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Bizzarri

[11] **4,165,848**

[45] **Aug. 28, 1979**

[54] **ROTARY THRUST DEVICE INCLUDING AXIALLY ELONGATED ROTOR ROTATABLE IN CASTING HAVING ELONGATED FLUID INTAKE AND DISCHARGE SLOTS**

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[22] Filed: **Jul. 28, 1977**

[30] **Foreign Application Priority Data**

Aug. 9, 1976 [IT] Italy 9556 A/76

[51] **Int. Cl.**[2] **B64C 29/02**

[52] **U.S. Cl.** .... **244/12.2;** 115/52; 244/19; 244/23 C; 415/66; 416/228

[58] **Field of Search** .... 244/12.2, 23 C, 9, 19, 244/2, 53 B; 115/50, 52; 416/228, 232, 236; 415/66; 180/1 P, 7 P, 7 J

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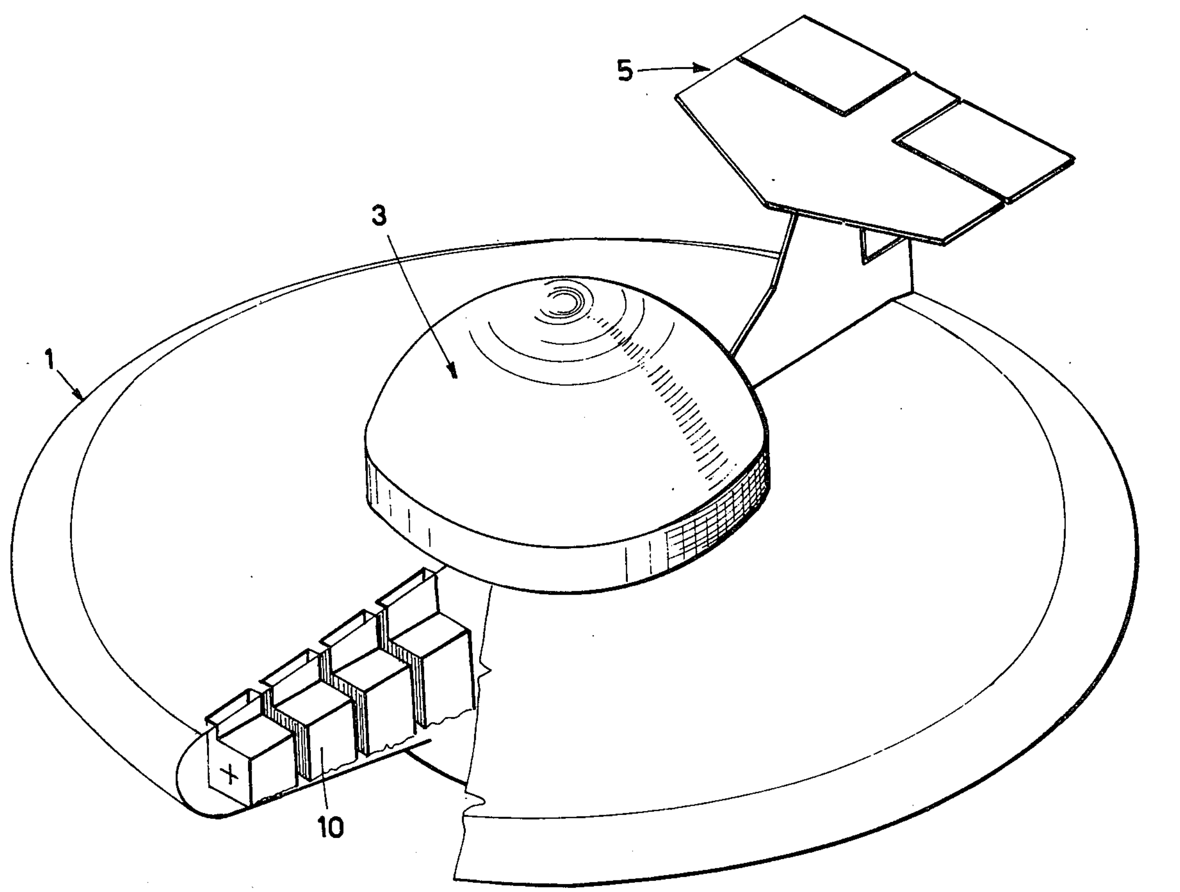
Primary Examiner—Barry L. Kelmachter
Attorney, Agent, or Firm—McGlew and Tuttle

[57] **ABSTRACT**

A fluid flow device comprises a rotor housed in a casing having slot-like intake and outlet openings. Groups of such devices can be used to form an aircraft propulsion system by drawing-in air from above through the intake openings and forcing the air downwardly through the outlet openings to provide lift and horizontal thrust, the effect being similar to that produced by the wing of a bird.

6 Claims, 13 Drawing Figures



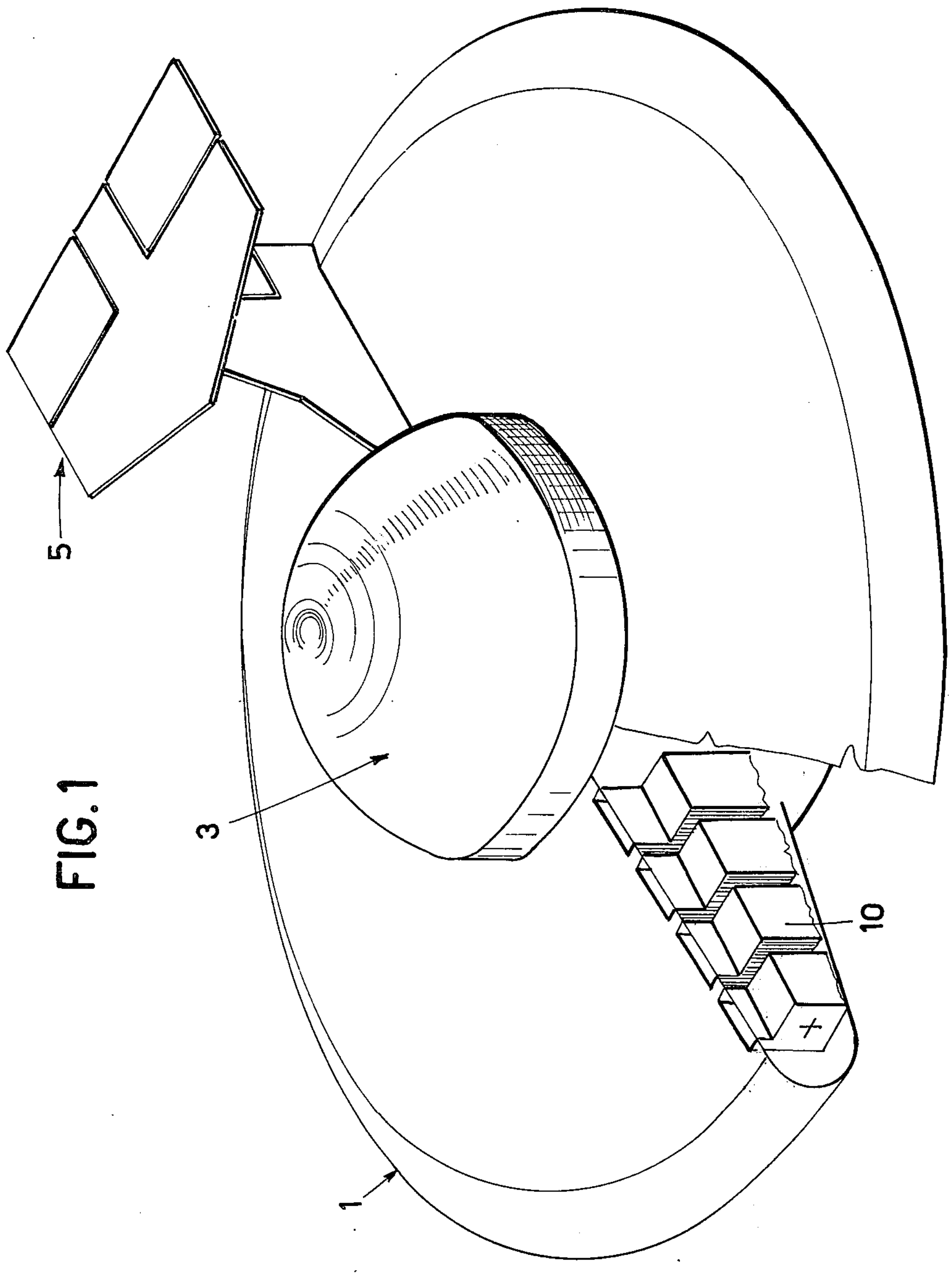


FIG. 1

FIG. 2

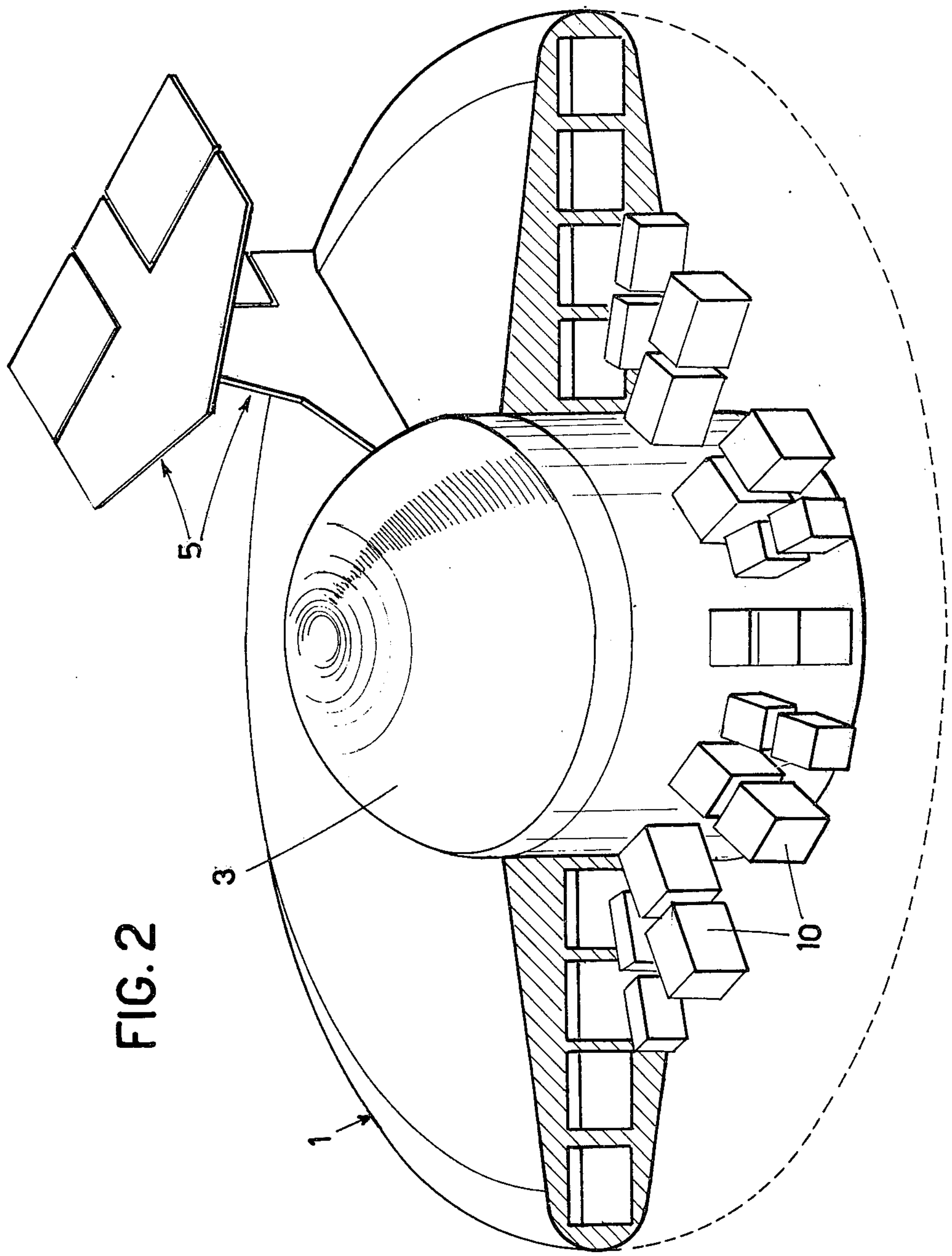


FIG. 3

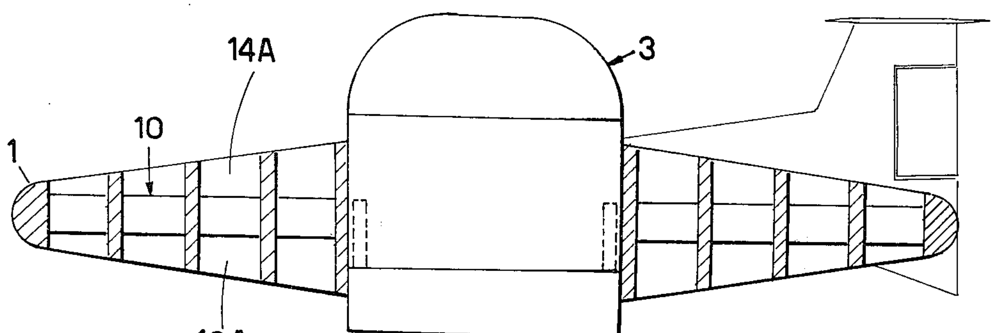

14A
3
10
1
16A

FIG. 4

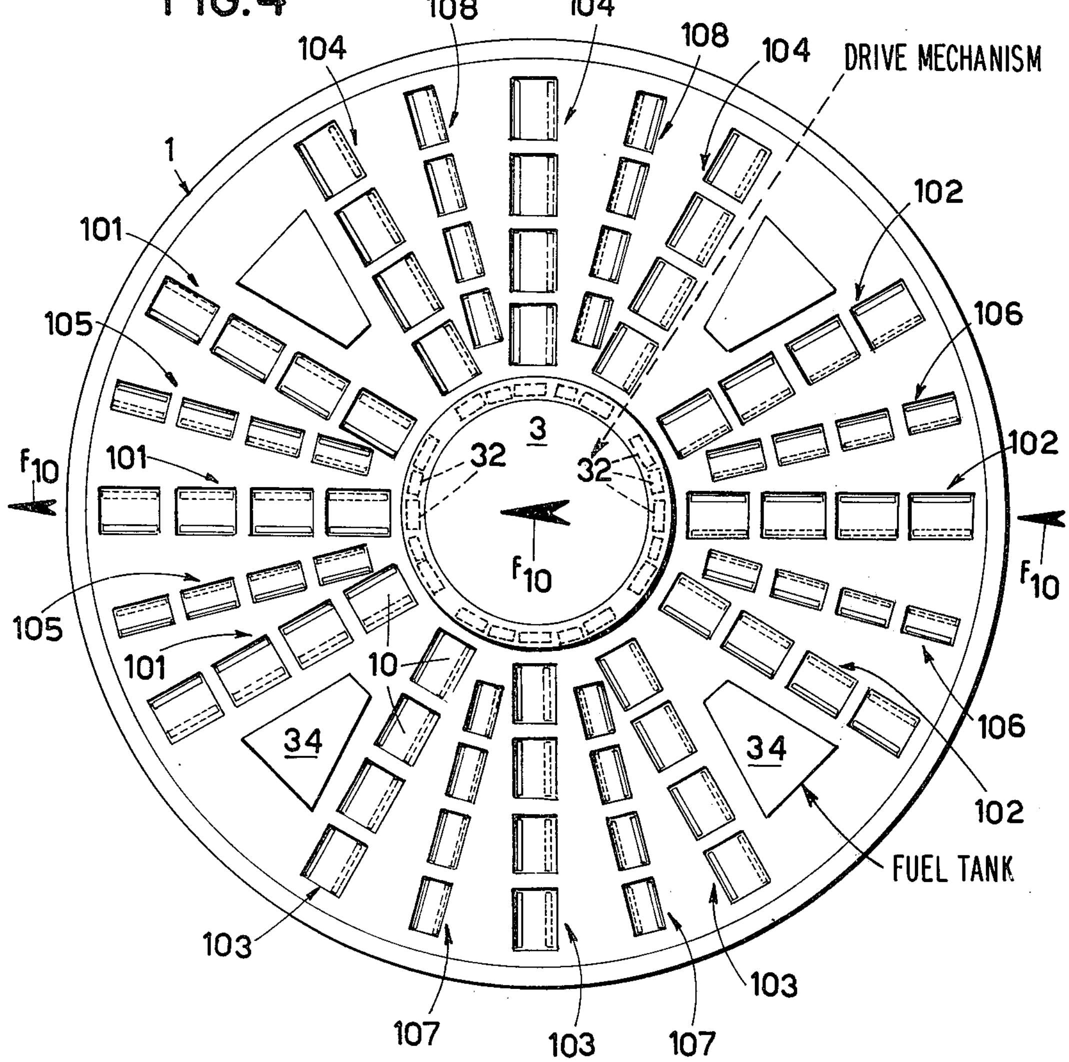

108
104
108
104
104
DRIVE MECHANISM
1
101
102
105
106
3
32
32
F_{10}
101
102
F_{10}
F_{10}
105
10
101
106
34
34
102
FUEL TANK
103
103
107
103
107

FIG. 5

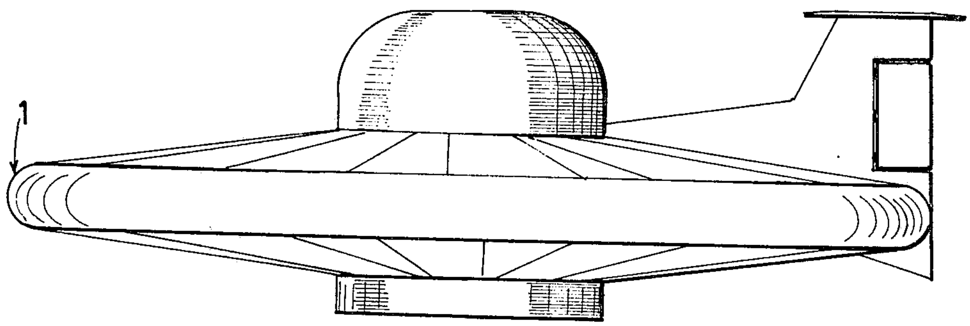


FIG. 6

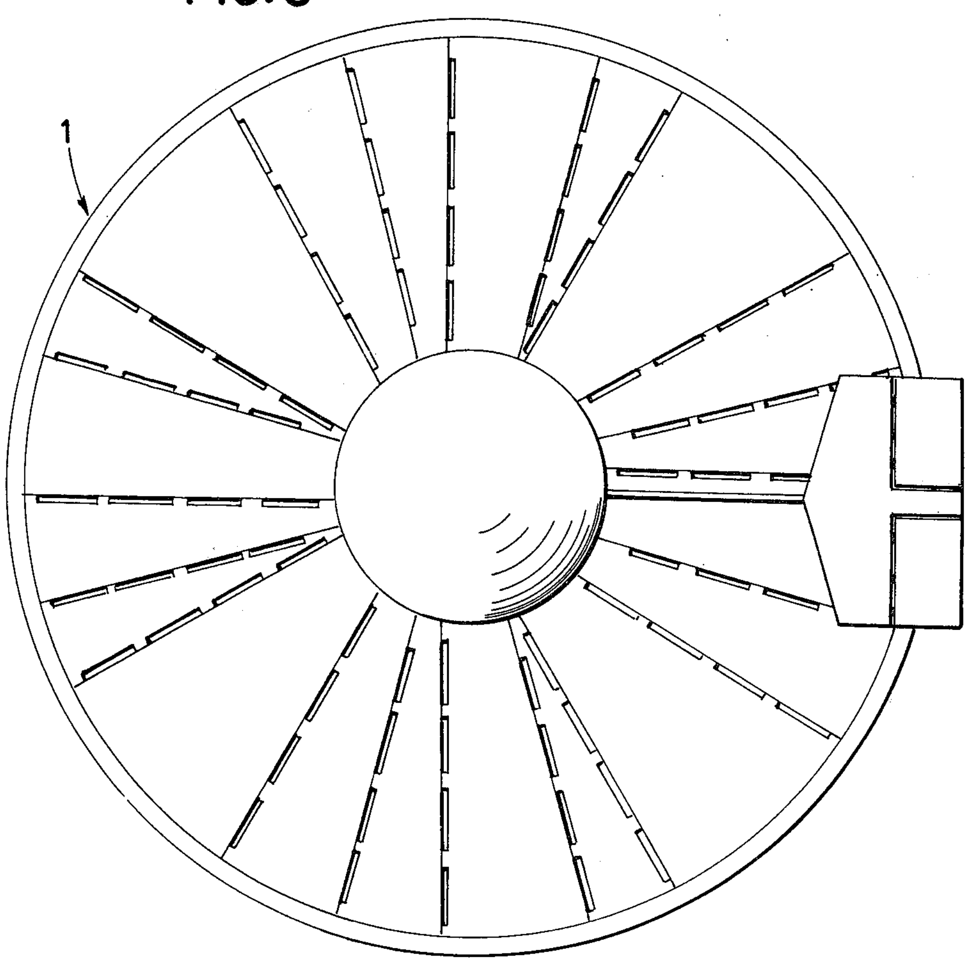
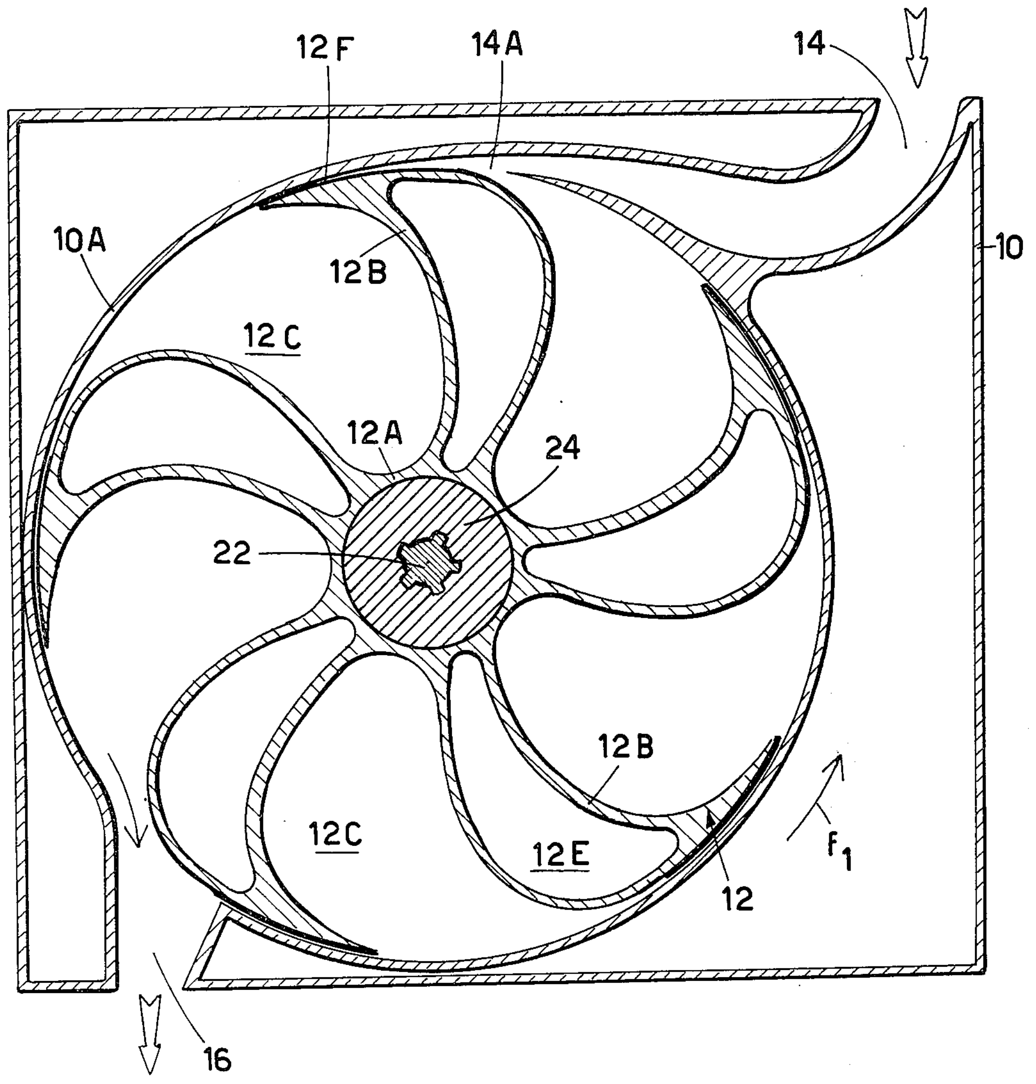


