penetration and directional properties.

FIG. **6**, **7**, **9** and **10**, are cut-away drawings that demonstrate the internal placement and locations of some of the components, relative to the stationary and moving parts. A lift component **22** is the top segment of the spherical aircraft **20** with an internal vertical air-duct **33–35** that extends upward and is attached to the compression pod **62** to the top of the lift component **22**. At the top is an air-intake opening **32–34** located at the top horizontal center of the lift component **22**. The propulsion component **60-62-64-66-30** are contained in the area above the well insulated ceiling **54** of the transport component **58** and the lower cargo compartment **46** just below the passenger area floor **50**. The propulsion component **60-62-64-66-30** is structurally independent and not made a part of the transport component **58**. A bearing fixture **78** is located below the compression pod **62** that contains the front part of the engines **60** and is a means to rotate the compression pod **62**, the engines **60**, and the vertica-air-duct **33–35** through three hundred sixty degrees clock-wise and counter-clockwise.

The ambient air inpute, to operate the engines **60** and the means of the ambient air supply to mix with the bleed-air from the engines **60–62** high-pressure-tap, is the ambient air ducted through the verticaal-air-duct **33–35**. Within the turbojet engines **60** fuel is mixed with the compressed air, and ignited to produce thrust that exits into the combustion pod **64** and thence into the augmented power thrust-tubes **66**. These thrust-tubes **66** extend to the outer circumference of the aircrafts **20** horizontal circumference spar **38**. Attached to the thrust tubes **66** and contained within the spar **38** are the control baffles **30**. The above means delivers the propulsion required to operate, fly, and control the spherical aircraft **20**. To expand upon the art-work in FIG. **9** it has been detailed to show the operation and the containment of a baffle **30**. In viewing the drawings, from left to right, the left drawing shows engine thrust **80** being deflected downward **82**. This downward deflection applies vertical pressure to raise that segment of the aircraft **20** during flight, the center drawing shows a baffle **30** with the baffle **30** deflector blades **82–84** closed to check the thrust, the right drawing shows a control baffle **30** configured and contained within the horizontal circumference spar **38** and pivot points **88** as the means to control and rotate each blade **82–84** within the baffle **30**.

FIG. **1**, **3**, **4**,**5** and **6**, represents art-work showing several views which make references to the transport component **24–58**, the bottom third of the aircraft **20–22**. Windows **26** viewed from the outside of the aircraft **20–22** are configured to contain the pressurized air within the transport component **24**. Windows **26** are located to conform the spherical shape of the aircraft **20** they are flush with the exterior **22**. Air-stair doors **44** open to become stairs and a ramp **44** from the passenger area **58**. The air-freight and baggage area **46** is located beneith the passenger area **58** that close with flush access doors **52**. The entire transport component **24-58-46** is a pressurized component. The transport component **24** is detachable where as to gain access into the interior of the aircraft for internal maintenance procedures on the propulsion components **60-62-64-66-30** and the lift component **22**. The electro-hydraulic landing struts **28** are controlled to lengthen or shorten. By this means the aircraft **20** can be lowered to the ground level or raised. The air-stair door and ramp **44** can be used for ingress or egress without ground support, or during an emergency. The large passenger area **58** can be user designed. A flight control center **68** can be placed into an area susceptible to its operation. The landing struts **28** can be activated to level the aircraft **20**, after landing. The struts **28** can either lower or raise the aircraft **20** when it is firmly on the ground. The landing struts **28** are not made a part of the transport component **24–58** and are configured into the spherical triangular spars **38–70**. The landing struts **28** retract into an enclosure covered for flight, and extend for landing.

FIG. **1**, **2**, **3** and **4**, shows the placement of strobe lights **36** at the exterior top of the lift component **22**. Red or green navigation lights **40** are shown each sixty degrees around the mid-horizontal-circumference spar **38**. These lights **40** are coordinated to show the direction of flight during night operations, as a safety item. The spherical aircraft **20** has neither a fabricated front nor rear, and can fly in any compass-card direction using the internal guidance system as the means of direction change. Placed alternately with the navigation lights **40** around the circumference spar **38**, are the locations for the baffle-box-frames**72**. Landing lights and other required lighting can be placed on the bottom portion of the spherical aircraft **20**.

FIG. **6**, **7** and **8**, shows oblique-spherical-triangular spars **70**, configured to form the mid-horizontal-circumference spar **38**, and the baffle-box-frames **72**. Spar **38** with the baffle-box-openings **72** indicate the locations of the flight control baffles **30**. These are attached to the augmented-power-thrust tubes **66**. The art-work shows horizontal spars **76** with other horizontal floor **50** area, and horizontal ceiling **54** members. Other horizontal members throughout, are entities that add strength and stability to the frame **70** of the aircraft **20**. With regard to the transport component, it can be configured for many purposes and accordingly, the scope of the invention should be determined, not by the embodiment illustrated, but by the appended claims and their legal equivalents.

The spherical aircraft herein describes a multi-purpose machine for flight with automated means to means to transport. Although its description is simplistic, this should not be construed as limitations of the scope of the invention but as an exemplification of the preferred embodiments. It is recognized, however, that departures may be made therefrom within the scope of the invention and that various modifications will occur with persons skilled in the arts.

What is claimed is:

1. A spherical aircraft including:

a spherical fuselage, the fuselage including an outer surface, said outer surface having an outer skin pattern means that disrupts the airflow over the outer surface, the fuselage including an upper section, a center section, and a lower section;

a propulsion system including; turbojet engines; an air intake duct; a compression pod; and a combustion pod, wherein hot air from the compression pod provides lift, and propulsion thrust from the combustion pod provides thrust for the aircraft;

directional control means including a flight control center with extensions from a flight computer, stabilization gyros that continually balance the aircraft; and control baffles that are located at the periphery of the center section of the aircraft, said control baffles receive signals, through the flight control center, from the gyros for attitude, altitude, and directional control;

and landing struts with means to level, raise, and lower, the fuselage when extended and in a landed configuration.