FIG.7



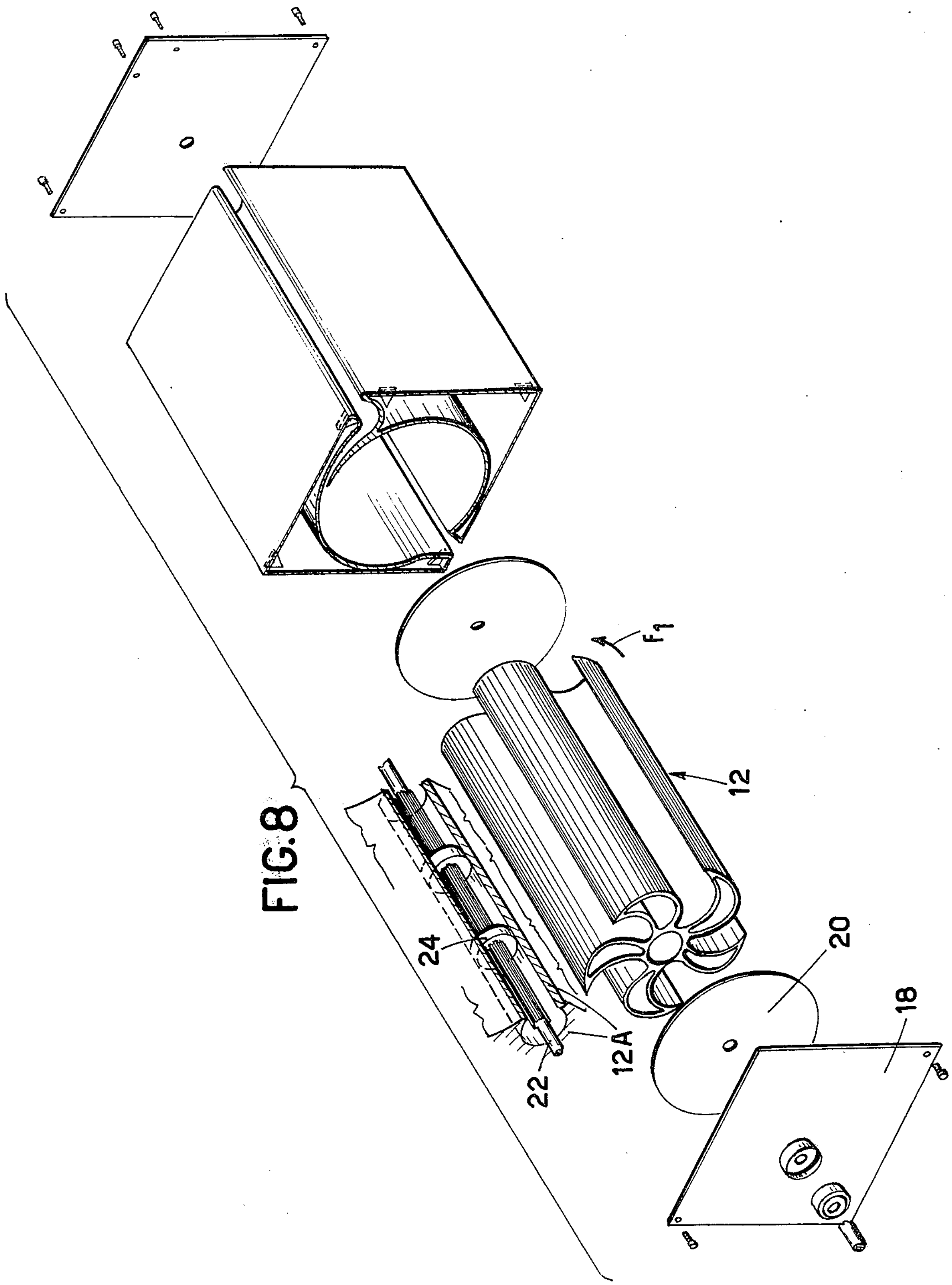


FIG. 8

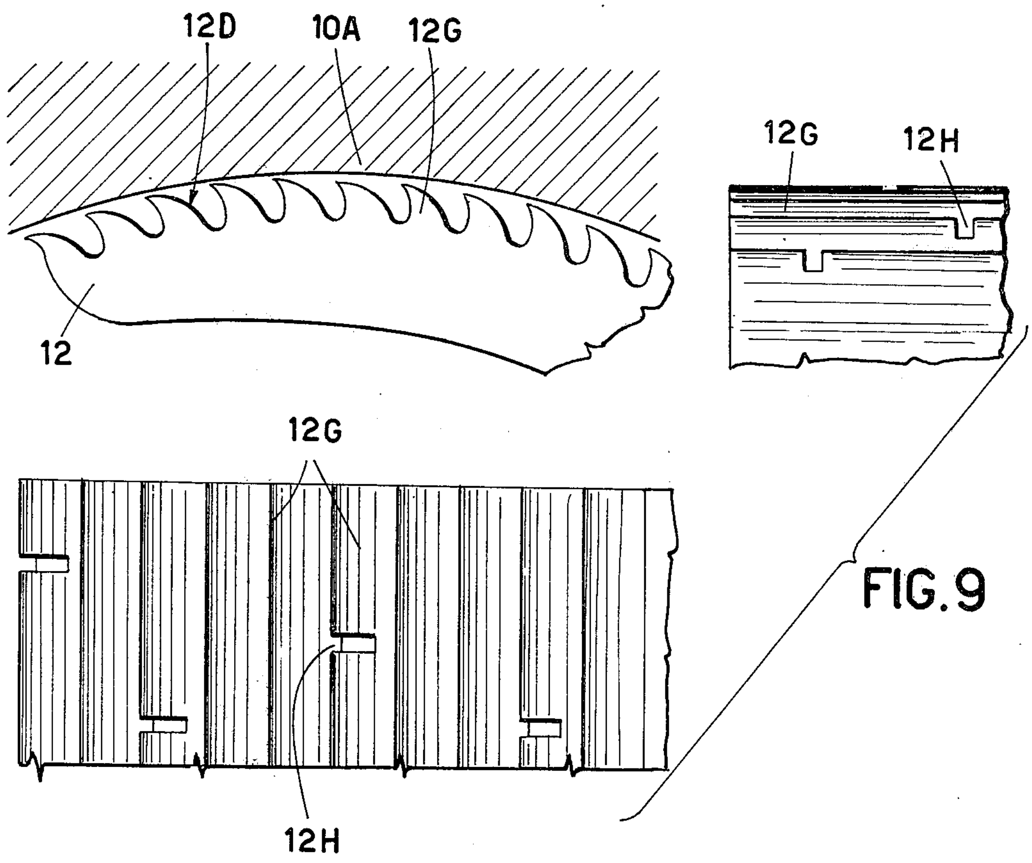


FIG. 9

FIG. 11

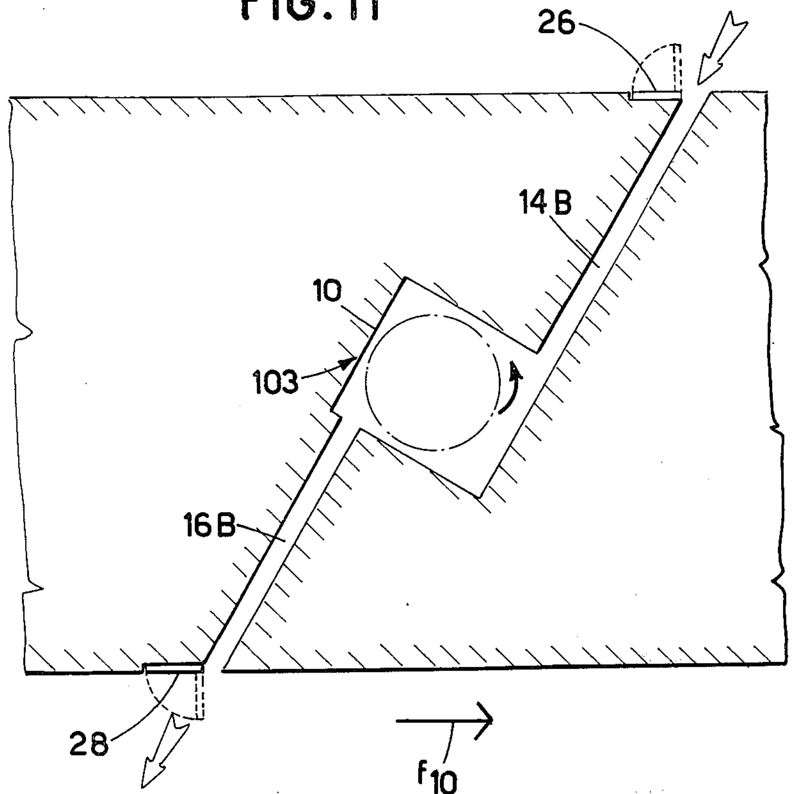


FIG. 10

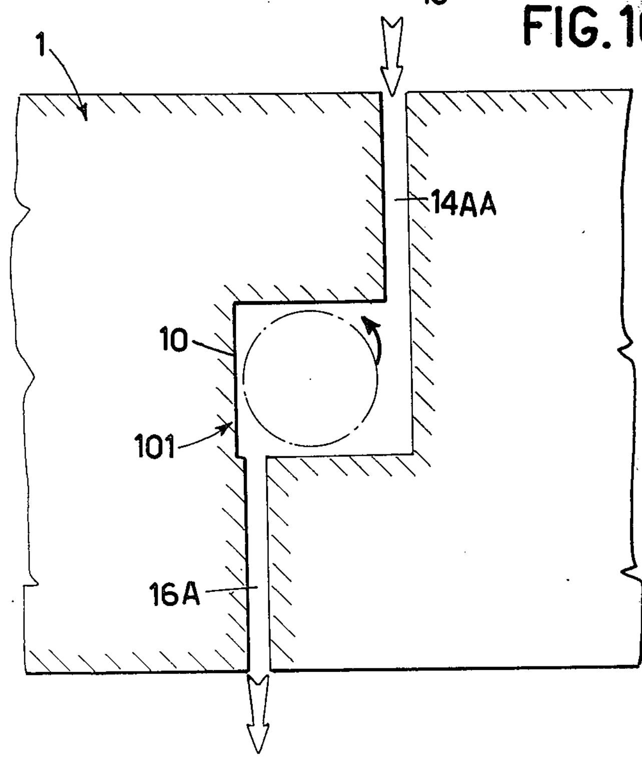


FIG.12

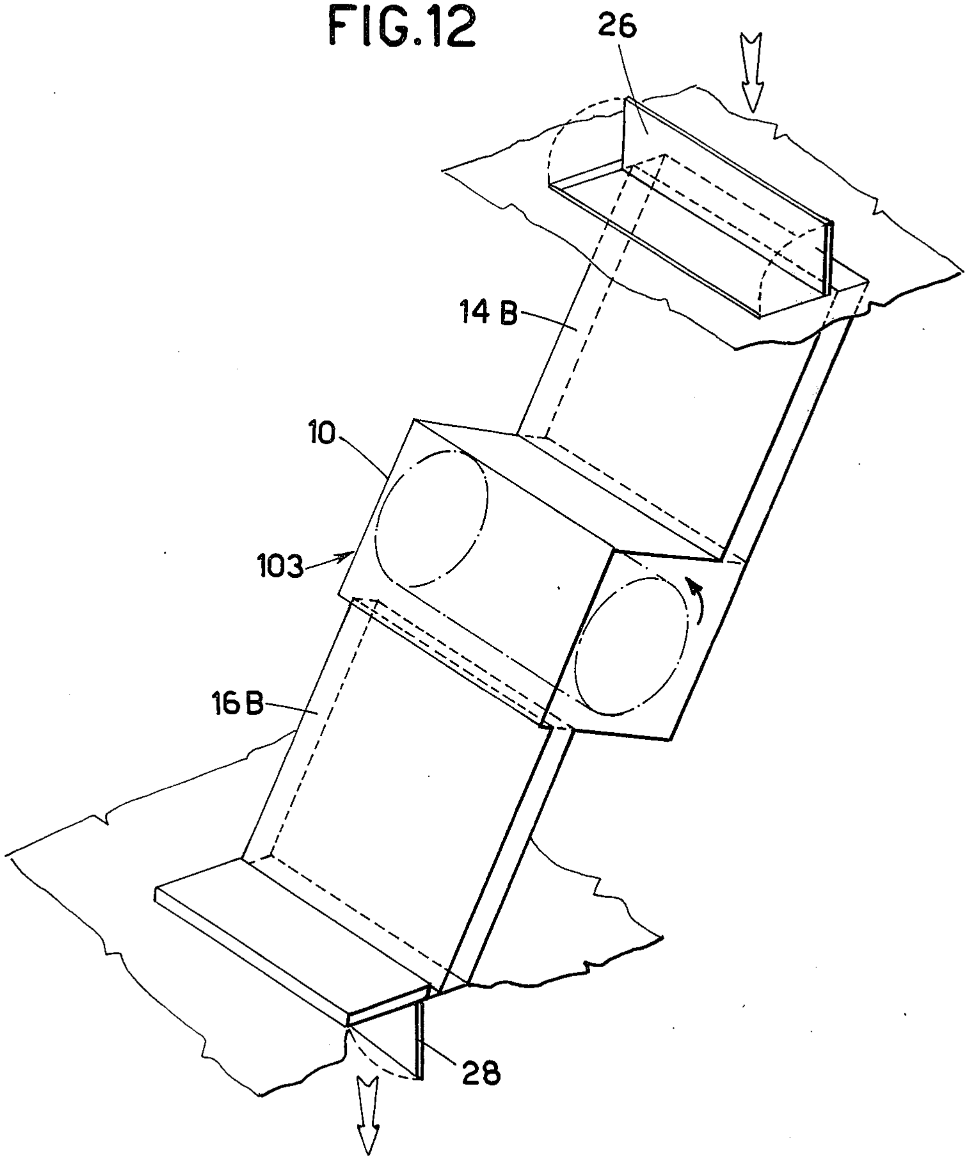
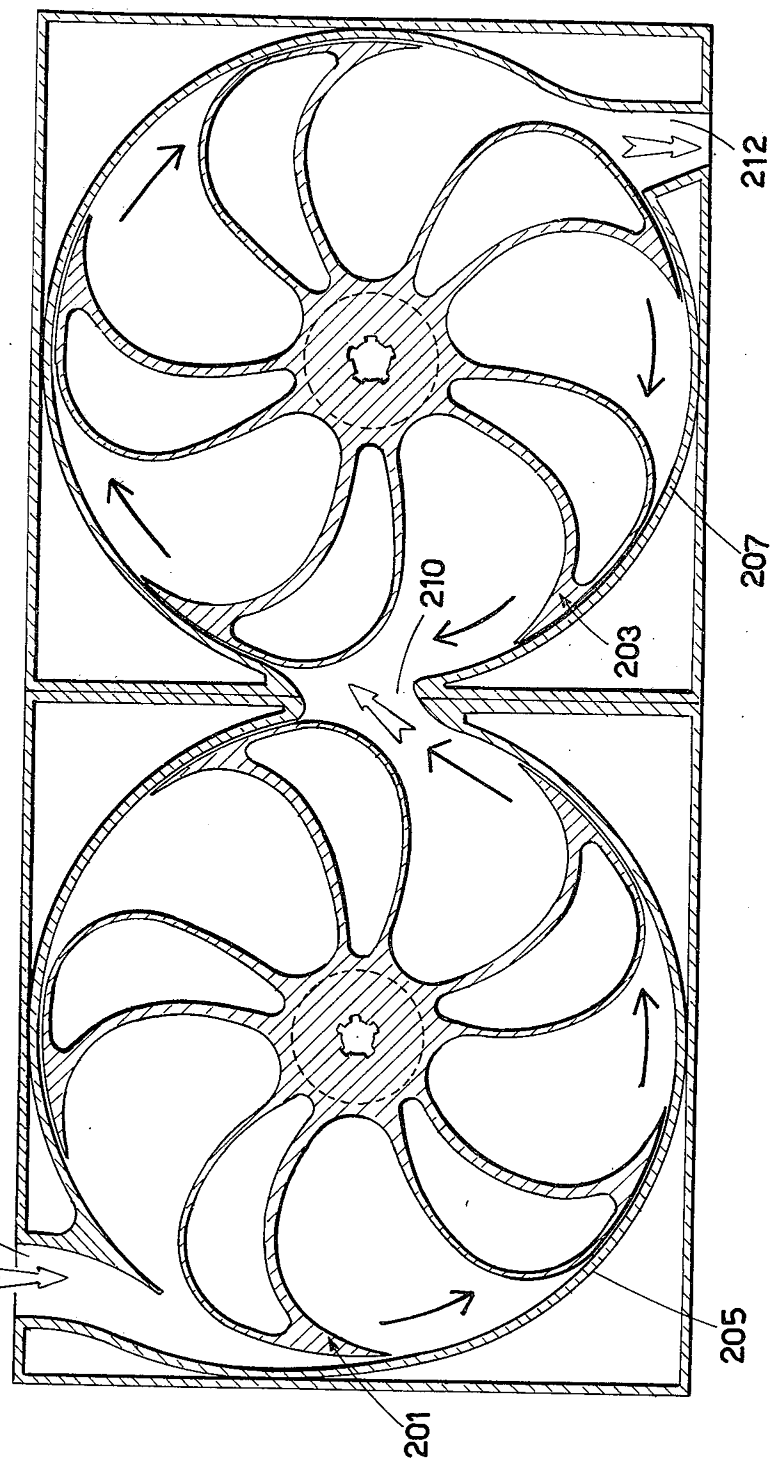


FIG.13



ROTARY THRUST DEVICE INCLUDING AXIALLY ELONGATED ROTOR ROTATABLE IN CASTING HAVING ELONGATED FLUID INTAKE AND DISCHARGE SLOTS

FIELD OF THE INVENTION

The invention relates to fluid flow devices and more particularly to fluid flow devices for providing a reactive thrust to provide lift or forward movement for an aircraft, or propulsion or braking for a ground vehicle or a water vessel, and to fluid flow devices for use as pumps or compressors.

SUMMARY OF THE INVENTION

According to the present invention, there is provided a fluid flow device comprising at least one rotor and a casing for the rotor, the casing having a slot-like intake opening and a slot-like outlet opening.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIGS. 1 and 2 are perspective views, with parts broken away of an aircraft having a propulsion system formed by fluid flow devices in accordance with the invention;

FIGS. 3 and 4 are respectively a vertical section and a horizontal section, showing the internal structure of the aircraft;

FIGS. 5 and 6 are respectively, a side elevation and a plan view of the aircraft;

FIG. 7 is a cross-section of a pneumatic drive unit formed by a fluid flow device in accordance with the invention;

FIG. 8 is an exploded perspective view of the drive unit;

FIG. 9 shows, from three views, a sealing arrangement between a rotor and a casing of the drive unit;

FIG. 10 is a schematic section of a drive unit for producing a lifting thrust;

FIG. 11 is a schematic section of a drive unit for producing a lifting thrust and a horizontal thrust;

FIG. 12 is a perspective view of the drive unit shown in FIG. 11; and

FIG. 13 is a sectional view of a drive unit comprising rotors in series.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The aircraft shown in the drawings comprises a substantially disc-like structure **1** and a central structure **3** forming the cockpit and, possibly, a housing for the propulsion units of the aircraft. The structure **1** is preferably defined by upper and lower continuous annular surfaces containing upwardly-directed suction intakes and downwardly-directed outlets. The aircraft also has vertical and horizontal rudder systems **5**.