2. The spherical aircraft of claim **1** wherein the landing struts are retractable.

3. The spherical aircraft of claim **2** wherein the landing struts include electro-hydraulic telescoping struts.

4. The spherical aircraft of claim **1** wherein hot air from the compression pod is channeled through pressurization units into a pressurized section of the aircraft.

5. The spherical aircraft of claim **4** wherein air in the pressurized section is derived from a combination of an oxygen system, an isobaric control, and a differential control, said pressurized section receives high temperature compressed air from the engine high-pressure-tap and ambient air from the air-duct.

6. The spherical aircraft of claim **1** wherein the baffles are made from titanium.

7. The spherical aircraft of claim **1** wherein the baffles receive thrust from tubes located within the center section of the aircraft that are linked with the thrust from the engines wherein each tube is augmented for additional thrust.

8. The spherical aircraft of claim **1** wherein the engines are located in the center of the center section of the aircraft, and are rotatable for directional control while the airframe maintains an attitude of horizontal.

9. The spherical aircraft of claim **8** wherein the baffles are made from titanium.

10. The spherical aircraft of claim **8** wherein the baffles receive thrust from tubes located within the center section of the aircraft that are linked with the thrust from the engines and augmented for additional thrust.

11. The spherical aircraft of claim **1** wherein a fuselage includes a pressurized passenger compartment located between the lower and the center section of the aircraft.

12. The spherical aircraft of claim **11** wherein air in the pressurized section is a combination of an oxygen system, an isobaric control, and a differential control, with high temperature compressed air from the engine high-pressure-tap, and ambient air from the air-duct.

13. A spherical aircraft including:

a spherical fuselage, the fuselage including an outer surface; an upper section; a center section; and a lower section;

a propulsion system including: turbojet engines, an air intake duct; a compression pod and a combustion pod; wherein hot air from the compression pod provides lift, and propulsion thrust from the combustion pod provides thrust for the aircraft;

directional control means including a flight control center with extensions from a flight computer, stabilization gyros that continually balance the aircraft, said control baffles receive signals, through the flight control center, from said gyros for attitude, altitude, and directional control;

and landing struts with means to level, raise, and lower, the fuselage, when extended and in a landed configuration.

14. The spherical aircraft of claim **13** wherein the landing struts means are electro-hydraulic telescoping struts.

* * * * *

US005971321A

United States Patent [19]

Libengood

[11] **Patent Number:** **5,971,321**

[45] **Date of Patent:** **Oct. 26, 1999**

[54] **BODY LIFT AIRPLANE ASSEMBLY**

[76] Inventor: **Ronald L. Libengood**, 73 Doris Dr., Security, Colo. 80911

[21] Appl. No.: **08/971,301**

[22] Filed: **Nov. 17, 1997**

[51] **Int. Cl.**[6] **B64C 1/00**

[52] **U.S. Cl.** .... **244/36**; 244/23 R; 244/23 B; 244/23 C

[58] **Field of Search** .... 244/23 B, 23 C, 244/23 R, 36, 45 A

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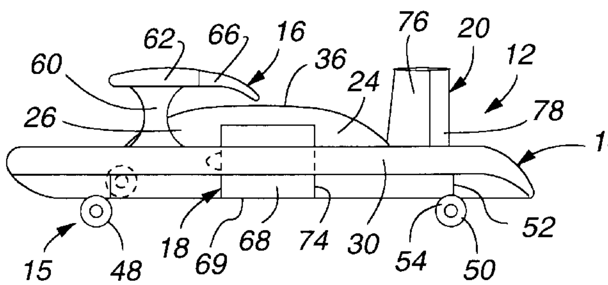
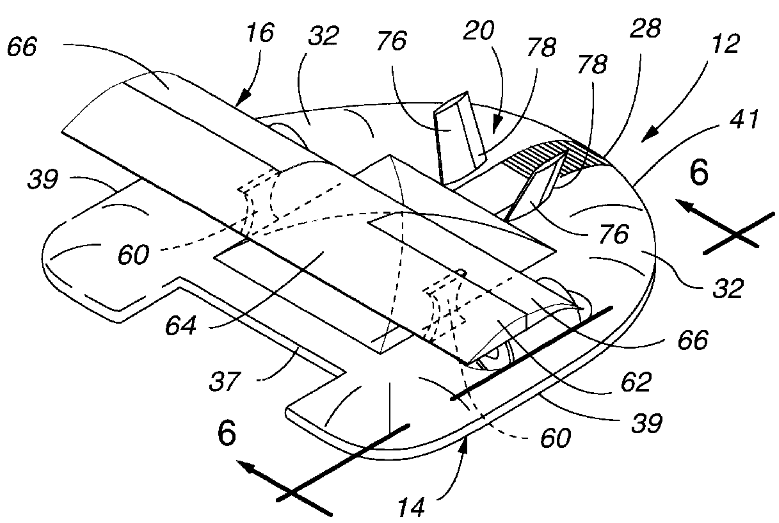
Primary Examiner—Charles T. Jordan
Assistant Examiner—Charles R. Ducker, Jr.
Attorney, Agent, or Firm—Phillip A. Rein

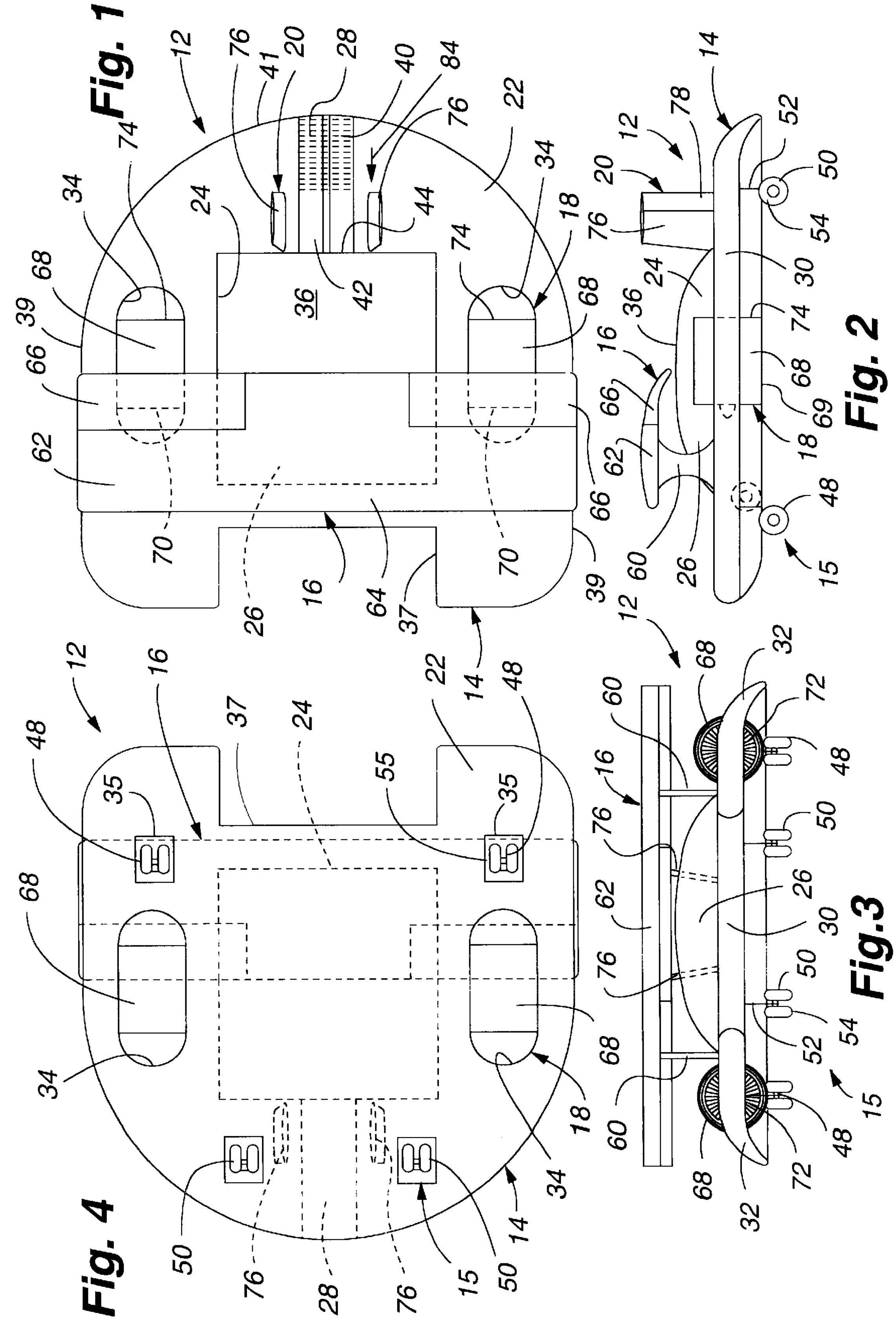
[57] **ABSTRACT**

A body lift airplane assembly including 1) a main air lift body assembly of substantial length and width; 2) a landing gear/wheel assembly retractably connected to the main air lift body assembly; 3) a fixed wing assembly secured to and extended above the main air lift body assembly and having a fixed wing member of a length equal to the width of the main air lift body assembly; 4) an engine propulsion power assembly having a pair of spaced jet engine pod assemblies mounted within engine cut-out portions in outer edges of the main air lift body assembly; and 5) a fin and rudder assembly of a V-shape connected to a central rear portion of the main air lift body assembly. The main air lift body assembly includes a main body assembly having outer peripheral side and rear edges formed with downwardly extended arcuate air lift portions to provide air lift characteristics to the overall main air lift body assembly. The main air lift body assembly is provided with a passenger compartment section and a pilot control section and access thereto through an access escalator assembly and not dependent on external airport facility structures for loading and unloading. The jet engine pod assemblies each are operable to receive air flow from both above and below the main body assembly of the main air lift body assembly to increase the fuel combustion efficiency.

8 Claims, 2 Drawing Sheets



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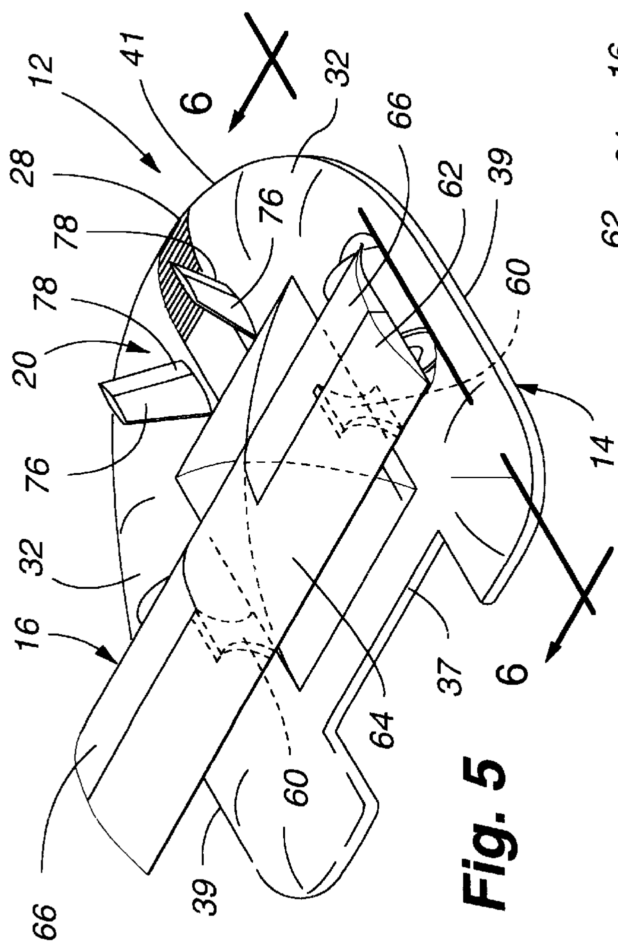
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Fig. 5