There are located in the interior of the structure **1** several groups of fluid flow devices forming groups of pneumatic drive units as more particularly shown in FIGS. 2, 3 and 4. The drive units draw-in air from above and thrust the same downwardly in the form of successive impulses to simulate the effect produced by the wing of a bird during flight. The groups of drive units are radially directed, and in each group the rotors are coaxial and are coupled to be driven by means of a single drive shaft. Although the various groups of drive units have at least partly differing functions, the configuration of each drive unit is substantially the same, and one drive unit will now be described in detail.

In particular, with reference to FIGS. 7 and 8, **10** indicates a casing having upper and lower walls which may also be a part of the upper and lower surfaces of the structure **1**. An internal wall **10A** in the casing **10** defines a seat or housing of substantially cylindrical or other rotational section defined around an axis which extends horizontally in the usual attitude of flight, and radially with respect to the structure **1**. The housing contains an elongate rotor **12** of a corresponding configuration. The rotor **12** includes a core **12A**, and shaped vanes **12B** which are separated by spaces **12C**, the vanes **12B** each having an internal cavity **12E** for lightness. The shaped vanes **12B** each have a front concave surface (with respect to the rotational direction shown by the arrow F1) and a rear convex surface, the two surfaces being connected at the periphery of the vanes by surfaces **12F** of cylindrical form, with a diameter slightly less than that of the internal surface of the housing formed by the wall **10A**; these surfaces **12F** are shaped to provide a seal and for this purpose (see particularly FIG. 9) these surfaces **12F** are toothed to provide rib-like projections **12G** and channels **12D** extending parallel to the rotational axis of the rotor **12**. The projections **12G** and the channels **12D** are of aerofoil section and the projections **12G** have offset transverse gaps **12H**.

A shaped intake duct **14** leading from the upper wall of the casing **10** opens at **14A** into the housing formed by the internal wall **10A**. A duct **16** leading from the housing at a position diametrally opposed to that of the duct **14** serves for expelling air through the lower wall of the casing **10**. The ducts **14** and **16** are of slot-like form in section and extend along the length of the casing **10**.

The housing defined by the wall **10A** is closed at its ends by walls **18** fixed to the casing **10**, and the inter-vane spaces **12C** of the rotor are closed at their ends by circular plates **20** (see FIG. 8). The walls **18** and the plates **20** are traversed by a splined shaft **22** on which are mounted splined supports **24** engaged with the core **12A**, which is hollow for lightening purposes. FIGS. 2 and 3 illustrate the arrangement of the drive units in groups which extend radially of the structure **1**, the drive units of each group being commonly driven. FIG. 3 more particularly illustrates how the intake slot **14A** and the discharge slot **16A** extend from each drive unit to the upper and lower surface, respectively, of the structure **1**, for the intake of air, for example, through the intake slot **14A** and the discharge of air, for example, from the discharge slot **16A** to provide a downwardly directed thrust.

If the drive units are located in the structure **1** and in such a manner as to be spaced from the upper and/or lower surfaces of structure **1**, the ducts **14** and **16** are provided with extensions **14AA** and **16A** perpendicular to the surfaces of the structure **1** (see in particular FIG. 10), or extensions **14B** and **16B** inclined to the surfaces of the structure for propulsive purposes (in particular see FIGS. 11 and 12); in the latter case, ailerons **26**, **28** may be provided at the outer ends of the extensions **14B** and **16B** to modify the dynamic functions of the drive unit.

FIG. 6 illustrates the arrangement of slots which form the intake openings on the upper surface of the structure 1, the slots of each group of drive units being radially aligned, FIGS. 2 and 3 show the casings 10 of the several groups of radially-directed drive units with the rotors of each group being coaxial. Reference 32, in FIG. 4, indicates drive assemblies and/or transmission units leading from one, two, or more propulsion units housed in the structure 3 or in another part of the aircraft, and reference 34 indicates possible positions of fuel tanks.

The rotor 12 and the housing 10A which contains it comply with all the requirements necessary and sufficient for a beating wing, that is: lightness, simplicity, and a high air-intake from above with successive downwards thrusts of air. The profile of the inlet duct 14 and the size of its mouth 14A, the length of the vane outer edge, the distance between the ends of the vane edges, and the external toothing of the vane edges have been designed in such a manner as to increase the air-intake.

The toothing 12G has a dual function. The first occurs in the intake stage, when the small channels 12D of aerofoil section draw in and pick up air in the mouth 14A and thus add to the intake effect produced by the inter-vane spaces 12C. The second occurs in the compression stage, when the air collected from each inter-vane space 12C is compressed by centrifugal action against the internal surface of the housing 10A; unless otherwise blocked, this air would tend to jump over the vane edge to pass between the vane and the housing surface. The small channels 12D compel the air threads entrained therein and rotating in a clockwise direction to move towards the bottom of the channels to be urged by centrifugal action onto the following edge of the toothing. In order to prevent additional air from forming threads adhered to the internal surface of the housing 10A, owing to blocking of the air on the bottoms of the channels, the channels are provided with the transverse offset gaps 12H which allow the transfer of a little air from each channel to the next one and thus prevent the threading effect. By use of aerofoil-section toothing on the edge of the vanes 12B, there is obtained a pneumatic seal which, without the high and dangerous friction which would result from direct contact between the rotor and the housing, prevents the escape of air along the surface of the housing to a sufficient extent to allow a compression which determines the violent expulsion of the air from the duct 16, as well as a sufficient suction in each inter-vane space after its passage past the duct 16, in order to draw air from the duct 14. In this manner, a regular continuity is provided for the intake, the compression and expulsion of the air.

The drive unit as above described may be used alone, that is, as a single rotor driven by its axle or, as is more advantageous and as shown in the drawings, a group of such drive units may be arranged in a row to be driven by a single axle. In this case, a common bearing is used to support the axle between the adjacent ends of adjacent rotors.

The drive unit is intended to reproduce the effect of a beating wing and its primary use is as a drive unit for an aircraft although it does have other uses as will be discussed later. With respect to conventional aircraft which have a substantial gliding action in flight, the wings of the aircraft shown in the drawings are shortened and are extended forward and backward until they join to form a disc-shape. If the aircraft is to be maintained in flight only by the beating effect induced by the drive unit or units and the aircraft is not to have a gliding action when the beating effect stops, it would not be necessary for the upper and lower surfaces of the disc to be continuous and smooth and it would be sufficient to have an exposed structure supporting the drive unit or units. As, however, it not convenient to omit the glide, or flight combinations involving the glide, in particular in the event of a breakdown, the disc surfaces are suitably covered and smooth, as indicated in the drawings.

FIG. 4 illustrates the positions of the different groups of drive units. The groups of drive units are formed into front and rear sets, and port and starboard lateral sets. The front and rear sets 101 and 102 (with respect to the direction of motion of the aircraft as indicated by the arrow f10) have only a supporting or lifting function during flight. The sets 101 and 102 are arranged in the longitudinal axial zone of the aircraft. In order to balance the effects of the drive units of the sets 101 and 102, those of the groups of drive units which are arranged at the lateral sides of the sets 101 and 102 are provided with intake and outlet slots arranged with mirror-like symmetry and the respective groups located on the longitudinal axis of the aircraft have their slots offset with respect to the longitudinal axis and symmetrically arranged about the longitudinal axis.

The lateral sets 103 and 104 have a dual lifting and tractive function.

Groups of drive units 105 and 106 respectively are arranged between the groups forming the front and rear sets 101 and 102, for manoeuvring purposes; similarly, groups of drive units 107 and 108 for manoeuvring purposes are arranged between the groups forming the lateral sets 103 and 104.

By comparing FIGS. 10 and 11, the difference between those drive units which have only a lifting function and those which have a dual lifting and tractive function will be evident. FIG. 10 shows one of the drive units for supporting or manoeuvring (in particular one of the drive units 101) in which the intake and discharge ducts 14A and 16A and the corresponding slots in the surface of the wing formed by the structure 1 are directed vertically so as to provide only a vertical thrust.

FIGS. 11 and 12 show one of the dual-effect drive units (in particular, one of the drive units 103) in which the intake and discharge ducts 14B and 16B are inclined to the vertical. Adjacent the rear part (in the flight direction) of the associated slots in the surface of the wing formed by the structure 1 are mounted the two ailerons 26 and 28 which are housed in the thickness of the wing behind the slots. Both ailerons are pivotal through 90° into positions in which they extend perpendicular to the wing, the aileron 26 moving in a clockwise direction, and the aileron 28 moving in a counterclockwise direction. When the two ailerons are in their inoperative positions they remain incorporated in the wing thickness and an intake and discharge occur in directions inclined to the vertical, thus providing a forward thrust, while the ailerons do not offer any drag to the air and thus do not disturb the horizontal motion of the aircraft. When the aircraft is to be moved only in a vertical direction, the ailerons are pivoted into their operative positions as shown in broken lines in FIG. 12, modifying the air intake flow direction at the outer ends of the ducts from inclined to vertical, and partly impeding the horizontal motion. The rotor casing 10 has been shown in FIGS. 11 and 12 in an oblique position merely to illustrate the dual function of the drive unit; in practice however, for ease of installation, the rotor casing will be mounted in the wing so that its walls extend vertically and horizontally, but the intake and outer ducts will still be inclined, as shown. These drive units can also be used to modify the transverse position of the aircraft.

The four sets of drive units **105**, **106**, **107**, **108** are smaller than the other sets of drive units and serve for manoeuvring the aircraft by combining the various thrusts. The aircraft may thus be moved in any direction, be inclined, manoeuvre, and be moved vertically and laterally as desired by the pilot.

Each set of drive units is powered by a respective turbine or other engine located within the structure **3**: more powerful turbines are used for the lifting and tractive drive units, and less powerful turbines for the manoeuvring drive units. For reasons of safety, it is preferred that, instead of using a single turbine for each set, two turbines of equal overall power are used, a part of the set being connected to one of the two turbines and the other part of the set being connected to the other turbine. In the event of engine failure, the aircraft will then be able to glide using the remaining working engine and the corresponding drive units.

The number, distribution, and dimensions of the drive units and of the fuel tanks **34** as shown in the drawings is only indicative of one of many possible arrangements. Experience will enable the optimum arrangements to be established.

The structure **3** also incorporates the passengers cabin and has, in its lower portion, components such as retractable wheels. As to the wheels, which are retractable inwards, there may be provided two groups, each of three wheels; a first group of large, strong supporting wheels, with small sprung movement, and a second group of lighter and smaller wheels, with a larger sprung movement. In this way, the aircraft will be also able to move on land, even on an uneven ground without losing its balance, the smaller wheels moving to meet the irregularities in the ground.

Although the fluid flow device in accordance with the invention has been described above in relation to its use as a drive unit in an aircraft propulsion system, it can also be used, singly or in series, for other purposes than that described above in order to provide a flow of air or of liquid, for example water or oil. Some examples of these other uses will now be given.

A. Supplementary thrust and braking for a motor-vehicle. One or two pairs of fluid flow devices with coaxial rotors are arranged transversely under the floor of the vehicle. One device (or one pair of devices) provides a propulsive thrust and its intake slot (or slots) is directed forwardly and its outlet slot (or slots) is directed rearwardly. The other device (or pair of devices) provides a braking thrust and its intake slot (or slots) is directed rearwardly and its outlet slots (or slots) is directed forwardly. The rotors are driven by the engine of the vehicle and the slots can be selectively opened and closed by means of appropriate controls, connected with the accelerator and the brake to provide either supplementary thrust or supplementary braking. The arrangement is such that, while keeping constant the direction of rotor rotation, by shutting off the braking device (or devices) by closing the corresponding slots and by drawing air into thrust device (or devices) from the front and urging the air rearwardly, it is possible to obtain a supplementary thrust; conversely by shutting off the traction device (or devices) and by opening the slots of the braking device (or devices) the air can be drawn in from the rear and urged forwardly to provide supplementary braking.

B. A suction and compression pump. The fluid flow device can be used together with other like devices as a pump for emptying reservoirs or channels. The possibility of using long intake/outlet slots instead of tubes as in conventional pumps, provides substantial advantages.

C. Propulsion for water vessels. The device may be used for propelling water vessels by locating sets of devices at each side of the vessel with the rotors extending perpendicular to the fore and aft axis of the vessel, so that water can be drawn in from the front and urged backwards. The conventional line of a hull, gradually narrowing to the keel, as well as towards the prow and stern, should afford a sufficient space for the application of a sufficient number of devices on both sides. The elimination of the conventional propeller with all its disadvantages, and the new propulsion system which provides a wide distribution of pulses along the hull walls, should result in smoother travel and fewer vibrations, and possibly a gain in the effective thrust provided by the engines.

FIG. **13** shows a power unit comprising two co-operating parallel rotors **201** and **203**, operating in series, and housed in respective casings **205**, **207**. The casing **205** has an intake **209** and an outlet **210** which directly communicates with the second rotor **203**; an outlet **212**, opposite to the intake **209**, serves for the outlet of the air under pressure. The two rotors **201** and **203** can be rotated in opposite directions at the same or at different speeds (in particular the second rotor at a higher speed than the first rotor), and they can have the same or different geometrical features and sizes. With two combined rotors, the first rotor draws air from outside (from the top when used to provide lift for an aircraft) and the second rotor receives from the first rotor air already under pressure and accelerated, to force it under greater pressure outwardly (downwards when used to provide lift for an aircraft).

What is claimed is:

1. A fluid flow device for propelling a vehicle comprising, in combination, a relatively elongated, substantially horizontally oriented casing having cylindrical wall means defining a horizontally oriented, axially elongated circular cross-section internal surface; an axially elongated rotor extending coaxially of said cylindrical wall means and mounted for rotation therein; longitudinally extending, peripherally spaced vanes on said rotor cooperable with said internal surface of said casing, each vane having plural longitudinal ribs on its periphery terminating adjacent to but out of contact with said internal surface of said casing, eaah of said ribs having an aerofoil cross-section and defining a channel between adjacent ribs and said vanes having radially concave leading surfaces considered in the direction of rotation of said rotor; said ribs cooperating with said internal surface to form a fluid seal between said vanes and said internal surface; a fluid intake slot formed in said wall means and extending longitudinally of said rotor coextensive therewith; and a fluid discharge slot formed in said wall means and extending longitudinally of said rotor coextensive therewith.

2. A fluid flow device as claimed in claim **1** and including a flap means pivotally mounted adjacent the respective fluid intake slot and fluid discharge slot for movement between operative and inoperative position whereby said flap means functions to vary the reactive forces of the fluid flowing through said slots.

3. A fluid flow device for propelling a vehicle comprising a casing having wall means defining a plurality of horizontally oriented axially elongated circular cross-section rotor chambers, said casing having a fluid intake slot and a fluid discharge slot, and one of said rotor chambers being connected into communication with said intake slot and another of said rotor chambers being in communication with said fluid discharge slot, and means for serially connecting adjacent rotor chambers into communication with one another, an axially elongated rotor rotatably mounted in each of said rotor chambers, each of said rotors extending coaxially of its respective chamber, each of said rotors including longitudinally extending peripherally spaced vanes cooperatively associated with the surfaces of its respective rotor chamber, each of said vanes of said respective rotors having a radially concave leading surface in the direction of rotation of said rotor, and each of said vanes having a curvilinear tip portion extending in the direction of rotation and terminating adjacent to but out of contact with the internal surface of its respective rotor chamber, said curvilinear tip having a plurality of longitudinally ribs projecting from the trailing outer edge of said vanes whereby said ribs are spaced slightly from said rotor chamber, each of said ribs having an airfoil cross section and defining a longitudinally extending channel between adjacent ribs, said ribs cooperating with the internal surface of the respective rotor chamber to form a fluid seal between said curvilinear vane tip and the surface of said respective rotor chamber, and said means serially connecting adjacent rotor chambers into communication being disposed so that the fluid flow therethrough causes said rotors in said adjacent chambers to rotate in opposite directions.

4. A fluid flow device as defined in claim 3 wherein each of said ribs include a gap means which are laterally offset with respect to one another so as to permit limited fluid flow between adjacent cavities defined between adjacent ones of said ribs.

5. An aircraft comprising a disc-like structure, said disc-like structure having an upper surface, and a lower surface, said upper surface having a plurality of surface fluid intake slots opening therethrough and said lower surface having a plurality of surface fluid discharge slots opening through said lower surface, a propulsion system located in said structure between said upper and lower surfaces, said propulsion system including a plurality of fluid flow devices, each of said fluid flow devices comprising a relatively elongated substantially horizontally oriented casing having cylindrical wall means defining a horizontally oriented, axially elongated circular cross-section internal surface, an axially elongated rotor extending coaxially of said cylindrical wall means and mounted for rotation therein, longitudinally extending peripherally spaced vanes on said rotor cooperable with said internal surface of said casing, each vane having plural longitudinal ribs on its periphery terminating adjacent to but out of contact with said internal surface of said casing, each of said ribs having an airfoil cross-section and said vanes having radially concave leading surfaces considered in the direction of rotation of said rotor, said ribs cooperating with said internal surface to form a fluid seal between said vanes and said internal surface, a fluid intake slot formed in said wall means and extending longitudinally of said rotor coextensive therewith, and a fluid discharge slot formed in said wall means and extending longitudinally of said rotor coextensive therewith, said fluid intake slots of said casing wall means and said fluid discharge slots of said wall means being in communication with the surface fluid intake slots of the upper surface and the discharge slots of the lower surface respectively, the rotors of said devices being driveable to draw in air through said surface intake slots and to discharge the air through said surface discharge slots to provide a downwardly directed thrust, certain of said devices providing a horizontal thrust component and all of said devices providing a vertical thrust component in a direction to provide lift to said aircraft, said fluid flow devices of said propulsion system being arranged in groups with the rotors of each group of said devices being coaxial and the common axis of the rotors of each group extending radially of said disc-like structure, the respective fluid flow devices of each group having the same function, and said fluid intake slots of said devices extending radially in said disc-like structure.

6. An aircraft as claimed in claim 5, in which said devices providing only a vertical thrust are arranged with their common axes aligned with a longitudinal center line of said aircraft, said longitudinal centerline extending in the direction of movement of said aircraft; said devices providing also a horizontal thrust component being aligned to extend transversely of said longitudinal centerline of said aircraft; said devices providing a horizontal thrust component including respective ailerons extending longitudinally of the respective fluid intake and fluid discharge slots thereof, and being operable to vary the horizontal advance thrust imparted to said aircraft and selectively to effect a change in the direction of horizontal movement of said aircraft.

* * * * *

United States Patent [19]

Heuvel

[11] **4,193,568**

[45] **Mar. 18, 1980**

[54] **DISC-TYPE AIRBORNE VEHICLE AND RADIAL FLOW GAS TURBINE ENGINE USED THEREIN**

[76] Inventor: **Norman L. Heuvel**, 14723 SE. 263rd, Kent, Wash. 98031

[21] Appl. No.: **842,673**

[22] Filed: **Oct. 17, 1977**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 702,523, Jul. 6, 1976, abandoned.

[51] **Int. Cl.**[2] **B64C 29/04**; F02C 3/14

[52] **U.S. Cl.** .... **244/23 C**; 60/39.16 C; 60/39.3 S; 60/39.36; 244/53 R

[58] **Field of Search** .... 244/7 R, 53 R, 12.1, 244/12.2, 23 R, 23 C; 60/39.34, 39.35, 39.16 C, 39.16 SI, 201, 268; 416/64, 194, 21

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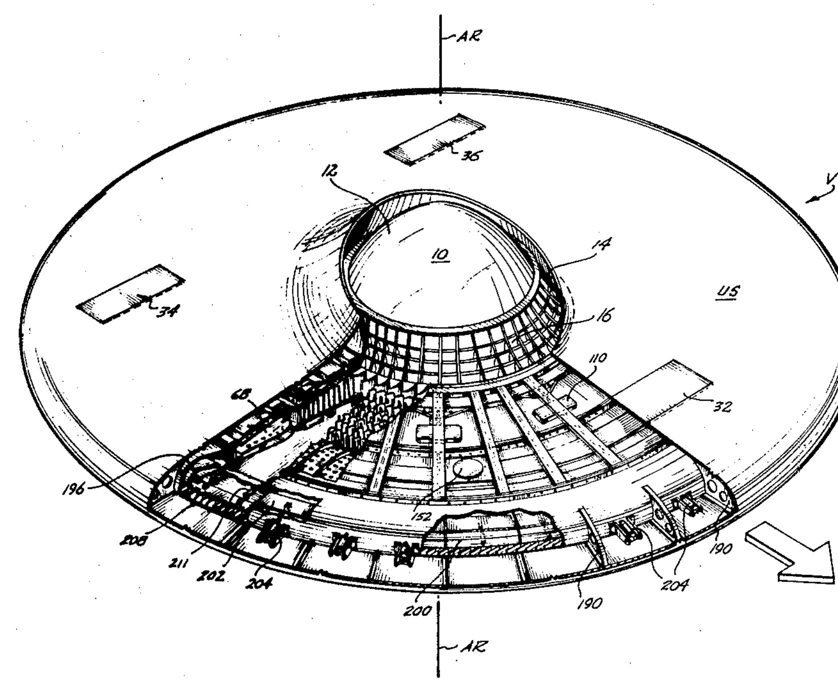
Attorney, Agent, or Firm—Graybeal & Uhlir

[57] **ABSTRACT**

An annular, radial flow gas turbine engine and airborne vehicle utilizing same for jet propulsion. The engine comprises counter-rotating rotors and a compressor section with counter-rotating annular rows of intermeshing compressor blades, an annular combustion section common to both rotors wherein the combustion zone is defined by oppositely rotating rotor walls, and a turbine section made up of annular rows of counter-rotating exhaust turbine blades. No stator blades are present in either the compressor or the turbine sections. The craft comprises a central hub on which the engine rotors rotate on thrust bearings, and air bearings maintain rotor tolerances with respect to each other and to nonrotating shell portions above and below the engine rotors. Air inlet guide vanes leading to the compressor section are also housed in the hub portion of the craft. Exhaust gases emitting from the turbine section are selectively ducted through annularly arranged, downwardly directed lift thrust producing ducts and/or rearwardly directed ducts or vanes for generation of forward propulsion. Directional control during hovering and low speed flight is by selective braking of one or the other of the rotors, and during high speed flight also by selective control of spoiler surfaces arranged in the upper and lower external surfaces of the craft.