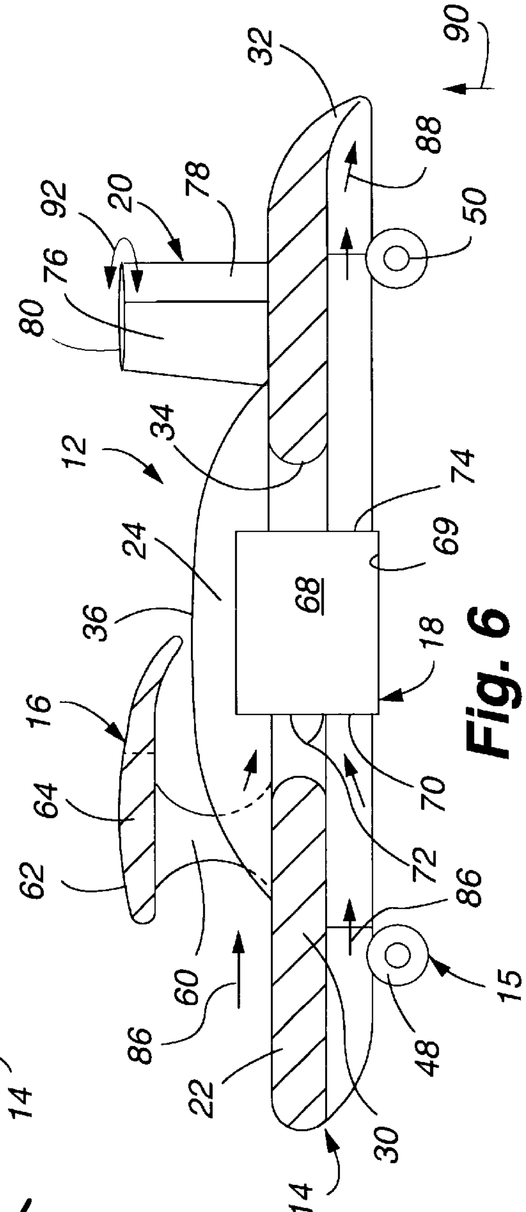
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Fig. 6

BODY LIFT AIRPLANE ASSEMBLY

PRIOR ART

A patent search was not conducted on this invention.

PREFERRED EMBODIMENT OF THE INVENTION

In one preferred embodiment of this invention, a body lift airplane assembly is provided including modernistic design and efficient flight characteristics and having a main engine passenger body assembly operable similar to a conventional airplane wing assembly to provide increased lift forces to achieve an efficient method of flight.

The body lift airplane assembly includes 1) a main air lift body assembly; 2) a landing gear/wheel assembly connected to the main air lift body assembly for normal flight landing operations; 3) a fixed wing assembly connected to and placed above the main air lift body assembly; 4) an engine propulsion power assembly connected to the main air lift body assembly; and 5) a fin and rudder assembly connected to a rear portion of the main air lift body assembly to provide controlled flight as will be explained.

The main air lift body assembly includes 1) a main body assembly; 2) a passenger compartment section; 3) a pilot control section connected to the passenger compartment section; and 4) an access escalator assembly providing means for entrance and exit into the main body assembly.

In a top plan view, the main body assembly is of generally C-shape having a support section provided with an arcuate air lift portion, engine cut-out portions, wheel receiver areas, and a forward cut-out portion.

The arcuate air lift portion is of an arcuate, downwardly extended shape from a main support body and is operable similar to a conventional airplane wing assembly to provide air lift features similar to an airfoil structure. The arcuate air lift portion extends downwardly from spaced side walls and a semi-circular rear wall of the main body assembly.

The passenger compartment section is a large auditorium dome structure including rows of seats for a plurality of airline passengers, such as 150 passenger members, and having a domed cover member. The domed cover member is constructed of an opaque type material allowing limited sunlight therethrough and will be light colored at night similar to material used in sunglasses which turn from a clear to a dark color depending on the amount of light present.

The pilot control section is mounted in an area forward of the passenger compartment section and having an airplane control and instrument panel therein in close proximity to an airplane pilot, a co-pilot, and a flight engineer personnel therein.

The airplane control and instrument panel is used in a conventional manner by the airline personnel in order to take off, control, and land the body lift airplane assembly during flight conditions in a conventional manner.

The access escalator assembly is mounted on a rear upper portion of the main body assembly and provided with 1) a moving step assembly similar to a normal escalator folding step means; 2) an escalator cover assembly which is selectively slidable to reveal the moving step assembly during passenger loading of the airplane assembly and enclose the moving step assembly during flight conditions; and 3) an entrance door member mounted at a rear portion of the passenger compartment section to selectively allow entrance and departure from the moving step assembly.

The land gear/wheel assembly includes 1) a pair of forward gear wheel assemblies; and 2) a pair of rearward gear wheel assemblies. Each of the forward and rearward gear wheel assemblies are provided with 1) landing gear struts having one end pivotally connected within a bottom surface of the main body assembly of the main air lift body assembly; and 2) a landing wheel assembly connected to respective outer ends of a landing gear strut. Each of the forward and rearward gear assemblies are enclosed by respective enclosure panels when in retracted positions.

Each landing gear/wheel assembly is operable to be extended during a landing operation and retracting after the main lift airplane assembly is airborne in a conventional manner. Operation of the landing gear/wheel assemblies is controlled by the airline personnel, namely the pilot and/or co-pilot, in a conventional manner through use of the airplane control and instrument panel and respective take-off and landing control members thereon.

The fixed wing assembly includes a pair of wing support struts having lower ends thereof secured to the main body assembly and having upper ends thereof secured to a fixed wing member.

The fixed wing member includes an elongated main wing body having a longitudinal axis extended and equal in length to the width of the support section of the main body assembly of the main air lift body assembly and having connected thereto a pair of spaced pivotal flap members.

The pivotal flap members are pivotal about respective, aligned pivot axes parallel with the longitudinal axis of the main wing body and operable to be conjointly raised and/or lowered. The alternately pivotal movement between these upper and lower positions during a flight control process results in movement of the entire body lift airplane assembly for right and left turning and up and down flight operations in a conventional manner.

The engine propulsion power assembly includes a pair of spaced jet engine pod assemblies, each selectively mountable within respective ones of the engine cut-out portions of the support section of the main body assembly. Each jet engine pod assembly is provided with a main engine housing having 1) an inlet air section; 2) rotatable inlet fan members; and 3) an engine discharge section. Inlet combustion air into the inlet air section is provided from air flow over and under adjacent portions of the support section of the main body assembly for increased fuel efficiency as will be explained.

Each jet engine pod assembly is operable in a conventional manner to receive inlet air into the inlet air section which is mixed with combustible jet fuel to rotate the inlet fan members and provide jet propulsion exhaust through the engine discharge section and being operable in a substantially conventional manner. However, a new and novel provision for inlet air into the inlet air section is provided as will be explained.

The fin and rudder assembly is provided with a pair of inclined fin members which, together, form a generally V-shape therebetween. Each inclined fin member is provided with a pivotal rudder member and an upper top section.

Each pivotal rudder member is selectively pivoted about a respective inclined axis in order to control turning movement of the body lift airplane assembly during flight in a known conventional manner.

The top section extends upwardly to a height substantially equal to a height of an upper surface of the main wing body of the fixed wing member of the fixed wing assembly. This provides maximum control during movement of the pivotal rudder members during an airplane control operation initiated through the airplane control and instrument panel being controlled by the airplane flight personnel, namely the airplane pilot and/or co-pilot.

OBJECTS OF THE INVENTION

One object of this invention is to provide a body lift airplane assembly having a main air lift body assembly of a substantial length and width being approximately equal to each other and being of an oval shape having an outer peripheral arcuate air lift portion so that the main air lift body assembly acts as an airfoil in conjunction with a fixed wing assembly to provide new, novel, and unique lift features for increased flight stability and fuel efficiency.

Another object of this invention is to provide a body lift airplane assembly including 1) a main air lift body assembly; 2) a fixed wing assembly secured to and extended above the main air lift body assembly; and 3) an engine propulsion power assembly mounted within the main air lift body assembly and a longitudinal length of a fixed wing member of the fixed wing assembly is substantially equal to a width of the main air lift body assembly and increased air flow about the main air lift body assembly operates to provide inlet air to the engine propulsion power assembly and substantial lift features acting as an airfoil for a more efficient flight operation.

One other object of this invention is to provide a body lift airplane assembly including a main air lift body assembly with 1) a support section provided with a peripheral arcuate air lift portion; 2) a passenger compartment section having a domed cover and having passenger seats therein to carry 150 passengers or more; and 3) a pilot control section to be occupied by airline personnel for normal flight control operations.

A further object of this invention is to provide a body lift airplane assembly including a main air lift body member with a large passenger compartment section to be accessed through an access escalator assembly having a moving step assembly which provides independent means of loading and unloading airline personnel and passenger members thereto, thus being completely self-supporting when landing on an airfield runway.

One further object of this invention is to provide a body lift airplane assembly including 1) a main air lift body assembly; 2) a landing gear/wheel assembly connected to the main air lift body assembly; 3) a fixed wing assembly having a fixed wing member connected to the main air lift body assembly and extended upwardly therefrom; 4) an engine propulsion power assembly connected to the main air lift body assembly; and 5) a fin and rudder assembly connected to a central rear portion of the main air lift body assembly and having inclined fin members angled outwardly relative to each other and the body lift airplane assembly is of generally oval shape of a width and length substantially equal to a longitudinal axis of the fixed wing member to provide for efficient flight operations providing a maximum amount of lift from both the main air lift body assembly and the fixed wing member.

Another object of this invention is to provide a body lift airplane assembly including a main body assembly operable to provide inlet air flow over upper and lower surfaces into engine propulsion power assemblies to provide efficient operation of jet fuel propulsion engines used thereon.

Still, one other object of this invention is to provide a body lift airplane assembly which is economical to manufacture; operable to obtain maximum air lift characteristics through use of a main body assembly and a fixed wing assembly; easily controlled by airline personnel during flight operations; efficient in flight and saves fuel; and substantially maintenance free.

Various other objects, advantages, and features of the invention will become apparent to those skilled in the art from the following discussion, taken in conjunction with the accompanying drawings, in which:

FIGURES OF THE INVENTION

FIG. **1** is a top plan view of the body lift airplane assembly of this invention;

FIG. **2** is a side elevational view thereof;

FIG. **3** is a front elevational view thereof;

FIG. **4** is a bottom plan view thereof;

FIG. **5** is a perspective view thereof; and

FIG. **6** is an enlarged sectional view taken along line **6—6** in FIG. **5**.

The following is a discussion and description of preferred specific embodiments of the body lift airplane assembly of this invention, such being made with reference to the drawings, whereupon the same reference numerals are used to indicate the same or similar parts and/or structure. It is to be understood that such discussion and description is not to unduly limit the scope of the invention.