27 Claims, 8 Drawing Figures



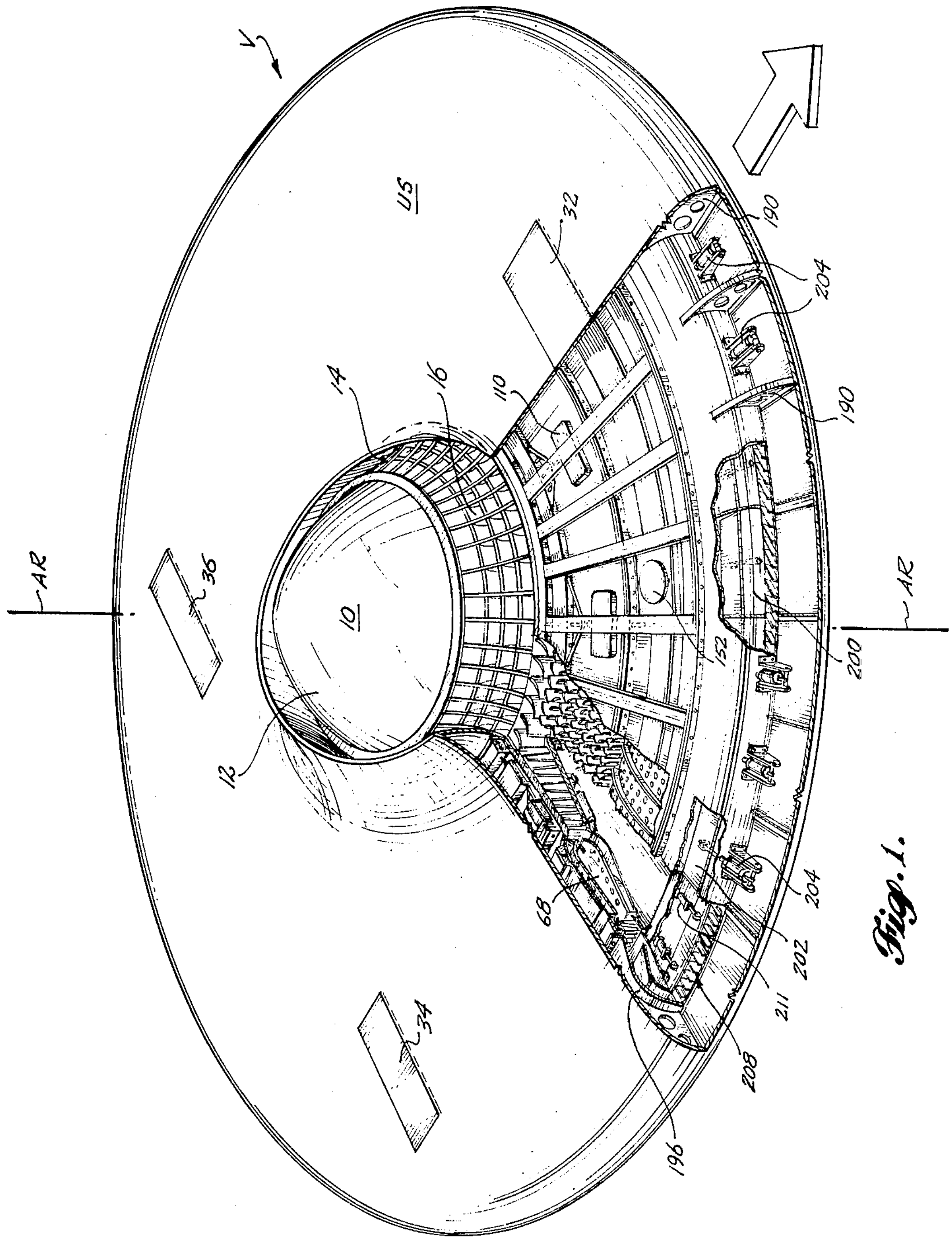

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Fig. 1.

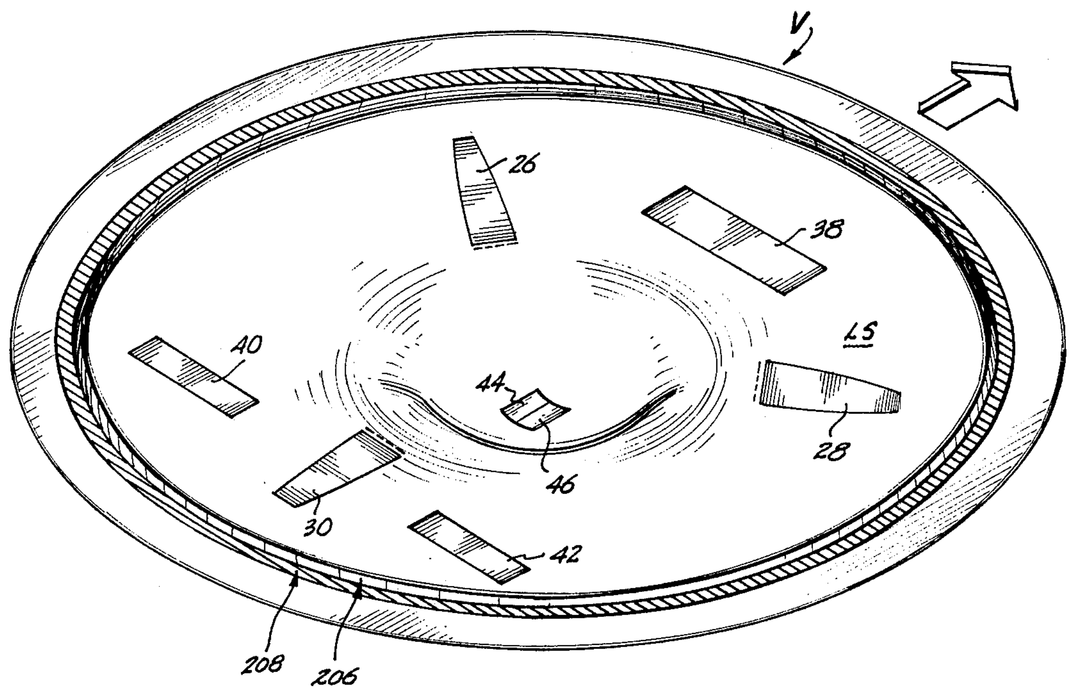

Fig. 2.

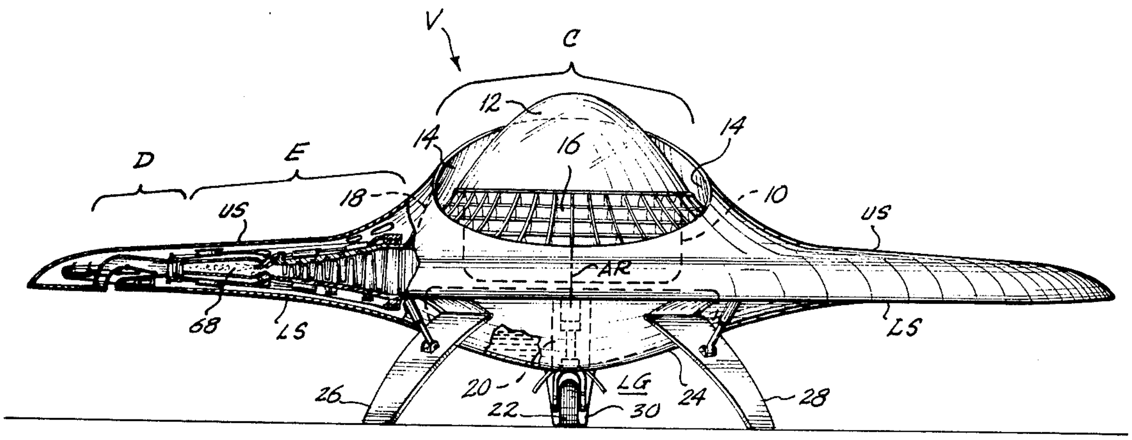
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Fig. 3.

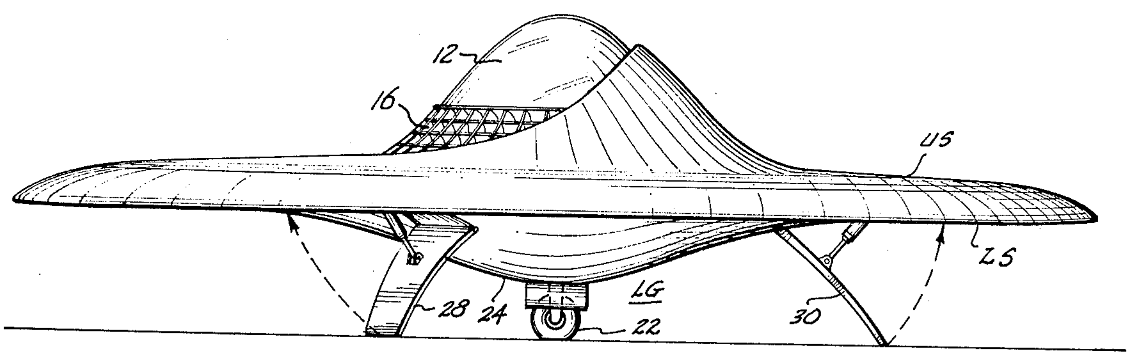
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Fig. 4.

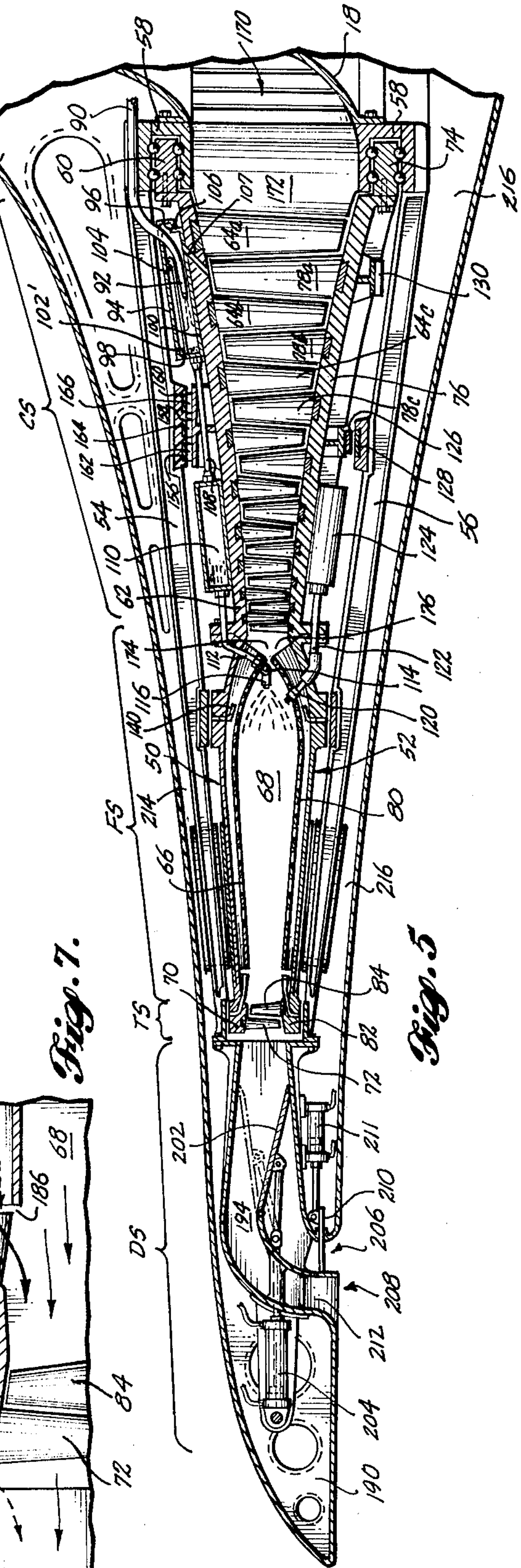

Fig. 5

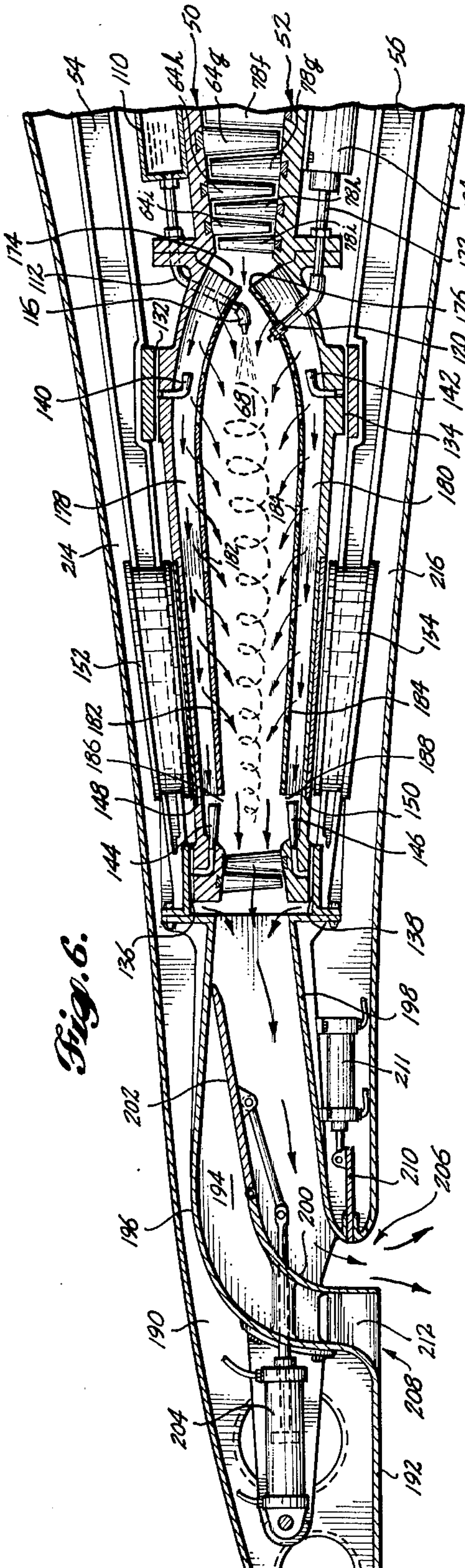

Fig. 6

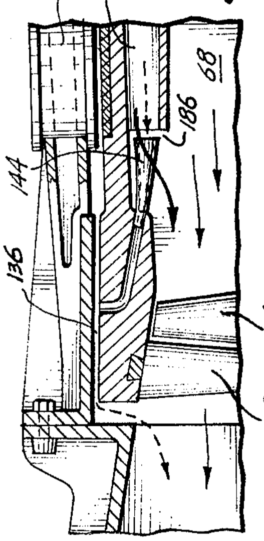

Fig. 7

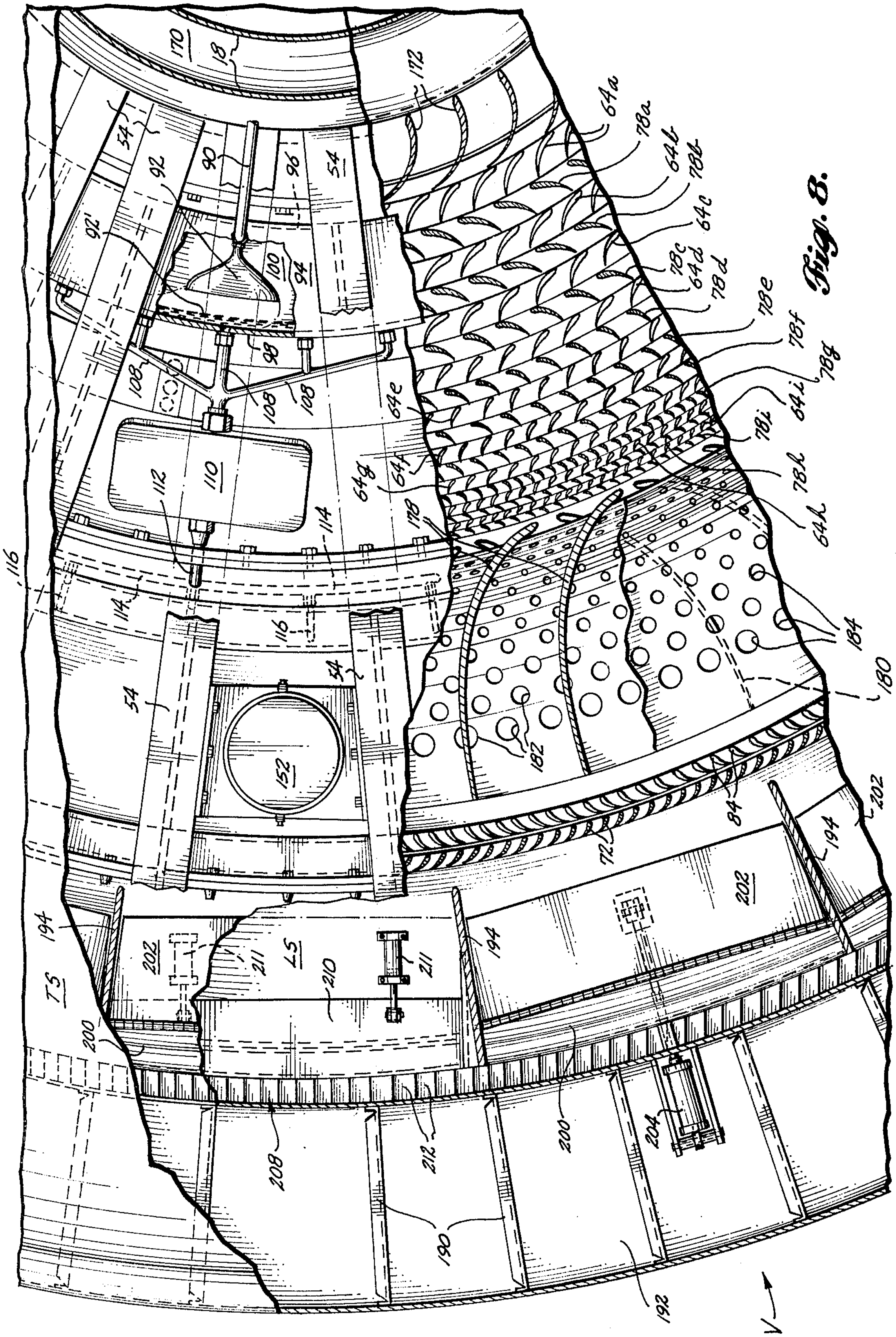

Fig. 8.

DISC-TYPE AIRBORNE VEHICLE AND RADIAL FLOW GAS TURBINE ENGINE USED THEREIN

CROSS REFERENCE TO RELATED APPLICATION

This is a continuation-in-part of application Ser. No. 702,523, filed July 6, 1976, now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an annular radial flow gas turbine engine and a disc type airborne vehicle employing same in conjunction with thrust and aerodynamic surface control means enabling the vehicle to take off and land vertically, to hover and to engage in both low speed and high speed aerodynamic flight.

2. Description of the Prior Art

The broad concept of an aircraft powered by a radial flow gas turbine engine is old, such as disclosed in Smith U.S. Pat. No. 2,850,250. In the engine disclosed by Smith, an internal set of stator blades is required for the compressor and turbine sections which adds weight to and unduly complicates the engine. Air input to the first stage of the compressor is restricted due to a plurality of conduits or openings of somewhat smaller diameter than the opening to the compressor. This feature together with the counter-rotational rotor blades creates a noncontinuous flow of air to the compressor input. Also, the Smith engine employs a plurality of so-called "can type combustion chambers" of relatively limited volumetric capacity per given weight and which of themselves simply house the combusting products, i.e. contribute no turbulence or mixing effect to the fuel air mixture or combusting products. It is also a disadvantage of the engine and aircraft arrangement disclosed by Smith that the products of combustion emitting from the annular array of combustion chambers are simply ducted in essentially only one direction from the craft.

Heinze U.S. Pat. No. 1,868,143 discloses a turbine engine utilizing a premixture of fuel and air for communication to a compressor comprising counter-rotational blades. This premixture is drawn into the compressor through an input chamber of relatively small diameter by a hollow rotating shaft having a plurality of holes at one end. As in the Smith patent, this feature creates a noncontinuous flow of premixed fuel and air to the compressor input. Heinze also teaches the use of a rectangular shape combustion chamber with a capacity of at least three times that of an input chamber in communication therewith prior to compression. This configuration has inherent safety and operational disadvantages in that Heinze discloses the compression of a potentially explosive fuel air mixture while providing a combustion chamber of a geometric shape insufficient to sustain combustion.

Frost et al Canadian Pat. Nos. 683,142 and 787,245 present essentially identical disclosures of disc type aircraft with essentially identical radial flow gas turbine engine propulsion systems. In the Frost et al propulsion systems the engines also require compressor and exhaust stator blading and also employ stationary can type combustion chambers with the same disadvantages as discussed above with respect to Smith. A further and significant disadvantage of the Frost et al engine is its use of a single rotating compressor and turbine element interfacing with corresponding stator elements in contrast to use of counter-rotating elements in the manner characteristic of the present invention. A single rotating compressor and turbine element result in excessive torque and the direction of the rotor rotation and also causes large gyroscopic precessional forces presenting serious design and operational complication in the practical use of this type of engine. Further, although Frost et al discloses the use of air bearings to support radial and axial loads, the Frost et al engine provides no conventional mechanical bearings for support of the rotor portions of the engine during engine start-up and shutdown and during other engine operating conditions when air bearings alone do not entirely satisfy required engine tolerances.

Mulgrave et al U.S. Pat. No. 2,997,254 discloses the use of lift means annularly disposed beneath a vehicle. Forward propulsion of the vehicle is provided by a plurality of panels sequentially disposed about the upper surface of the vehicle. Although Mulgrave teaches the use of the propulsion in the forward direction by ducting a portion of the exhaust gases, such propulsion is not accomplished by a continuous annular ducting means generally disposed peripherally around the underside of the vehicle.

Freeland U.S. Pat. No. 3,045,951 shows a propulsion ducting system which appears to be continuous but is on the horizontal side of a vehicle and is not disposed peripherally beneath the vehicle.

McDevitt U.S. Pat. No. 3,568,955 although showing annular propulsion means disposed beneath a vehicle, does not teach the use of a continuous annulus of forward propulsion. In McDevitt, forward propulsion is provided by four dampers located at opposite ends of the vehicle.

Finally, viturally all aircraft gas turbine engines in present use are of the axial flow type providing only point thrust axially of a jet nozzle and aircraft using this type of engine must be designed accordingly. While axial flow gas turbine engines have been used for propulsion purposes in a few prototype vertical take-off and landing vehicles, the design limitations dictated by the inherent point thrust of the axial flow type engine necessitates extensive exhaust ducting and control features with the result that these vehicles have met with only modest overall success.

SUMMARY OF THE INVENTION

Radial flow jet engines according to the present invention receive air at a central cylindrical hub section and compress the air in an outward, radial direction under action of two counter-rotating, generally symmetrical rotors made up of a plurality of alternating, intermeshed rotor blades. The air thus compressed is delivered in radial flow into the combustion chamber through holes interspersed in the combustion chamber walls, with air turbulating vanes being also provided in the air flow path into the combustion chamber to aid in cooling the combustion chamber walls. Fuel is injected into the combustion zone and is continuously burned with the air to add velocity or kinetic energy to the air mass. Energy is extracted from the products of combustion by reaction thereof with counter-rotating turbine blades in the turbine section, with a portion of the energy thus extracted being used to drive the compressor section, and the remaining portion of the energy being utilized as jet thrust through annular exhaust outlets arranged generally peripherally of the craft to provide what may be termed "area" thrust, as distinguished from the "point" thrust characteristic of thrust systems used with axial flow jet engines.

The jet thrust system used in airborne vehicles according to the present invention comprises an annular array of lift thrust producing ducts, each occupying a sector of the craft, and also an annular array of forward propulsion thrust generating ducts or vanes, both of which arrays of thrust producing devices are arranged generally peripherally of the lower surface of the craft near the edge thereof. As will be apparent, such thrust ducts, acting in concert, effectively provide thrust over a substantial "area", as distinguished from one or more "point" thrust producing devices of the axial exhaust nozzle type, and inherently provide a more stabilized craft attitude during flight.

No stator blading is present or required in either the compressor or turbine sections of the engine, with the result that the net torque of the engine is nominally zero in that all rotating engine elements are essentially equal and oppositely reacting. The essentially symmetrical nature of the opposed rotor elements of the engine, particularly with regard to the opposed turbulating vanes in the combustion section, provide favorable air flow characteristics in terms of improved cooling and enhanced combustion efficiency.

It is a significant feature and advantage of the airborne vehicle of the present invention that the engine rotor elements, and particularly the counter-rotating compressor blades and thrust blades thereof, rotate at radii of relatively great length, i.e. several feet. As a consequence, for any given rotational speed desired (in terms of lineal feet per second), the revolutions per minute (rpm) of the rotor elements is relatively quite low so that much lower centrifugal forces are developed. Stated otherwise, the relatively high rpm characteristically needed for axial flow jet engines in order to develop a given amount of gas flow and thrust is not necessary in radial flow engine according to the present invention. As a further and somewhat related advantage and feature, the annular, continuous configuration of the combustion chamber defined by the oppositely rotating combustion chamber wall portions of the rotor elements of the engine presented inherently provides a relatively large combustion chamber volume for a given engine weight, as compared with the weight and relative complexity of a comparable propulsion system involving a plurality of can-type combustion chambers of like total volume.

Additional features and advantages of jet engines and airborne vehicles incorporating same according to the invention will be apparent from the following description of a typical, illustrative embodiment thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top perspective view of a disc-type aircraft embodying the invention, with various parts broken away to further show the constructional detail of certain portions thereof;

FIG. 2 is a bottom perspective view of said aircraft in flight attitude;

FIG. 3 is a front view of said aircraft in landed attitude, with a portion thereof broken away in radial section through one radial dimension of the engine and control components thereof;

FIG. 4 is a side view of said aircraft;

FIG. 5 is an enlarged radial section view of a portion of the engine of said aircraft, taken substantially on a line perpendicular to the forward direction of flight, i.e. taken substantially along the cutaway portion shown in FIG. 3;

FIG. 6 is a further radial sectional view on a larger scale of certain parts of the engine and thrust control components shown in FIG. 5;

FIG. 7 is a fragmentary, sectional view on a further enlarged scale of certain parts of the engine shown in FIG. 6, particularly in the portion thereof at the downstream end of the combustion section FS and the thrust section TS; and

FIG. 8 is a top, fragmentary view with various parts broken away and shown in section, further illustrating the structure and internal detail of the engine and thrust control components associated therewith.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In general, the disc-type airborne vehicle V shown in FIGS. 1-4 comprises a central section C surrounded by an annular, radial flow jet engine generally designated E and an annular thrust control duct section generally designated D, the external shell of the vehicle being made up of respective upper and lower aerodynamic surfaces generally designated US and LS, with suitable landing gear, generally designated LG, incorporated in the latter. The central section C is functionally, in relation to the engine E, a relatively stationary central hub and includes a cockpit area 10 for the occupant(s) and controls (not shown). The cockpit area 10 is enclosed by a transparent or translucent canopy 12, the configuration of the craft upper surface US around the cockpit area 10 being such that an annular air intake plenum 14 is provided in a generally forwardly open configuration (note FIGS. 3 and 4) to provide ram air ingress into the engine E during cruising flight, the incoming air moving into the plenum 14 and through cascade deflection vanes 16 in the forward portion of the plenum, and annular ducting 18 (also note FIGS. 5 and 6) to the air intake area of the engine E. Central section C also houses wheel well 20 into which landing wheel 22 retracts, and fuel storage tank means 24, as well as appropriate miscellaneous accessory equipment (not shown). In addition to the landing wheel 22, the landing gear LG comprises retractable ground engaging stabilizer panels 26, 28, 30 which, when retracted, form part of the aerodynamic lower surface LS (FIG. 2). Both the upper aerodynamic surface US and lower dynamic surface LS include respective aerodynamic spoiler and control surface panels 32, 34, 36 and 38, 40, 42 for attitude control during flight, in a manner conventional per se. As shown in FIG. 2, wheel well 20 is provided with cover panels or doors 44, 46 maintained in closed position when the landing wheel 22 is retracted.

The radial flow engine E, as best shown in FIGS. 3, 6 and 7, generally comprises a central section C, a compressor section CS, a combustion section FS and a turbine section TS, all in a radial flow relation. The radial flow relationship introduces novel restrictions and advantages as compared to conventional axial flow engines.

With reference to FIG. 3, it can be seen that, in the embodiment of the invention illustrated, the central area C with plenum chamber 14 occupies about forty percent of the radial length of engine E. As will be understood, although the preferred embodiment shows an air intake plenum chamber of about forty percent of the radial length of engine E, other embodiments may involve plenum chamber sizes of somewhat smaller or even larger proportions. A relatively large chamber size is required to prevent engine "choking" (i.e. the inability of the engine to effectively input additional air when air flow mach numbers approach 1.0), and in this respect it is considered that the radial length of the air intake plenum chamber should be at least about one-third the radial length of the engine overall. Additionally, the chamber inlet geometry is such as to allow inlet air to smoothly and continuously to approach and impinge upon the first stage of the compressor CS when inlet air fails to smoothly impinge upon the first stage of the compressor or impinges on the first stage in less than a full compressor blade width, recirculation of inlet air usually occurs resulting in ineffective compressor operation and overheating of the compressor blades.

In the embodiment shown, the compressor CS is of a radial length approximately one-quarter of the radial length of engine E and is characterized by radial geometry with sharply contracting or decreasing radial side wall members **62** and **76**. As inlet air is compressed its pressure and density tend to increase with a resulting decrease in velocity. The contracting side walls of the compressor maintain the relative velocity of the compressed air constant as it moves radially away from the chamber **14**. With each row of compression blade **64** and **68** in counter-rotation with respect to each other the compression ratio per pair of blade rows is substantially higher than would be expected from a conventional pair of blade rows under the same conditions of air flow mach number from axial type engines.

The combustion chamber FS, in the embodiment illustrated, also occupies approximately one-quarter the radial length of the engine E. The important consideration in this respect is that the combustion chamber be of a sufficient length to ensure complete air-fuel mixture prior to burning. Additionally, the substantially larger cross-sectional area of the combustion chamber **14** downstream from that where the air-fuel mixture entered produces a large volume in which the velocity of the mixture decreases to ensure complete combustion. As shown in FIG. **6** and described below, vortexing of the compressed air and fuel as it enters the combustion chamber assists in the mixture of the two and promotes "flame holding" without which combustion within the chamber could not be self-sustaining.

Turbine TS, in the embodiment shown, occupies less than about five percent of the radial length of the engine E. In conventional axial flow engines the turbines generally have an increasing cross-sectional area, however this requirement is substantially reduced in the radial engine of the present invention due to the naturally increasing cross-sectional area of the radial geometry. Since turbine TS is disposed rear the extreme outboard end of vehicle V and at the outboard end of engine E, blades **72** and **74** are small since blade velocities at such a radial distance from the axis of rotation tend to be high.

Viewed structurally, respective upper and lower rotor elements, generally designated **50**, **52**, counter-rotate during engine operation between respective relatively stationary upper and lower engine housings **54**, **56** about a center or axis of rotation designated diagrammatically in FIGS. **1** and **3** at AR. As will be noted, each of the rotor elements **50**, **52** is essentially a symmetrical reversal of the other. Upper rotor **50** is journaled to the stationary frame member **58** in the central section C by means of bearing ring **60** and its portion **62** in compressor section CS mounts a series of compressor blades **64***a*, **64***b*—**64***i*. Outboardly of the compressor section CS, the upper rotor element **50** comprises a further wall portion **66** which functions as the upper wall of the combustion chamber **68** of the combustion section FS. Outboardly of the combustion chamber wall portion **66** of rotor **50** is a further annular portion **70** in which is mounted an annular ring of turbine blades, one of which is indicated at **72** in FIGS. **5**, **6** and **7**, in the turbine section TS of the engine E. Similarly, lower rotor element **52** is journaled to the stationary frame member **58** of the central section C by means of bearing rings **74** and comprises portion **76** in the compressor section CS which mounts successive, annularly disposed series of compressor blades **78***a*, **78***b*—**78***i*. Similarly, also, the lower rotor element **52** further comprises an annular portion **80** serving as the lower wall of combustion chamber **68**, and in its portion **82** in the turbine section TS mounts an annularly disposed series of turbine blades **84**.

For gravitational reasons, the upper rotor element **50** carries the rotating components of the fuel delivery system. More specifically, the fuel system of the engine E comprises a stationary fuel delivery line **90** leading to relatively stationary fuel discharge nozzles **92** which, as best shown in FIG. **8**, deliver a fuel spray **92'** into an annular fuel manifold made up of stationary walls **94**, **96** and rotating walls **98**, **100** provided with labrynth seals **102'**, **104**, **106** (FIG. **5**) therebetween. One or more vent lines, one of which is indicated at **107** in FIG. **5**, provide reduced pressure communication between the annular fuel manifold and an upstream stage of the compressor section CS to provide negative pressure to scavenge fuel vapors. Fuel pickup from the rotating portion of the fuel manifold is by centrifugal flow through manifold fuel lines **108** (FIG. **8**) into fuel control units, one of which is shown at **110**, wherein the fuel flow is metered or modulated in a manner conventional per se, to meet demand. The fuel output from the control units **110** passes through fuel line **112** to manifold line **114** and from there is distributed to the various nozzles **116** and discharged therefrom into the combustion chamber **68**. In a typical design, for example, some sixteen fuel control units **110** may be employed to deliver fuel to a sixty-four unit array of fuel nozzles **116** in the combustion chamber **68**.

In the engine configuration shown in FIGS. **5**–**8**, the bottom rotor element **52** carries one or more fuel igniter plugs **120**, fired in a manner conventional per se, such as through lead **122** from coil **124**, which is energized through contactor and contact ring **126**, **128**. Lower rotor element **52** also carries an annular ring gear **130**, engageable by a starter motor (not shown), which can also serve as a drive gear for accessory units.

Respective annular air bearings are appropriately provided in outboard portions of the engine, such as near the inboard and outboard extremities of the combustion section FS. Thus, for example, as best shown in FIG. **6**, inboard annular air bearings **132**, **134** are provided between the upper rotor element **50** and upper engine housing **54** and between lower rotor element **52** and lower engine housing **56**, respectively, and outboard air bearings **136**, **138** are provided in the turbine section TS. As also shown in FIG. **6**, pressurized air is suitably supplied to the air bearings, as by venting a portion of the air being delivered to the combustion chamber to the air bearings through respective impact tubes **140**, **142** and air passages **144**, **146**.

Also carried by the respective upper and lower rotor elements **50, 52** are respective annular ferromagnetic rings **148, 150** which function with a plurality (preferably at least four) of opposed electromagnetic coils, two of which are shown in FIG. **6** and designated **152, 154**, to provide yaw control. Selective energization of either the upper or lower set of electromagnetic coils **152** or **154** functions to brake the rotation of the corresponding rotor element proportionally to the extent of energization of the electromagnetic coils. Since the upper and lower rotor elements **50, 52** nominally counter-rotate at essentially equal velocities, if one is slowed down by energization of its associated yaw control electromagnetic coils, the resulting differential in rotational speeds of the rotor elements generates a rotational reaction thrust on the vehicle to change its directional heading. In this respect it is notable that such yaw control is entirely independent of aerodynamic factors.

Electrical circuit contact rings **156, 158, 160** and associated contact buttons **162, 164, 166** are arranged between the upper engine frame **54** and upper rotor element **50** and serve as individual electrical circuit connectors, such as for the throttle control signal delivered to the fuel control unit **110**, and for a grounding contact or the like.

Air flow to the engine E at cruising speed, as earlier indicated, is by ram pick-up of air by plenum chamber **14** and, in the forward portion of such chamber, through the cascade deflection vanes **16**. The chamber **14** is configured to deliver the incoming air into what may be termed an engine air intake region **170** which is occupied by stationary air inlet guide vanes **172** (note FIG. **8**) immediately ahead of the first stage compressor blades **64*a***. As will be understood, the first stage compressor blades and each successive stage of compressor blades **78*a*, 64*b*** through **64*i*, 78*i***, adds additional pressure and energy to the air until the air enters the diffuser zone **174** immediately downstream of the last stage of the compressor section CS. Several advantages of a compressor section with counter-rotating rotors are to be noted. First, all compressor blades are adding energy to the oncoming flow of air since there are no stator blades required to straighten the air flow for each successive stage of compression. Stator blades in axial flow type compressors in fact actually absorb or extract energy in the process of changing air flow direction. Secondly, for a given amount of compression, a much lower rotor rotational speed is required than in conventional axial type compressors since the relative speed between successive stages of compressor blades is nominally twice the speed of rotation of either of the rotors with respect to the associated stationary structure, and since each stage of compression adds energy to the air without intervening absorption of energy by stator means. Thirdly, the high degree of symmetry of the compressor blades, and indeed the whole of the rotating elements of the entire engine, results in little or no net torque being generated. Fourthly, the centrifugal force on the compressor blade tips is very largely offset by the reaction of the blade tips with the incoming air, which acts in the opposite direction. Fifthly, the direction of air flow through the compressor is essentially straight, arriving at the diffuser zone by movement along an essentially radial direction of movement with respect to the axis of rotation AR.

The compressed air in the diffuser zone **174** is in a relatively static state even though enclosed by counter-rotating elements. A small portion of the air is bled directly from the diffuser zone **174** through the gap **176** between the leading edges of the two opposed combustion zone walls **66, 80**, for the primary purpose of cooling the fuel manifold **114** and associated nozzles **116**. This air then joins the primary air for fuel combustion, which is picked up from the diffuser zone **174** by oppositely rotating turbulating vanes **178, 180** (also note FIG. **8**) and enters the combustion chamber through holes interspersed along the combustion chamber walls **66, 80**, certain of which holes are shown at **182** in wall **66** and at **184** in wall **80**, the directions of air flow in this regard being generally shown by arrow designations in FIG. **6**. As will be understood, since air delivery holes **182, 184** are dispersed along most of the radial dimension of the combustion chamber walls **66, 80**, there is a progressive delivery of combustion air to the fuel combustion zone. In commonly used fuel combustion parlance, the air entering the relatively inboard region of the combustion zone is the first air combusted or the so-called primary combustion air, the air entering the zone intermediately of the radial dimension thereof is what may be termed intermediate or secondary combustion air, and the air entering the combustion zone most downstream thereof is what may be termed dilution or tertiary combustion air. As earlier indicated, certain portions of this air are also delivered to the impact tubes **140, 142** and air passages **144, 146** to pressurize the respective air bearings **132, 134, 136, 138**. It is an advantage of this manner of delivery of air to the combustion chamber **68** that the air flow through the holes **182, 184** in part serves to cool the combustion chamber walls **66, 80** and in part to elongate the flame envelope for more effective and complete combustion of the fuel. It is theorized that the mixing of the fuel and air mixture in the combustion zone **68** is considerably enhanced by reason of the counter-rotating movement of combustion chamber walls **66, 80** as the air is delivered through the holes therein, the oppositely moving air delivery holes **182, 184** in effect providing a mixing action of a spiralling nature of more or less equal turbulence throughout the annular combustion zone and a materially increased loiter or dwell time for the fuel/air mixture. Stated otherwise, the primary air being delivered through the holes **182** in the upper chamber wall **66** has a tangential component of velocity and pressure equal and opposite to the primary air being delivered through the holes **184** of the bottom wall **80**, with a vortical motion being generated in the gases throughout the combustion zone.

As will be appreciated, the turbulating vanes **170, 180** not only act as stiffeners along both radial and circumferential vectors with respect to the combustion chamber walls, i.e. as stiffeners in a structural sense, but function as a centrifugal compressor or supercharger for the air being delivered to the combustion zone.

In the combustion chamber as shown in FIGS. **5, 6** and **7**, it is also notable that the air not delivered to the combustion zone or to the air bearings by the turbulating vanes **178, 180** is fed through respective upper and lower annular slots **186, 188** to provide cooling throughout the outboard extent of the combustion chamber walls **66, 80** and to the turbine blades **72, 84**, and also to the exhausting products of combustion.

In a manner conventional per se, reaction and expansion of the products of combustion as they pass through the blades of the turbine section TS are used to drive the compressor section CS and appropriate accessories (as by ring gear **130**). Arranged outboardly of the engine E, generally peripherally of the vehicle is what may be termed a thrust ducting section DS, which in general includes an annular arranged series of selectively controllable lift thrust producing duct means and forward propulsion thrust generating duct means. As will be observed, the duct section DS is a stationary portion of the vehicle in the sense of being nonrotating relative to the central section CS. In that these two sections are in more or less rigid relationship to each other, the duct section DS can readily serve a structural strengthening function with regard to the thrust generating components. In this respect, for example, the duct section DS includes vertical stiffening panels **190** joining with the sheeting forming the upper surface skin US and the outboard portion **192** of the skin forming the lower surface LS, and vertical panels **194**, which also serve as certain vertical wall portions of the thrust ducting structure, the other walls of which are essentially provided by upper walls as at **196**, lower walls as at **198**, and separator walls as at **200**.

Vertical stiffening panels are also provided between the engine framing **54, 56** and the respective upper and lower skins US, LS, as at **214, 216**.

Deflector vanes **202**, pivotally movable by action of respective fluid cylinders **204**, serve to selectively deliver the exhaust gases discharging from the turbine section TS through either the annularly arranged series of lift thrust exhaust nozzles **206** or the annularly arranged series of forward thrust exhaust nozzles **208**, or both, as determined by the relative position of associated deflector vanes **202**. By way of example, FIG. **5** shows a deflector vane **202** in its attitude for maximal delivery of the exhaust gases to the forward thrust exhaust nozzles **208**, and FIG. **6** shows such deflector vane **202** in its attitude for delivery of maximal flow of exhaust gases to the lift thrust nozzles **206**. In addition, each of the lift thrust exhaust nozzles **206** is provided with a fluid cylinder actuated lift gate valve **210**. The lift gate valves **210** are provided at equally spaced locations annularly of the vehicle, such as at four locations, to provide control means for effecting vehicle stability and attitude control during hover and transitional phases of flight. These control functions are accomplished by closing to a selected degree one or more of the gate valves **210**, thus creating a sector imbalance in the cylindrical sheet of high pressure gases issuing from the lift thrust exhaust nozzles **206**. As will be understood, if the right side of the vehicle drops, for example, the gate valve **210** on the left side can be closed or partially closed, as by selective actuation of fluid cylinder **211**, to reduce or cut off a segment of the lift thrust at the left side of the craft, thus creating the necessary corrective force at the right side. Similarly, a quartering correction can be made by actuating two adjacent lift gate valves in a similar manner. As will also be understood, the controlling effect of these lift gate valves is at a maximum during hovering flight and diminishes proportionately as the vehicle transitions to forward aerodynamic flight as determined by the positioning of the exhaust deflection vanes **202**. In aerodynamic cruising flight, the spoiler or attitude control surfaces **32-42** constitute the primary control elements.

The forward thrust exhaust nozzles **208** are provided with cascade deflector vanes **212** in fixed, continuous array around the entire annular nozzle array, it being understood that the progressive configurations of these cascade vanes **212** are such that each deflects the downwardly moving exhaust gases moving therethrough in a rearward or primarily rearward direction. It is theorized that the gases emerging from the forward thrust exhaust nozzles **208** will "Coand" along the lower surface skin LS.