DESCRIPTION OF THE INVENTION

On referring to the drawings in detail, and in particular to FIG. **1**, a body lift airplane assembly of this invention, indicated generally at **12**, is of a modernistic design utilizing new air lift features on a main body assembly **22** to provide more efficient flight characteristics with increased speeds and fuel efficiency. The main body assembly **22** resembles a flying disc with a wing assembly and a rudder assembly connected thereto to achieve controlled flight as will be explained.

The body lift airplane assembly **12** includes 1) a main air lift body assembly **14**; 2) a landing gear/wheel assembly **15** pivotally and retractably connected to the main air lift body assembly **14**; 3) a fixed wing assembly **16** secured to and positioned upwardly in an elevational position above the main air lift body assembly **14**; 4) an engine propulsion power assembly **18** having a pair of jet engine pod assemblies **68** connected to the main air lift body assembly **14**; and 5) a fin and rudder assembly **20** connected to a rear portion of the main air lift body assembly **14** to provide flight air control features.

The main air lift body assembly **14** includes 1) the main body assembly **22** of a generally oval C-shape; 2) a passenger compartment section **24** mounted in a central portion of the main body assembly **22**; 3) a pilot control section **26** mounted adjacent and forwardly of the passenger compartment section **24**, both of which are mounted within the main body assembly **22**; and 4) an access escalator assembly **28** secured to a rear portion of the passenger compartment section **24** to selectively allow passenger members and flight personnel to enter and exit the passenger compartment section **24**.

The main body assembly **22** includes a support section **30** having 1) an arcuate air lift portion **32** about an outer peripheral edge thereof; 2) a pair of spaced engine cut-out portions **34**; 3) a plurality of spaced wheel receiver areas **35**; and a forward cut-out portion **37**.

The arcuate air lift portion **32** is of a downwardly curved shape as best noted in FIGS. **2** and **3** extended about the outer periphery of the support section **30** except for forward edges thereof More particularly, the arcuate air lift portion **32** extends about spaced parallel side walls **39** and a semi-circular curved rear wall **41**.

The passenger compartment section **24** is of a large auditorium size with numerous rows of passenger seat members and covered by a domed cover member **36**. The passenger seat members have aisles therebetween and are provided with television and video movie features to provide for the normal comfort and entertainment of the passenger members as found on modern airline airplanes.

The domed cover member **36** is constructed of a known material which darkens during sunlight conditions and become clear under darkened conditions for the enjoyment and comfort of the passenger members within the support section **30** of the main body assembly **22**.

The pilot control section **26** is of a conventional nature having an enclosed, private area therein for the airplane control personnel, namely the pilot, co-pilot, and engineer, and having an airplane control and instrument panel (not shown).

As best shown in FIG. **1**, the access escalator assembly **28** includes 1) a moving step assembly **40** having exposed and collapsible step members of a conventional nature; 2) an escalator cover assembly **42** to selectively reveal and enclose the moving step assembly **40**; and 3) an entrance door member **44** positioned at an upper end of the moving step assembly **40** to provide ingress and egress into the passenger compartment section **24**.

The moving step assembly **40** is operable to be reciprocally mounted about end support members with endless step members to be exposed when moving upwardly into the passenger compartment section **24** for loading thereof or moving in an opposite direction to convey airline personnel and passenger members embarking from the passenger compartment section **24**.

The escalator cover assembly **42** is operable to provide an enclosed air sealed cover to the moving step assembly **40** during flight conditions.

The access escalator assembly **28** provides a new and novel feature to the invention as not requiring a passenger disembarkment step assembly necessary for loading and unloading passenger members from the main air lift body assembly **14**. Therefore, the body lift airplane assembly **12** can be utilized in any airstrip landing conditions as the personnel thereon can readily load and disembark therefrom without requiring external airport equipment to do so.

Further, the access elevator assembly **28** may be provided with an extension feature so that the moving step assembly **40** can be selectively extended downwardly from a lower surface of the main body assembly **22** to contact a ground support surface for ease of loading and unloading personnel thereon.

The landing gear/wheel assembly **15** is of a conventional nature having a pair of forward gear wheel assemblies **48** and a pair of rearward gear wheel assemblies **50**.

Each forward and rearward gear wheel assembly **48, 50** is substantially identical, each having a pair of spaced landing gear struts **52** pivotally connected at an upper end to the main body assembly **22** and connected at respective outer ends to a landing wheel assembly **54**.

Each forward and rearward gear wheel assembly **48, 50** is provided with an adjacent enclosure panel **55** so as to enclose respective ones thereof when in the fully retracted position folded within outer confines of the wheel receiver areas **35** of the support section **30** of the main body assembly **22** of the main air lift body assembly **14**.

Each landing wheel assembly **54** is operable having pairs of wheel members thereon to provide necessary support when landing on a ground support surface on an airport runway.

Each of the forward gear wheel assemblies **48** are conjointly pivotal about a respective vertical axis during a landing procedure operation to control turning movement of the entire body lift airplane assembly **12** in a known conventional manner.

The fixed wing assembly **16** includes a pair of spaced wing support struts **60** having lower ends thereof secured to the main body assembly **22** through an upper surface thereof and upper ends of the respective wing support struts **60** are secured to spaced portions of a fixed wing member **62**.

The fixed wing member **62** is provided with an elongated main wing body **64** having a pair of spaced pivotal flap members **66** connected thereto. The pivotal flap members **66** are each individually pivotal about an aligned axis extended parallel to a longitudinal axis of the fixed wing member **62**.

As clearly shown in FIGS. **1, 3**, and **4**, a length of the fixed wing member **62** is substantially equal or slightly greater than a width of the main body assembly **22** of the main air lift body assembly **14**. Therefore, both the main body assembly **22** and the fixed wing member **62** will provide beneficial air lift characteristics (similar to an airfoil) and control features plus provide inlet combustion air flow features to the engine propulsion power assembly **18** as will be explained.

The engine propulsion power assembly **18** includes a pair of spaced jet engine pod assemblies **68** with each one thereof respectively mounted in one of the engine cut-out portions **34** in the main body assembly **22** of the main air lift body assembly **14**.

Each jet engine pod assembly **68** includes 1) an engine housing **69** having an air inlet section **70**; 2) inlet fan members **72** mounted within the engine housing **69**; and 3) an engine discharge section **74** through which exhaust gases and propulsion means are directed therefrom.

Each jet engine pod assembly **68** operates in a conventionally known manner to receive inlet air which is mixed with combustible jet fuel therein which is ignited and provides the power means for the entire body lift airplane assembly **12** in a known manner.

The use of the pair of spaced jet engine pod assemblies **60** which are balanced within the main air lift body assembly **14** to provides for controlled and fuel efficient jet propulsion means.

The fin and rudder assembly **20** includes a pair of inclined fin members **76** which conjointly are of a generally V-shape with an apex thereof below an upper surface of the main body assembly **22** as noted in FIG. **5**. Each inclined fin member **76** has a pivotal rudder member **78** and a top section **80**.

The pivotal rudder members **78** are each pivotal about a respective upwardly inclined axis to act on air passing thereby to provide for a turning control function as normally found on conventional tail members in prior art aircraft structures.

The top section **80** has an upper edge height substantially equal to that of an upper surface of the fixed wing member **62** to provide maximum control features through the pivotal rudder members **78**.

USE AND OPERATION OF THE INVENTION

In the use and operation of the body lift airplane assembly **12** of this invention, we will first assume a parked or landed condition as noted in FIGS. **2** and **3** and positioned at an airport terminal gate area for the purpose of loading passenger members and flight personnel thereon in a first step in a flight operation procedure.

First, the access escalator assembly **28** is operable so as to reciprocate the moving step assembly **40** when the escalator cover assembly **42** is retracted. A plurality of top steps are exposed and movable upwardly as noted by an arrow **84** shown in FIG. **1**. The moving top steps allow passenger members to be transported and conveyed upwardly on the reciprocating moving step assembly **40** through the entrance door member **44** so as to gain access and subsequent seating in the passenger compartment section **24**.

Numerous of the passenger members, such as a number of 150 or greater, are allowed access into the passenger compartment section **24** to be serviced by airline flight attendants to receive their assigned seat member in preparation for eventual departure from the airport terminal.

Concurrently, additional flight control personnel, namely an airline pilot, co-pilot, and engineer, are allowed access on the moving step assembly **40** and the entrance door member **44** and operable to position themselves within the pilot control section **26** for access to the airplane control and instrument panel and other flight control elements therein. The flight control personnel prepare for starting and energization of the engine propulsion power assembly **18** for planned departure from the gate area of the airline terminal.

After the airline flight personnel and passenger members have been loaded into the passenger compartment section **24** and the pilot control section **26**, authorization from a control tower is normally given whereupon the body lift airplane assembly **12** is allowed to leave the air terminal gate area and proceed outwardly to a terminal runway for a controlled flight departure therefrom.

The body lift airplane assembly **12** is thereupon allowed to enter the runway area under control tower supervision and energize the engine propulsion power assembly **18** to travel down the runway and obtain an airborne flight condition.

During the air flight conditions, it is noted that air will flow over upper and lower surfaces of the fixed wing member **62** to provide known flight lift characteristics as in airfoil due to curved portions of the fixed wing member **62**. Direction and elevation of the body lift airplane assembly **12** is controlled by movement of the pivotal flap members **66** in a known flight procedure to provide controlled operations about horizontal and vertical axes in a known manner.

At this time it is noted that air flow, similar to that over upper and lower surfaces of the fixed wing member **62**, will occur over upper and lower portions of the support section **30** of the main body assembly **22** in front of respective ones of the jet engine pod assemblies **68** as noted by arrows **86** in FIG. **6**.

The air flow shown by the arrows **86** provide a vacuum air condition to provide positive air flow through the inlet fan members **72** and the inlet air section **70** of the respective jet engine pod assemblies **68** to achieve a more efficient mixture of air and jet fuel therein to increase combustion and fuel efficiency.

Further, the combination of burned jet fuel and exhaust gases emitting from the engine discharge section **74** as noted by the arrows **88**, act on rearward portions of the arcuate air lift portion **32** of the main body assembly **22** which then increases an upward lift force as noted by arrow **90** in FIG. **6**.

The existence of additional upward forces against the arcuate air lift portion **32** on the curved rear wall **41** operates

to increase lift efficiency and allow the entire main body assembly **22** to act similar to an airplane wing assembly to provide for additional efficiency and fuel saving overall flight characteristics of the body lift airplane assembly **12** of this invention.

Also, during flight, the air flow rearwardly over the upper surface of the main body assembly **22** is engageable with the pivotal rudder members **78** of the fin and rudder assembly **20** so as to efficiently and effectively control turning movement of the overall body lift airplane assembly **12**. This pivotal movement of the respective pivotal rudder members **78** is indicated by an arcuate arrow **92** in FIG. **6**.

It is noted that the air flow between the fixed wing assembly **16** and an upper surface of the main body assembly **22** and the domed cover member **36** moves rearwardly to be acted upon by the respective pivotal rudder members **78** to add more efficiency in flight control operations.

On obtaining air flight characteristics at leaving the runway, it is obvious that the flight control personnel would activate the necessary control levers within the airplane control and instrument panel to cause the respective landing wheel assemblies **54** on the forward and rearward gear wheel assemblies **48**, **50** to be pulled upwardly into a retracted position within the wheel receiver areas **35** in the main body assembly **22** to be covered by the wheel enclosure panels **55** in a conventional manner.

On reaching a flight destination, it is obvious that the flight control personnel would activate the landing gear/wheel assembly **15** to position the respective landing wheel assemblies **54** in the extended position as noted in FIG. **6** in preparation for landing on a runway at a destination airport terminal during a flight descent in a conventional manner.