In the light of the foregoing discussions of certain structural and operational aspects of the invention, it is to be observed that the craft and engine configuration presented is characterized by the craft in general being annularly symmetrical and relatively thin with aerodynamically clean interfacing between the engine nacelle, wing and fuselage, all three such components, conventionally considered, being essentially the same thing.

Since the radial flow engine presented is relatively quite thin, its use permits a skin configuration having a very low drag profile during forward flight, notwithstanding that the size of the engine is relatively large in terms of its combustion chamber volume. The thin, compact configuration capability of the engine affords a wide range of flexibility in designing and adapting the engine and craft to prescribed vehicle power, load and range requirements. Also, no vertical stabilizers are required for the vehicle because of the internal yaw control components discussed, so that less drag and weight are involved in any given craft design.

The overall efficiency of the engine, in terms of its high thrust to weight ratio, is quite high, in that, with the exception of the combustion zone walls and internal fuel delivery elements, all internal rotating elements are adding or extracting heat and pressure energy. The radial vane stiffeners (turbulating vanes **178, 180**) also increase engine efficiency in that the positive compression or supercharging action on the air being delivered to the combustion zone, serves to keep the compressor section "unloaded" and improve the overall air flow characteristics of the engine.

As will also be apparent, the engine is adaptable to so-called "fan" or high-bypass-ratio engine modifications, with appropriate redesign of the engine radial support strut housings to accommodate the bypass fan blades for "fan" type engine operation, in a manner conventional per se.

Since jet engine exhaust noises are caused primarily by the concentrated stream of hot exhaust gases reacting with cooler ambient air, the propulsion duct system of the present invention enables substantial reduction in external noise level because its exhaust gases are emitted in thin, cylindrical sheets of relatively large surface area, making it possible for ambient air to more quickly and effectively mix with and cool the hot exhaust gases over a larger interface area than is the case with the exhaust gases from conventional axial flow type jet engines.

Another type of noise problem encountered with conventional axial flow type jet engines is that of intake "whine". This type of noise phenomenon is much less severe in the radial flow engine of the present invention because of its characteristically lower rpm during operation, and because this type of noise is primarily radiated along the plane of rotation of the rotor means and may be readily suppressed in the present engine by sound absorbent materials placed in the vehicle plenum chamber surrounding the engine.

Although the invention has been described with particular attention to and discussion of a generally circular, disc-type airborne vehicle of the aircraft type, capable of high or low altitude atmospheric flight, it will be readily understood that the invention is also applicable to airborne vehicles which are non-circular in configuration and that certain aspects of the invention, such as the radial flow engine thereof, are readily adaptable to other types of vehicles, such as so-called ground effect machines (GEMs), and even to certain stationary jet engine installations, or otherwise, and to any power generating application where an efficient, symmetrical, thin, annularly configured jet engine, producing relatively large amounts of exhaust products at relatively low engine rpm and at relatively high thrust-to-weight ratios, is desired.

It is theorized that a further advantage of the radial flow engine of the present invention for use in aircraft and the like is that the engine rotor elements inherently provide gyroscopically induced inertial stabilization of the craft (enabling ground maneuverability on a single landing gear wheel, for example), with the rotor generated precessional forces being cancelled or at least minimized by reason of the two rotor elements generating nominally equal and opposite precessional forces relative to one another.

These and other objects, features, advantages and characteristics, and other modifications and applications of the present invention, will be apparent to those skilled in the art to which the invention is addressed, within the scope of the following claims.

What is claimed is:

1. In a disc type airborne vehicle having a central section including a cockpit area, jet engine means annularly surrounding said cockpit area, and thrust ducting means in a duct section annularly surrounding said jet engine means, the improvement wherein said jet engine means is characterized by:

(a) an annular compressor section having decreasing side wall members in the radial dimension wherein air is compressed under action of a plurality of counter-rotating compressor blades and delivered to an annular diffuser zone;

(b) air intake means of a radial length at least about one-third the radial length of said engine, disposed within said central section, said air intake means being in constant communication with said compressor section and delivering a supply of air thereto, said supply of air continuously impinging upon the entire width of said plurality of compressor blades;

(c) an annular combustion chamber including upper and lower counter-rotating combustion chamber walls having air delivery openings therein, with said annular diffuser zone delivering compressed air directly into said combustion chamber and around said counter-rotating combustion chamber walls and into said combustion chamber through said air delivery openings in said counter-rotating combustion chamber walls;

(d) means for continuously delivering fuel directly into said combustion chamber for admixture therein with the compressed air delivered thereto from said compressor section annular diffuser zone;

(e) an annular turbine section wherein counter-rotating turbine blades are driven by combustion products exhausting in radial flow from said combustion chamber; and

(f) means delivering the exhaust gases discharging from said turbine section to said duct section.

2. A vehicle according to claim **1**, wherein said engine exhaust gas discharge means comprises a continuous annular array of lift thrust producing duct means and a continuous annular array of forward thrust generating duct means.

3. A vehicle according to claim **2**, wherein said array of forward thrust generating duct means is arranged generally adjacent to and outboardly of said array of lift thrust producing duct means.

4. A vehicle according to claim **1**, comprising ram type air intake means in said central section.

5. A vehicle according to claim **4**, further comprising fuel storage means in said central section.

6. A vehicle according to claim **1**, wherein said engine comprises upper and lower nonrotating engine support framing, respectively annularly arranged above and below upper and lower rotor elements each carrying alternately arranged compressor blades and alternately arranged turbine blades, said support framing being rigidly attached to said central section, with air bearing means arranged between each said rotor element and its associated engine support framing.

7. A vehicle according to claim **6**, including annular air bearing means situated between said engine support framing and rotor elements at about the inboard and outboard extremities of the combustion wall forming portions of said rotor elements.

8. In a disc type airborne vehicle having a central section including a cockpit area, jet engine means annularly surrounding said cockpit area, and thrust producing means annularly surrounding said jet engine means, the improvement wherein the overall configuration of the vehicle is characterized by convergent upper and lower surfaces extending outwardly to a generally circular peripheral edge with the outboard portion of the said lower surface extending generally radially of the vehicle, said thrust producing means are arranged annularly in said lower surface outboard portion and include a continuous annulus of lift thrust nozzles arranged in and selectively controllable in each of a plurality of sectors, and further include a continuous annulus of forward propulsion thrust nozzles comprising a plurality of cascade deflector vanes in fixed continuous array around said annulus, and control means selectively delivering the exhaust gases from said jet engine means to either or both of said lift thrust duct means and said forward propulsion thrust duct means to exert on the vehicle any desired combination of lift thrust and/or forward propulsion thrust.

9. A vehicle according to claim **8**, wherein said control means selectively delivering the exhaust gases to either or both of said lift thrust producing means and forward propulsion thrust producing means comprises fluid actuatable vane means arranged in the exhaust gases flow path.

10. A vehicle according to claim **8**, wherein each sector placed lift thrust duct means comprises fluid actuatable gate means for varying the volume of flow of exhaust gases passing through the associated lift thrust duct means in each said sector.

11. An airborne vehicle according to claim **8**, wherein said annular array of lift thrust duct means is situated inboardly of said annular array of forward propulsion thrust duct means.

12. A vehicle according to claim **11**, wherein each sector placed lift thrust duct means comprises a plurality of fluid actuatable gate means for individually varying the volume of exhaust gases passing through the associated lift thrust duct means in each said sector.

13. A radial flow gas turbine engine, comprising:

(a) an annular compressor section having decreasing side wall members in the radial dimension wherein air is compressed under action of a plurality of counter-rotating compressor blades and delivered to an annular diffuser zone;

(b) air intake means of radial length at least about one-third the radial length of said engine, said air intake means being in constant communication with said compressor section and delivering a supply of air thereto, said supply of air continuously impinging upon the entire width of said plurality of said compressor blades;

(c) an annular combustion chamber including upper and lower counter-rotating combustion chamber walls having air delivery openings therein with said annular diffuser zone delivering compressed air directly into said combustion chamber and around said counter-rotating combustion chamber walls and into said combustion chamber through said air delivery openings in said counter-rotating combustion chamber walls;

(d) means for continuously delivering fuel directly into said combustion chamber for admixture therein with the compressed air delivered from said compressor section annular diffuser zone; and

(e) an annular turbine section wherein counter-rotating turbine blades are driven by combustion products exhausting in radial flow from said combustion chamber.

14. An engine according to claim **13**, comprising upper and lower rotor elements, each of said rotors carrying alternate compressor blades in said compressor section, one wall of said combustion chamber, and alternate turbine blades in said turbine section.

15. An engine according to claim **14**, wherein each rotor element is substantially symmetrical of the other, being essentially the reverse of the other.

16. An engine according to claim **14**, wherein said engine further comprises upper and lower nonrotating engine support framing in generally annular arrangement, respectively above and below said upper and lower rotor elements, and air bearing means arranged between each said rotor element and its associated engine support framing.

17. An engine according to claim **16**, including annularly arranged air bearing means situated between said engine support framing and rotor elements at about the inboard and outboard extremities of the combustion wall forming portions of said rotor elements.

18. A radial flow gas turbine engine, comprising:

(a) an annular compressor section having decreasing side wall members in the radially axis wherein air is compressed under the action of a plurality of counter-rotating compressor blades;

(b) air intake means of radial length at least about one-third the radial length of said engine, said air intake means being in constant communication with said compressor section and delivering a supply of air thereto, said supply of air continuously impinging upon the entire width of said plurality of compressor blades;

(c) an annular combustion chamber receiving compressed air and radial flow from said compressor section, and including counter-rotating combustion chamber walls;

(d) means for delivering fuel to said combustion chamber for admixture with the compressed air delivered thereto by said compressor section;

(e) an annular turbine section wherein counter-rotating turbine blades are driven by combustion products exhausting in radial flow from said combustion chamber;

(f) upper and lower rotor elements, each of said rotors carrying alternate compressor blades in said compressor section, one wall of said combustion chamber, and alternate turbine blades in said turbine section; and,

(g) wherein each of the combustion chamber walls comprises air turbulating vanes arranged on said walls externally of the chamber defined by said walls, with the leading edges of said vanes disposed adjacent to and in air flow communication with the discharge areas of the compressor section, and with the trailing portions thereof extending substantially across the radial dimensions of the combustion chamber wall.

19. An engine according to claim **18**, comprising air delivery holes in said combustion chamber walls, and means for delivering air from said compressor section to said combustion chamber through said air delivery holes.

20. A radial flow gas turbine engine, comprising:

(a) an annular compressor section having decreasing side wall members in the radial dimension wherein air is compressed under action of a plurality of counter-rotating compressor blades and delivered to an annular diffuser zone;

(b) air intake means of radial length at least about one-third the radial length of said engine, said air intake means being in constant communication with said compressor section and delivering a supply of air thereto, said supply of air continuously impinging upon the entire width of said plurality of compressor blades;

(c) an annular combustion chamber including upper and lower counter-rotating combustion chamber walls having air delivery openings therein with said annular diffuser zone delivering compressed air directly into said combustion chamber and around said counter-rotating combustion chamber walls and into said combustion chamber through said air delivery openings in said counter-rotating combustion chamber walls;

(d) an annular turbine section having counter-rotating turbine blades driven by combustion products exhausting in radial flow from said combustion chamber;

(e) upper and lower rotor elements, each of said rotors carrying alternate compressor blades in said compressor section, one of said counter-rotating combustion chamber walls and alternate turbine blades in said turbine section; and,

(f) means for continuously delivering fuel directly into said combustion chamber for admixture therein with the compressed air delivered thereto from said compressor section annular diffuser zone comprising annular manifolding having stationary and rotor wall portions said rotor wall portions being carried by said upper rotor element inboardly of said combustion chamber.

21. A radial flow gas turbine engine, comprising:

(a) an annular compressor section having decreasing side wall members in the radial axis wherein air is compressed under the action of a plurality of counter-rotating compressor blades;

(b) air intake means of radial length at least about one-third the radial length of said engine, said air intake means being in constant communication with said compressor section and delivering a supply of air thereto, said supply of air continuously impinging upon the entire width of said plurality of compressor blades;

(c) an annular combustion chamber receiving compressed air and radial flow from said compressor section, and including counter-rotating combustion chamber walls;

(d) means for delivering fuel to said combustion chamber for admixture with the compressed air delivered thereto by said compressor section;

(e) an annular turbine section wherein counter-rotating turbine blades are driven by combustion products exhausting in radial flow from said combustion chamber;

(f) upper and lower rotor elements, each of said rotors carrying alternate compressor blades in said compressor section, one wall of said combustion chamber, and alternate turbine blades and said turbine section; and,

(g) air delivery holes in said combustion chamber walls, and means for delivering air from said compressor section to said combustion chamber through said air delivery holes comprising turbulating vanes carried by said combustion chamber walls and configured to further pressurize the air being delivered to said air delivery holes.

22. An engine according to claim **21**, further comprising air bearing means situated near the combustion chamber discharge region, said turbulating vanes in part functioning to additionally pressurize the air delivered to said air bearing means.

23. A radial flow gas turbine engine having an annular compressor section within an annular combustion section in turn arranged within an annular turbine section, said engine comprising:

(a) a non-rotary central section encircled by said compressor section and including air intake means and fuel supply means;

(b) counter-rotating upper and lower rotor elements journaled for rotation about said central section and each carrying

(1) alternately arranged compressor blades in said compressor section,

(2) a combustion chamber wall in said combustion section, and

(3) alternately arranged turbine blade means in said turbine section;

(c) non-rotary upper and lower engine support framing respectively annularly disposed above and below said upper and lower rotor elements;

(d) fuel delivery means between said central section and the combustion chamber defined by such combustion chamber walls, and including annular fuel manifold means receiving fuel from said fuel supply means, said fuel manifold means being in part arranged in fixed relationship with respect to one of such engine support framing means and in part carried by the rotor element support thereby; and,

(e) vent means interconnected between said fuel manifold means and an upstream stage of said compressor section and providing reduced pressure in said fuel manifold means to scavenge fuel vapor therefrom.

24. A radial flow gas turbine engine according to claim **23**, wherein said fuel delivery means comprises a plurality of fuel control units carried by one of said rotor elements and receiving fuel from the annular fuel manifold, and delivering such fuel to a plurality of fuel injection nozzles arranged in annular array in said combustion chamber.

25. A radial flow gas turbine engine according to claim **24**, wherein one of said rotor elements is the upper rotor element.

26. A disc type airborne vehicle including engine means according to claim **25**, and comprises a cockpit area in said central section, and thrust ducting means through which exhaust gases from said turbine section discharge.

27. A disc type airborne vehicle including engine means according to claim **23**, and comprising a cockpit area in said central section, and thrust ducting means through which exhaust gases from said turbine section discharge.

* * * * *

United States Patent [19]

Mutrux

[11] **4,196,877**

[45] **Apr. 8, 1980**

[54] **AIRCRAFT**

[76] Inventor: **Jean L. Mutrux,** 6 Sumac La., St. Louis, Mo. 63124

[21] Appl. No.: **806,580**

[22] Filed: **Jun. 15, 1977**

[51] **Int. Cl.**[2] **B64C 27/22;** B64C 3/12

[52] **U.S. Cl.** .... **244/12.2;** 244/23 C; 244/17.19; 416/114

[58] **Field of Search** .... 244/12.1, 12.2, 12.3, 244/23 R, 23 C, 23 B, 17.19, 6, 91, 34 A, 45 R; 416/114

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Primary Examiner—Galen L. Barefoot

Attorney, Agent, or Firm—Senniger, Powers, Leavitt and Roedel

[57] **ABSTRACT**

An aircraft comprising a generally annular wing structure surrounding a circular central structure to form an annular air duct, a pair of fuselages extending longitudinally at opposite sides of the aircraft, and rotor blades extending radially across the air duct from the central structure and rotatable relative to the central structure around the duct for inducing airflow through the duct to effect a lift on the aircraft. The annular wing structure consists of forward and rear wings forming air foils, the forward wing having a generally semicircular trailing edge and the rear wing having a generally semicircular leading edge.

8 Claims, 9 Drawing Figures

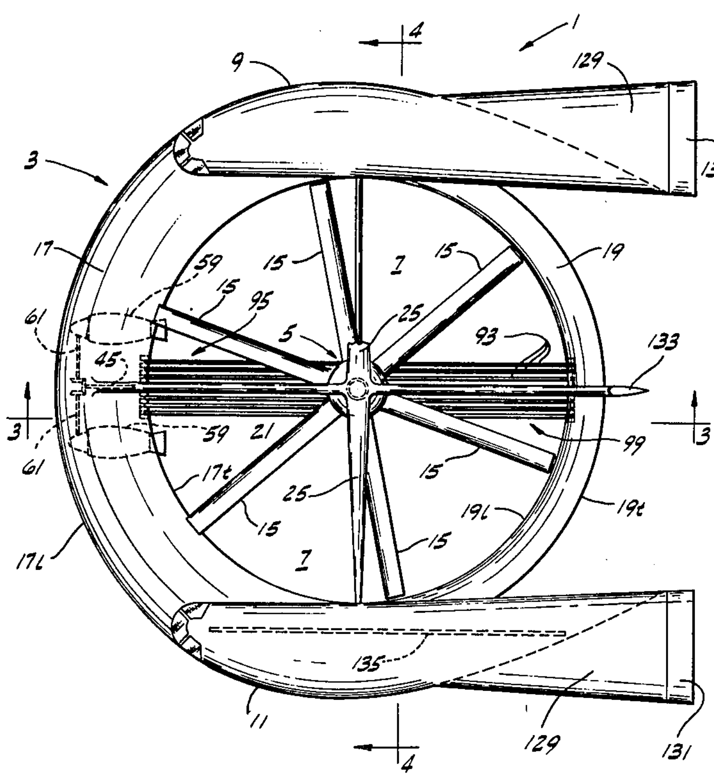
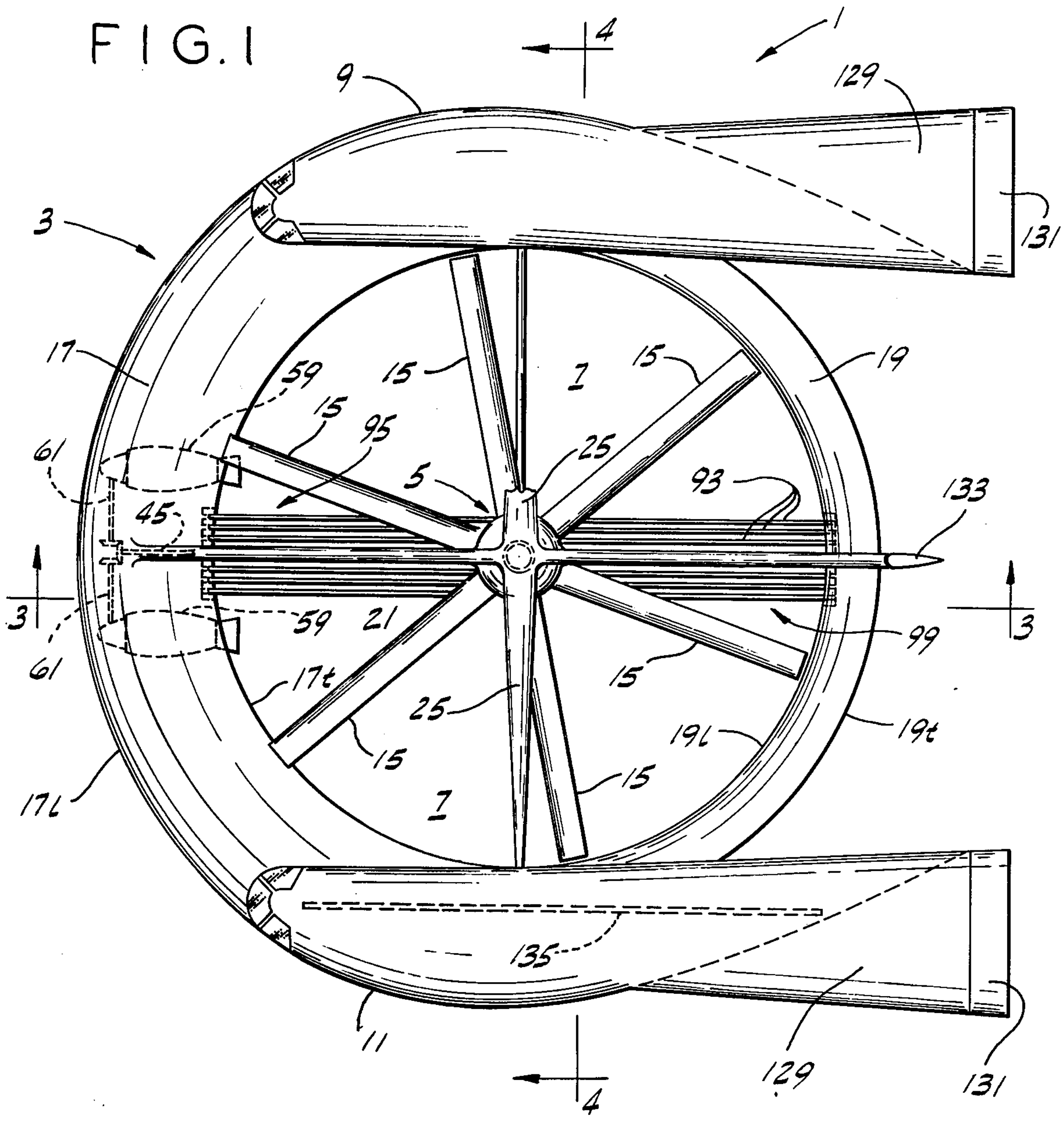