On landing on the runway at the airport terminal, it is obvious that the flight control personnel would activate various controls in the airplane control and instrument panel to cause pivotal movement about respective vertical axes of the landing wheel assembly **54** of the forward gear wheel assembly **48** so as to cause turning movement of the body lift airplane assembly **12** on the runway to direct the same to the desired terminal at the airport terminal. The engine propulsion power assembly **18** would de-energize on stopping at the terminal gate area.

The flight attendant personnel would then activate the escalator cover assembly **42** to an opened position and then open the entrance door member **44**. A flight attendant would then energize the moving step assembly **40** so that the passenger members and airline personnel can disembark and move through a gate into the airline terminal which completes the overall flight operation and method of this invention.

The body lift airplane assembly provides a main air lift body assembly being of a substantial width and length with the width equal to the length of the fixed wing members. This provides new and novel air flow characteristics above and below the main air lift body assembly to provide 1) superior air lift characteristics normally not found in an airplane body which normally relies on air lift from a fixed wing assembly; and 2) provides new and novel air flow into the engine propulsion power assembly to achieve superior power efficiency and fuel saving characteristics.

The body lift airplane assembly provides a new and novel main air lift body assembly and control features which is economical to manufacture; operable to support a plurality of passenger members in a comfortable domed passenger compartment section; easy to fly and control by flight control personnel; efficient in fuel and flight operations resulting in increased speed and efficiency with fuel savings; and substantially maintenance free.

While the invention has been described in conjunction with preferred specific embodiments thereof, it will be understood that this description is intended to illustrate and not to limit the scope of the invention, which is defined by the following claims:

I claim:

1. A body lift airplane assembly, comprising:

a) a main air lift body assembly being of a disc shape including a pilot control section and a passenger compartment section;

b) a fixed wing assembly secured to said main air lift body assembly and having a fixed wing member with a longitudinal axis extended transversely of a body longitudinal axis of said main air lift body assembly;

c) said fixed wing member having a length substantially equal to a width of said main air lift body assembly; and

d) an engine propulsion power assembly having a pair of spaced jet engine pod assemblies mounted within cut-outs in said main air lift body assembly and operable to receive air flow inlet both from above and below spaced surfaces of said main air lift body assembly to use aerodynamic airfoil forces and air flow over a curved surface to achieve efficiency and fuel saving operation of said engine propulsion power assembly,

whereby said main air lift body assembly operates as an airfoil lift element in conjunction with said fixed wing member to increase flight and fuel efficiency.

2. A body lift airplane assembly comprising:

a) a main air lift body assembly being of a disc shape including a pilot control section and a passenger compartment section;

b) a fixed wing assembly secured to said main air lift body assembly and having a fixed wing member with a longitudinal axis extended transversely of a body longitudinal axis of said main air lift body assembly;

c) said fixed wing member having a length substantially equal to a width of said main air lift body assembly;

d) a landing gear/wheel assembly having gear wheel assemblies secured both forwardly and rearwardly on said main air lift body assembly, thus providing four sets of wheel members for take-off and landing of said body lift airplane assembly; and

e) said gear wheel assemblies being retractably mounted and movable within lower confines of said main air lift body assembly when in the retracted positions.

3. A body lift airplane assembly comprising:

a) a main air lift body assembly being of a disc shape including a pilot control section and a passenger compartment section;

b) a fixed wing assembly secured to said main air lift body assembly and having a fixed wing member with a longitudinal axis extended transversely of a body longitudinal axis of said main air lift body assembly;

c) said fixed wing member having a length substantially equal to a width of said main air lift body assembly; and

d) a fin and rudder assembly connected to an upper rear portion of said main air lift body assembly including cooperating inclined fin members having pivotal rudder members thereon operable to provide for an efficient turning operation of said body lift airplane assembly.

4. A body lift airplane assembly, comprising:

a) a main air lift body assembly being of a disc shape including a pilot control section and a passenger compartment section;

b) a fixed wing assembly secured to said main air lift body assembly and having a fixed wing member with a longitudinal axis extended transversely of a body longitudinal axis of said main air lift body assembly; and

c) said passenger compartment section operable to comfortably receive and support a plurality of passenger members therein and being enclosed by a domed cover member constructed of a transparent light sensitive material to turn dark during daylight sunlight conditions and turn to a lighter condition under decreasing dark conditions.

5. A body lift airplane assembly, comprising:

a) a main air lift body assembly including a main body section having a compartment section to receive passenger members and flight control personnel; and

b) a landing gear/wheel assembly pivotally connected to and extended from an undersurface of said main air lift body assembly and selectively movable from an extended landing position to a retracted air flight position.

6. A body lift airplane assembly, comprising:

a) a main air lift body assembly including a main body section having a compartment section to receive passenger members and flight control personnel; and

b) said main air lift body assembly having a pair of spaced engine cut-out portions having mounted therein respective ones of a jet engine pod assembly.

7. A body lift airplane assembly as described in claim **6**, wherein:

a) each of said jet engine pod assemblies having an engine housing with an air inlet section and an exhaust gas discharge section; and

b) said inlet air section includes portions positioned above and below upper and lower surfaces of said main body section so as to efficiently and effectively direct inlet air through said inlet air section to provide for greater flight and fuel efficiency achieved from said jet engine pod assemblies.

8. A body lift airplane assembly, comprising:

a) a main air lift body assembly including a main body section having a compartment section to receive passenger members and flight control personnel; and

b) said main air lift body assembly having about a outer periphery integral with downwardly arcuate air lift portions to achieve air foil features and provide substantial air lift characteristics to said main air lift body assembly as normally found and achieved through an airplane's wing assembly; and

c) said arcuate air lift portions extended along outer parallel side walls and a curved rear wall of said main air lift body assembly to achieve air foil lift characteristics.

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