FIG. 1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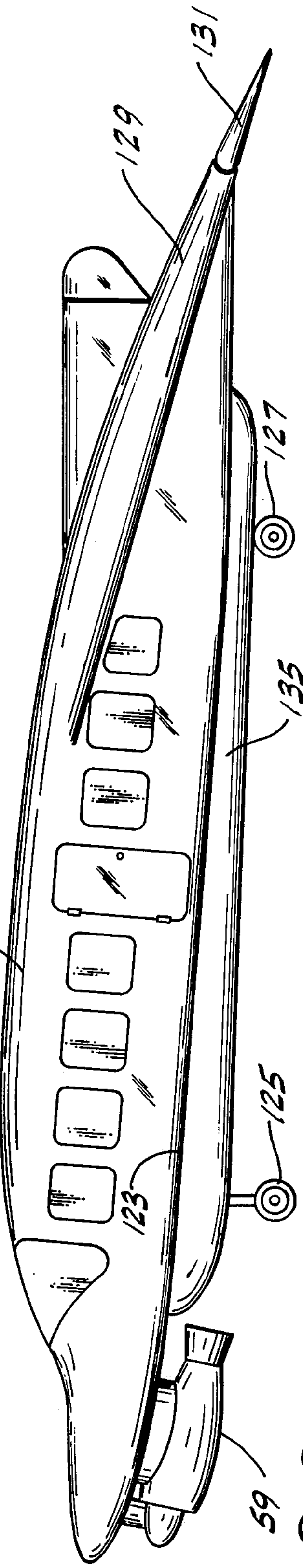

FIG. 2

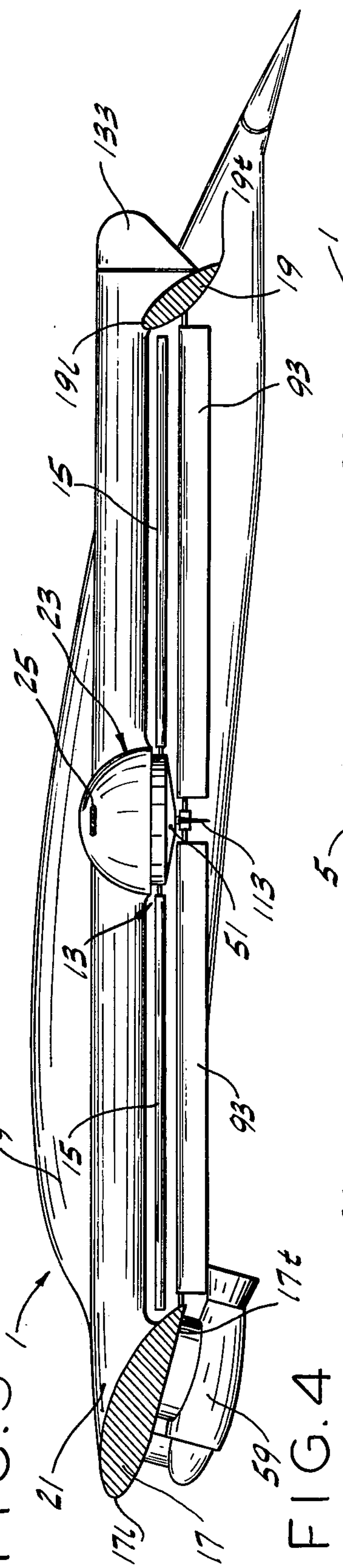

FIG. 3

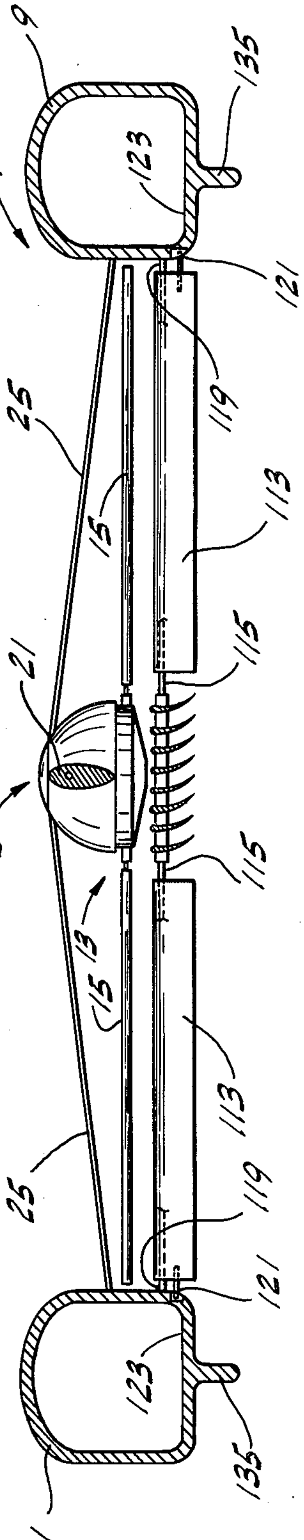

FIG. 4

FIG. 5

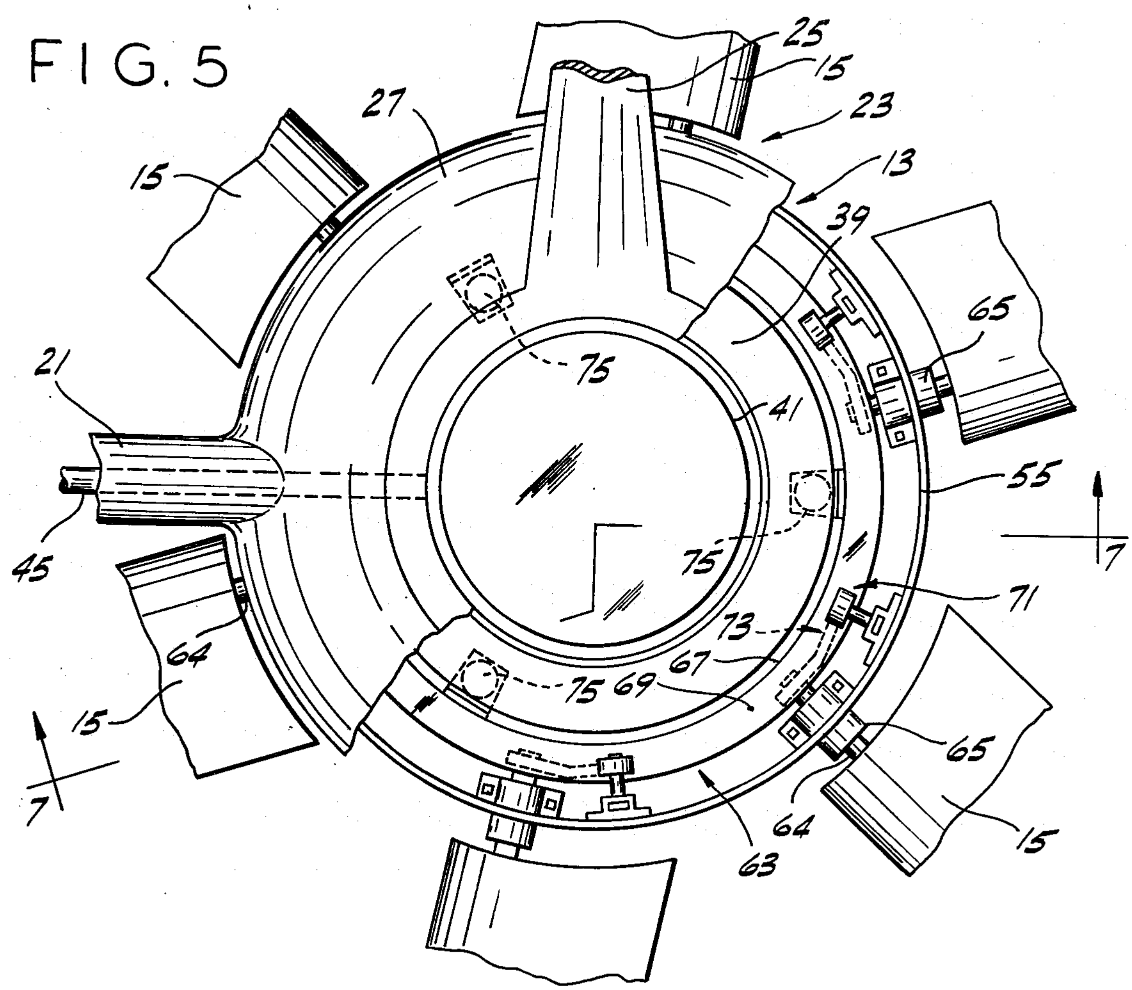
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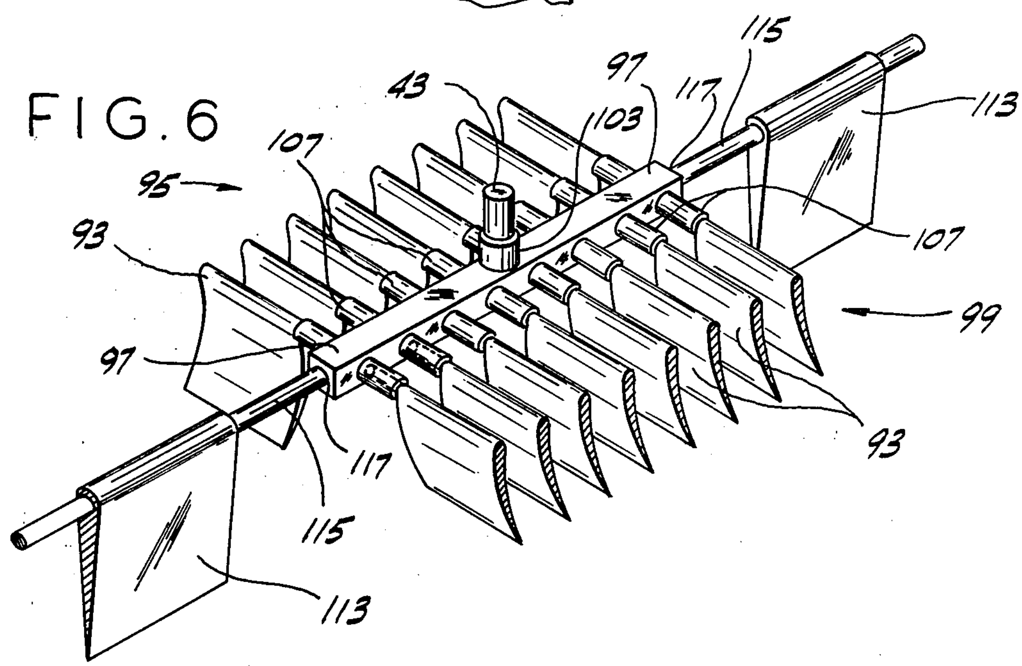
FIG. 6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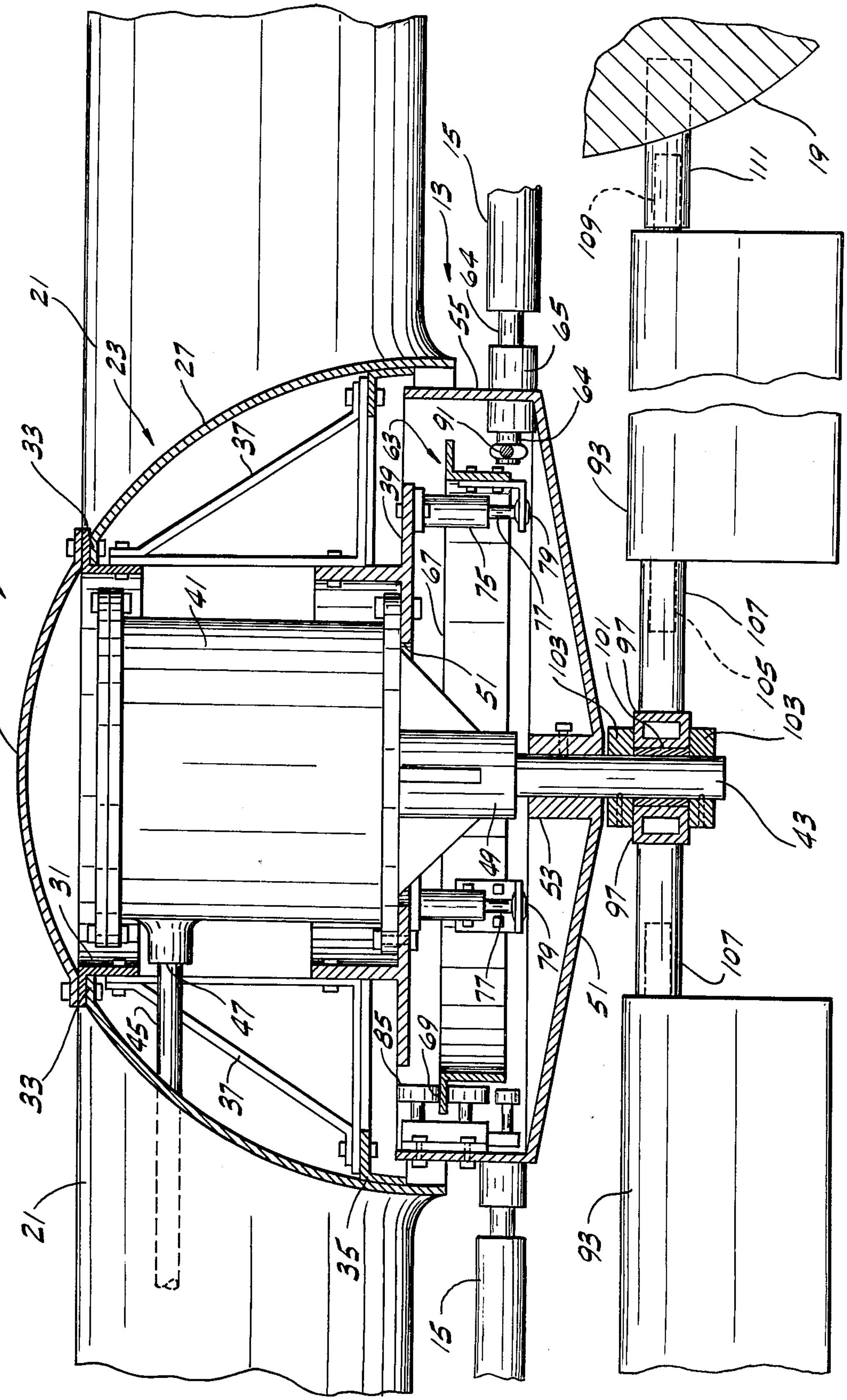

FIG. 7

FIG. 8

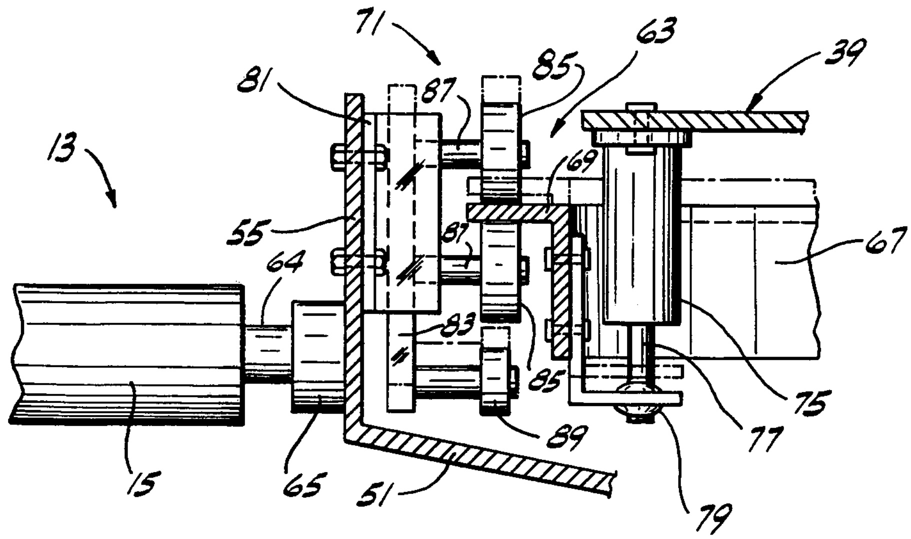
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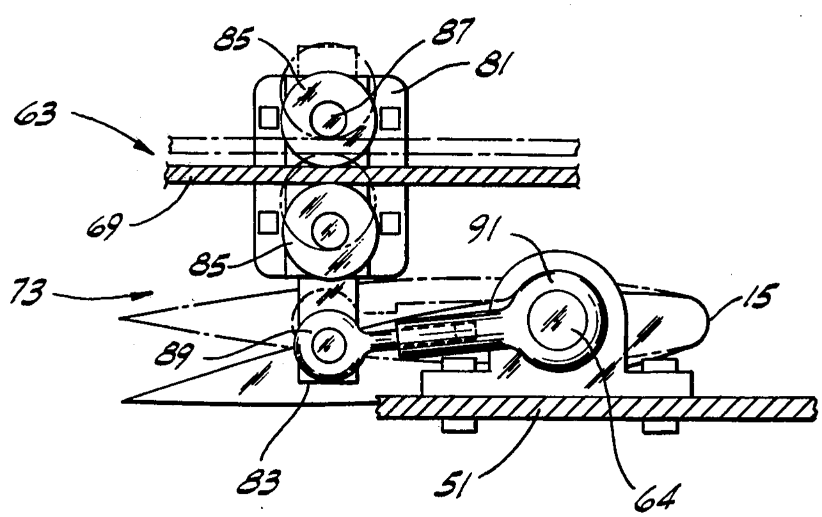
FIG. 9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AIRCRAFT

BACKGROUND OF THE INVENTION

This invention relates to aircraft, and more particularly to a vertical takeoff and landing (VTOL) aircraft of the type shown in my U.S. Pat. No. 3,640,485, issued Feb. 8, 1972.

SUMMARY OF THE INVENTION

Among the several objects of this invention may be noted the provision of an improved VTOL aircraft wherein, for a given power input, the lift is increased; the provision of such an aircraft which is readily maneuverable during takeoff, flight and landing; the provision of such an aircraft which, while capable of increased lift, is subject to reduced drag during flight; the provision of such an aircraft in which the power source is isolated from the fuselages thereby to minimize the noise level in the passenger compartments during operation of the aircraft; the provision of such an aircraft having twin fuselages adapted to be maintained generally horizontal during flight; the provision of such an aircraft having a protected propulsion system (e.g., rotor blades) for reducing the danger of damage to the system; and the provision of such an aircraft having fewer moving parts and precision mechanisms for lower manufacturing and maintenance costs.

In general, an improved aircraft of this invention comprises a generally annular wing structure surrounding a circular central structure forming an annular air duct, a first fuselage extending longitudinally of the aircraft at one side of the wing structure, and a second fuselage extending longitudinally of the aircraft at the other side of the wing structure. Rotor means carried by the central structure comprises a plurality of rotor blades extending radially across the duct from the central structure, the blades being rotatable relative to the central structure around the duct for inducing airflow through the duct to effect a lift on the aircraft. The annular wing structure consists of forward and rear wings having cross sections forming air foils. The forward wing has a generally semicircular trailing edge and the rear wing has a generally semicircular leading edge with these edges defining a circle generally concentric with and spaced from the central structure.

Other objects and features will be in part apparent and in part pointed out hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan of an aircraft of this invention;

FIG. **2** is a side elevation of the aircraft;

FIG. **3** is a vertical longitudinal section on line **3—3** of FIG. **1**;

FIG. **4** is a vertical transverse section on line **4—4** of FIG. **1**;

FIG. **5** is an enlarged fragment of FIG. **1** with parts broken away to show details;

FIG. **6** is a perspective illustrating certain navigational control elements;

FIG. **7** is a vertical section on line **7—7** of FIG. **5**;

FIG. **8** is an enlarged fragment of FIG. **7**; and

FIG. **9** is a vertical section on line **9—9** of FIG. **8**.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, first more particularly to FIGS. **1** and **3**, an aircraft of this invention, designated in its entirety by the reference numeral **1**, is shown to comprise a generally annular wing structure **3** surrounding a circular central structure indicated generally at **5** to form an annular air duct **7** in the form of a venturi. A first fuselage **9** extends longitudinally of the aircraft at one side of the wing structure **3** (its right side) and a second fuselage **11** extends longitudinally of the aircraft at the opposite side (the left side) of the wing structure. Carried by the central structure **5** and indicated generally at **13** is a rotor means comprising a plurality of cantilever rotor blades, each designated **15**. These blades, which are of air foil cross section, extend radially across the air duct **7** and are rotatable relative to the central structure around the air duct on the vertical central axis of the central structure for inducing flow of air down through the duct to effect a lift on the aircraft **1**. Six rotor blades are shown, and it will be understood that any suitable number of blades may be used without departing from the scope of this invention. The blades are located in the plane of and are surrounded by the annular wing structure **3**, the latter thus protecting the blades from damage.

The annular wing structure **3** comprises a forward wing **17** having generally semicircular leading and trailing edges **17*l*** and **17*t*** and a rear wing **19** having generally semicircular leading and trailing edges **19*l*** and **19*t***, the semicircles of these edges being generally centered in the vertical axis of the central circular structure **5**. As shown in FIG. **1**, the annular air duct **7** is constituted by the space between the central circular structure and the semicircular trailing and leading edges **17*t*** and **19*l*** of the forward and rear wings, respectively, which edges **17*t***, **19*l*** are generally on a circle generally concentric with the vertical central axis of structure **5**. Each of the wings **17** and **19** has an air foil cross section (see FIG. **3**). The forward wing **17** is of substantially longer cross section than the rear wing and has a generally forward angle of air attack. Rotation of the rotor blades **15** around the duct **7** causes a high-velocity flow of air over the upper surface of the forward wing which, in accordance with aerodynamic principles, provides lift augmenting the lift due to the downflow of air through the annular air duct **7**. The rear wing **19** also has a forward angle of air attack.

A rigid truss or bridge **21** extends longitudinally of the aircraft in its central vertical longitudinal plane bridging the forward and rear wings **17** and **19**. The circular central structure **5** comprises a housing in the form of a dome generally designated **23** at the center of this bridge, the dome forming the central part of the bridge. The dome is braced against side sway by means of tie bars **25** connected in tension between the dome and the fuselages **9** and **11** in the central vertical transverse plane of the aircraft. The dome **23** comprises a lower annular shell **27** forming the central part of the bridge, and a cover **29** for the shell secured on an upper ring **31** inverted on the rim **33** of the shell. The dome further comprises a lower ring **35** within the shell adjacent the open bottom of the shell. Frames **37** brace the rings and support an annular platform **39** within the dome adjacent its open bottom concentric with the dome. Mounted on this platform is a gear box **41** having an output shaft **43** extending down from the bottom of the box on the vertical axis of the dome. Conventional gearing in the box transmits power from a main drive shaft **45** to the output shaft **43**, the drive shaft **45** extending longitudinally of the aircraft generally in the central vertical longitudinal plane of the aircraft from the forward wing **17** through the forward part of the bridge **21** to the input of the gear box at **47**. The output shaft **43** extends down through a tubular bearing **49** at the lower end of the gear box, this bearing being generally centered in the central opening **51** of the annular platform **39**.

The rotor blades **15** are carried by and extend radially outwardly from a central rotor member **51** constituted by a dished disk having a hub **53** secured on the shaft **43** below the bearing **49** and an upwardly directed annular rim **55** which extends up into the dome **23** between the lower end portion of the dome and the periphery of the annular platform **39**. The rotor blades **15** extend radially outwardly from the rim **55** of the rotor member **51** and are spaced at equal intervals (at 60° intervals in the case of six blades) around the rim **55** of the rotor member. The main drive shaft **43** is adapted to be driven to drive the rotor member **51** and blades **15** via the gear box **41** by means of a pair of suitable engines **59** mounted on the bottom of the forward wing **17** on opposite sides of the central vertical longitudinal plane of the aircraft and connected to drive the shaft **45** via suitable transmissions as indicated at **61**. The arrangement is preferably such that both engines may be used for takeoff (and landing) with one engine sufficient for powering the rotor blades **15** after the desired altitude and speed have been attained. With the engine located on the forward wing, the noise level in the fuselages **9** and **11** during operation of the engines is minimized for passenger comfort.

For ready maneuvering of the aircraft, the rotor blades **15** are supported by the rotor member **51** in such manner as to enable the angle of attack of the blades readily to be changed, and circular cam means indicated generally at **63** is provided for changing the angle of attack of the blades. Thus, blades **15** have pivot shafts **64** at their inner ends rotatable in radial bearings **65** spaced at equal intervals (e.g., 60° intervals for six blades) around the rim **55** of the rotor member **51**, enabling each blade to swing about the axis of its pivot shaft for changing its angle of attack. Means **63** comprises a swash ring **67** having an outer radial flange forming in effect an annular cam **69**. The ring **67** surrounds the output shaft **43** and is located in the central rotor member **51** adjacent its rim **55** below the annular platform **39**. Cam follower means indicated generally at **71** is engageable with opposite sides of the cam **69** and is connected via linkages **73** to the rotor blade pivot shafts **64** in such manner that the blades are swung and their angle of attack changed as the elevation and/or tilt of the cam is varied, as will appear.

Means for universally raising, lowering and tilting the swash ring **67** is shown to comprise a plurality of hydraulic cylinders **75** extending down from the bottom of the annular platform and spaced at equal intervals (e.g., 120° for three cylinders) around the platform. Piston rods **77** extend down from pistons (not shown) in the cylinders **75** to univeral ball joint connections at **79** with the swash ring. By selectively actuating the cylinders, the swash ring **67** and cam **69** may be hydraulically raised and lowered while either level or tilted to any desired angle with respect to the platform **39** (and the plane of the annular wing structure **3**).

Linkages **63**, which connect the rotor blade pivot shafts **64** to the cam follower means **71** for varying the angle of attack of the blades as the elevation and/or tilt of the cam **69** is changed, are shown in FIGS. **8** and **9** each to comprise a guide block **81** mounted on the inside of the rim **55** of the central rotor member **51** generally above and to the side of a respective pivot shaft **64** and an elongate control bar **83** slidable vertically in the block. Carried by the control bar **83** is the cam follower means **71**, the latter comprising a pair of rollers **85** journaled on shafts **87** projecting from the upper end of the bar toward the swash ring **67**. As shown, the rollers are spaced apart for rolling contact with both the top and bottom surfaces of the cam **69**, this dual roller arrangement being effective for avoiding undesirable gyroscopic effects. Linkage **63** also includes a crank means comprising a crank arm **89** pinned at its left and (as viewed in FIG. **9**) to the lower end of the bar **83** and having its right end axially slidable in a crank **91** which is keyed to the pivot shaft **64**. Thus, when the swash ring **67** and cam **69** are raised (via hydraulic cylinders **75**), for example, the cam acts via the cam follower means **71** to pull the control bar **83** upwardly from the position shown in solid lines in FIGS. **8** and **9** to the position shown in broken lines. This, in turn, rotates the crank arm **89** and crank **91** clockwise to pivot the shaft **64** and the rotor blade **15** thereon for reducing the angle of attack of the blade and, as a result, the lift induced by the blade. The crank arm **89** slides in the crank **91** upon rotation of the crank assembly to avoid binding of the control bar **83** in the guide block **81**.

With the swash ring **67** and cam **69** generally level (i.e., parallel to the platform **39**), the angle of attack of each blade during a revolution around the air duct remains substantially constant. By hydraulically raising or lowering the cam while level, the angle of attack of all the blades **15** is simultaneously and equally changed via cam follower means **71** and linkages **63** for controlling the magnitude of the vertical lifting thrust induced by rotation of the blades. When the cam **69** is tilted (by selectively actuating the hydraulic cylinders **75**), the angle of attack of each blade varies as it revolves around the air duct inasmuch as the rollers **85** ride opposite high and low parts of the cam. With the cam tilted down toward one side of the aircraft, the blades **15** are pivoted counterclockwise while engaging the lower part of the tilted cam for increasing their angle of attack and, as a result, the lift on that side of the aircraft. Conversely, when engaging the opposite high part of the cam, the blades are rotated clockwise for reducing the angle of air attack and, therefore, the lift on the opposite side of the aircraft. Consequently, a resultant moment tending to tilt the aircraft is created. It will be understood, therefore, that by adjusting the swash ring **67** and cam **69** to the appropriate angular position, a moment may be established for trimming the craft to any desired nonlevel attitude (so that the aircraft may, for example, be caused to bank in a turn) or for counterbalancing forces, e.g., air gusts, shifts in payload, etc. tending to tilt the aircraft from level flight.

Counterrotation vanes **93**, of airfoil cross-section, are provided for countering the torque reaction on the aircraft of the rotating blades **5** to prevent the aircraft from rotating on the axis of shaft **43**. These vanes **93** are arranged in two sets, a forward set **95** extending from a central vane support **97** which extends transversely of the aircraft at the lower end of the shaft **43** to the forward wing **17**, and a rearward set **99** extending from the central vane support **97** to the rear wing **19** in a plane below the plane of the rotor blades **15**. Each set comprises a plurality of vanes (e.g., eight vanes) extending parallel to one another on opposite sides of the central vertical longitudinal plane of the aircraft. The central vane support **97** is in the form of an elongate bar having a vertical bearing **101** at its center in which the lower end of shaft **43** is rotatable, the shaft having collars **103** above and below the bar. The airfoil section vanes **93** have shafts **105** at their inner ends received in bearings **107** on the sides of the bar **97** and shafts **109** at their outer ends received in bearings indicated at **111** on the wings (see FIG. 7) for pivoting the vanes for swinging moment about axes extending longitudinally of the vanes (and longitudinally of the aircraft). Suitable controls are provided in the wings for varying the pitch of the vanes in each set **95**, **99**, the pitch employed being such as to provide the proper balancing torque on the aircraft to offset the torque on the central structure **3** caused by rotation of the blades **15**. The vanes are also useful in that by appropriately adjusting the pitch of the vanes in the forward and rear banks **95**, **99**, a resultant lateral force may be achieved for navigating the aircraft in a side-to-side direction without tilting the aircraft (especially desirable during takeoff and landing).

Navigation fins **113** are provided for maneuvering the aircraft forwardly and rearwardly in a generally level attitude (which, again is especially desirable during takeoff and landing). These fins are rotatably mounted on a pair of lower tie bars **115** extending from the vane support bar **97** to the fuselages **9**, **11** in the central vertical transverse plane of the aircraft, the tie bars being connected at **117** to opposite ends of the vane support and at **119** to the fuselages where suitable mechanisms **121** are located for adjusting the pitch of the fins to achieve the desired forward and rearward motion. The lower tie bars **115** also act as tension members and assist the upper tie bars **25** in bracing the central structure **5** against side sway.

With the aircraft at rest on the ground as shown in FIGS. **2** and **3**, the rotor blades **15** lie generally in a horizontal plane and the floor **123** of each fuselage slopes downwardly from the front to the rear of the aircraft. This comparative slope between the fuselage floors and the plane of the rotor blades **15** avoids excessive floor inclination when the aircraft is cruising since the rotor blades should, at such time, preferably be at a forward angle (i.e., the blades slope upwardly from the front to the rear of the aircraft). As illustrated, forward and rear landing wheel assemblies indicated at **125** and **127**, respectively, are provided on the underside of each fuselage **9**, **11**.

The aircraft **1** has a wide downwardly sloping tail **129** extending rearwardly from each of the fuselages **9**, **11** for providing rear lift to counterbalance the lift produced by the forward wing **17**. A flap **131** is mounted at the rear of each tail for swinging about an axis extending generally transversely of the aircraft between the positions shown in broken lines in FIG. **2**. These flaps increase the maneuverability of the aircraft and may be used for trimming the aircraft in flight, banking the aircraft into a turn, and other maneuvers. A rudder **133** mounted on the aft end of the bridge **21** at the center of the rear wing **17** (FIGS. **1** and **3**) constitutes auxiliary means for controlling the aircraft during horizontal flight and turning.

A deflector fin **135** extends along the bottom of each fuselage for preventing the air blown through the air duct from flowing laterally beneath the fuselages, instead deflecting the air downwardly for maximizing the lift generated by the rotor blades **15** (see FIGS. **2** and **4**). This is particularly important during takeoff and landing maneuvers when maximum lifting power is essential.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results obtained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An aircraft comprising a generally annular wing structure surrounding a circular central structure forming an annular air duct, said central structure having a vertical central axis,

a first fuselage extending longitudinally of the aircraft at one side of the wing structure,

a second fuselage extending longitudinally of the aircraft at the opposite side of the wing structure,

rotor means carried by said central structure comprising a plurality of rotor blades extending radially across said duct, said blades being rotatable relative to said central structure around the duct generally on the vertical central axis of said central structure for inducing airflow through the duct to effect a lift on the aircraft,

said annular wing structure comprising forward and rear wings forming air foils, the forward wing having a trailing edge and the rear wing having a leading edge which are generally on a circle generally concentric with the vertical central axis of the central structure, the trailing edge of the forward wing and the leading edge of the rear wing being semicircles of said circle, the annular air duct being constituted by the space between said central structure and said circle, the forward wing having a generally forward angle of air attack such that the rotation of said rotor blades around said duct causes a high-velocity airflow over the upper surface of the forward wing for increasing said lift,

parallel counterrotation vanes extending across said air duct below the rotor blades and between said forward and rear wings generally parallel to the fuselages for preventing rotation of the aircraft in reaction to rotation of the blades, said vanes being mounted at their outer ends on said wing structure for swinging about their longitudinal axes, and

a rotor drive shaft carried by the central structure and extending along the axis of rotation of said blades for rotating the blades around the duct, said vanes being arranged in forward and rearward sets extending from a central vane support at the lower end of the shaft to said forward and rearward wings, respectively.

2. An aircraft as set forth in claim **1** wherein navigation fins extend from said vane support to the fuselages generally perpendicular to said counterrotation vanes, said fins being swingable about axes extending longitudinally of the fins for controlling the axial flow of air through the duct thereby to allow navigation of the aircraft generally forwardly and rearwardly.

3. An aircraft comprising a generally annular wing structure surrounding a circular central structure forming an annular air duct, said central structure having a vertical central axis,

a first fuselage extending longitudinally of the aircraft at one side of the wing structure,

a second fuselage extending longitudinally of the aircraft at the opposite side of the wing structure, and

rotor means carried by said central structure comprising a plurality of rotor blades extending radially across said duct, said blades being rotatable relative to said central structure around the duct generally on the vertical central axis of said central structure for inducing airflow through the duct to effect a lift on the aircraft,

said annular wing structure comprising forward and rear wings forming air foils, the forward wing having a trailing edge and the rear wing having a leading edge which are generally on a circle generally concentric with the vertical central axis of the central structure, the trailing edge of the forward wing and the leading edge of the rear wing being semicircles of said circle, the annular air duct being constituted by the space between said central structure and said circle, the forward wing having a generally forward angle of air attack such that the rotation of said rotor blades around said duct causes a high-velocity airflow over the upper surface of the forward wing for increasing said lift,

parallel counterrotation vanes extending across said air duct below the rotor blades for preventing rotation of the aircraft in reaction to rotation of the blades, said vanes being mounted at their outer ends on said wing structure for swinging about their longitudinal axes, and

navigation fins extending across the air duct between said central structure and said fuselages at substantially the same elevation as said counterrotation vanes, said fins being swingable about axes extending longitudinally of the fins for controlling the axial flow of air through the duct thereby to allow navigation of the aircraft generally forwardly and rearwardly.

4. An aircraft comprising a generally annular wing structure surrounding a circular central structure forming an annular air duct, a first fuselage extending longitudinally of the aircraft at one side of the wing structure, a second fuselage extending longitudinally of the aircraft at the opposite side of the wing structure, rotor means carried by said central structure comprising a rotor member rotatable relative to the central structure and a plurality of rotor blades pivoted to the rotor member and extending radially outwardly therefrom toward the annular wing structure across said duct, said blades being rotatable relative to said central structure around the duct for inducing airflow through the duct to effect a lift on the aircraft, said annular wing structure comprising forward and rear wings forming air foils, the forward wing having a generally semicircular trailing edge, and the rear wing having a generally semicircular leading edge, said edges defining a circle generally concentric with and spaced from said circular central structure, circular cam means carried by the central structure and disposed around the axis of rotation of said blades, means rigidly carried by the central structure for tilting the cam means in any of various directions relative to the central structure and for changing the elevation of the cam means relative to the blades at any or no tilt while preventing rotation of the cam means relative to the central structure, follower means engageable with opposite sides of the cam means at any tilt and elevation thereof, and linkages connecting the rotor blades with the follower means for pivoting the blades whereby the angle of air attack of the blades is simultaneously and equally changed when the elevation of the cam means is changed and the angle of attack of each blade is varied from a maximum to a minimum during one revolution of the blade around said duct when the cam means is tilted, each of said linkages comprising a guide block on said rotatable ring, a control bar slidable in the guide block in a direction parallel to the axis of rotation of the rotatable ring and having said follower means secured thereto, and a crank means connecting the control bar and a respective rotor blade pivot whereby the bar is adapted to slide in the guide when the elevation of said cam means is changed thereby to rotate the crank means and the rotor blade pivot for pivoting the blade.

5. An aircraft as set forth in claim **4** wherein said follower means comprises a pair of rollers mounted on the control bar for rolling engagement with the top and bottom of the cam means.

6. An aircraft comprising a generally annular wing structure surrounding a circular central structure forming an annular air duct, said central structure having a vertical central axis,

a first fuselage extending longitudinally of the aircraft at one side of the wing structure,

a second fuselage extending longitudinally of the aircraft at the opposite side of the wing structure,

rotor means carried by said central structure comprising a plurality of rotor blades extending radially across said duct, said blades being rotatable relative to said central structure around the duct generally on the vertical central axis of said central structure for inducing airflow through the duct to effect a lift on the aircraft,

said annular wing structure comprising forward and rear wings forming air foils, the forward wing having a trailing edge and the rear wing having a leading edge which are generally on a circle generally concentric with the vertical central axis of the central structure, the trailing edge of the forward wing and the leading edge of the rear wing being semicircles of said circle, the annular air duct being constituted by the space between said central structure and said circle, the forward wing having a generally forward angle of air attack such that the rotation of said rotor blades around said duct causes a high-velocity airflow over the upper surface of the forward wing for increasing said lift,

a tail extending rearwardly from each of said fuselages, and

a rudder mounted at the center of said rear wing between said tails.

7. An aircraft as set forth in claim **6** wherein each of said tails has a flap mounted at its rear for rotation about an axis extending generally transversely of the aircraft.

8. An aircraft comprising a generally annular wing structure surrounding a circular central structure forming an annular air duct, said central structure having a vertical central axis,

a first fuselage extending longitudinally of the aircraft at one side of the wing structure,

a second fuselage extending longitudinally of the aircraft at the opposite side of the wing structure, rotor means carried by said central structure comprising a plurality of rotor blades extending radially across said duct, said blades being rotatable relative to said central structure around the duct generally on the vertical central axis of said central structure for inducing airflow through the duct to effect a lift on the aircraft,

said annular wing structure comprising forward and rear wings forming air foils, the forward wing having a trailing edge and the rear wing having a leading edge which are generally on a circle generally concentric with the vertical central axis of the central structure, the trailing edge of the forward wing and the leading edge of the rear wing being semicircles of said circle, the annular air duct being constituted by the space between said central structure and said circle, the forward wing having a generally forward angle of air attack such that the rotation of said rotor blades around said duct causes a high-velocity airflow over the upper surface of the forward wing for increasing said lift, and

deflector fins extending longitudinally along the bottom of said fuselages for deflecting downwardly the axial flow of air through said duct.

* * * * *

United States Patent [19]

DeSautel

[11] **4,214,720**

[45] **Jul. 29, 1980**

[54] **FLYING DISC**

[76] Inventor: **Edwin R. DeSautel,** P.O. Box 1052, Richland, Wash. 99352

[21] Appl. No.: **15,410**

[22] Filed: **Feb. 26, 1979**

[51] **Int. Cl.**[3] **B64C 27/20**; B64C 29/00

[52] **U.S. Cl.** .... **244/12.2**; 244/12.3; 244/12.5; 244/23 C; 244/56

[58] **Field of Search** .... 244/12.2, 12.3, 12.4, 244/12.5, 23 C, 23 B, 23 D, 12.1, 56

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Primary Examiner—Charles E. Frankfort
Attorney, Agent, or Firm—Wells, St. John & Roberts

[57] **ABSTRACT**

A flying disc capable of vertical takeoff, hovering, or powered horizontal flight. The disc includes a discoidal wing that is circular and includes a convex surface on an upper side and a concave lower surface. The wing also includes an inward leading edge that defines a circular opening centered on an upright central axis. The arcuate surfaces converge at the leading edge and at an outer concentric trailing edge. The discoidal wing is freely rotatable on a central support structure that also supports a cockpit. Two sets of turbine blades are affixed to the discoidal wing adjacent the leading edge. Thrust producing engines are mounted to the central support structure to direct thrust radially outward through the turbine blades. This results in rotation of the discoidal wing and produces lift. The angle of thrust may be adjusted such that the thrust is directed only across one or the other set of turbine blades or any selected variation between extreme positions to change the lift characteristics. A set of compressor blades is provided about an upper surface of the disc adjacent the cockpit. The compressor blades rotate with the discoidal wing to receive and direct air downwardly into the central support structure. They supply combustion air for the engine and reduce the air pressure above the disc. Horizontal thrust engines are supplied below the concave wing surface to provide horizontal thrust. Steering and rotational stabilization of the cockpit and central support structure is provided by a thrust diverting mechanism.

24 Claims, 8 Drawing Figures

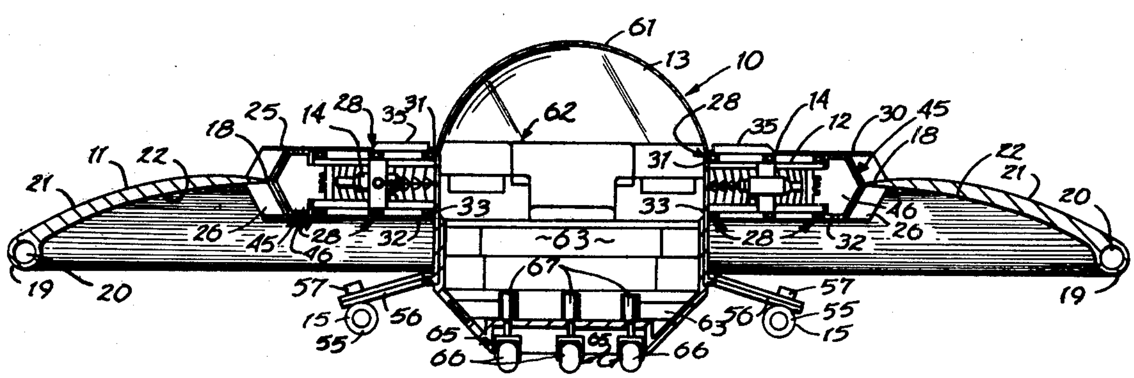
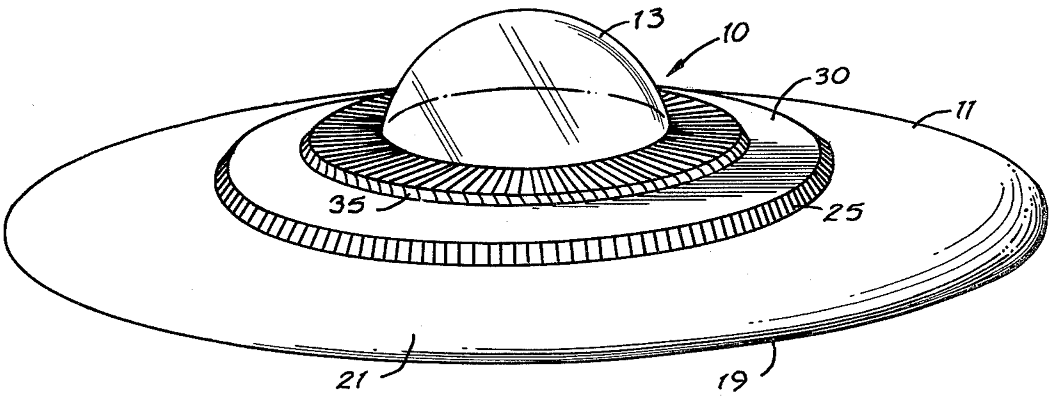


Fig 1



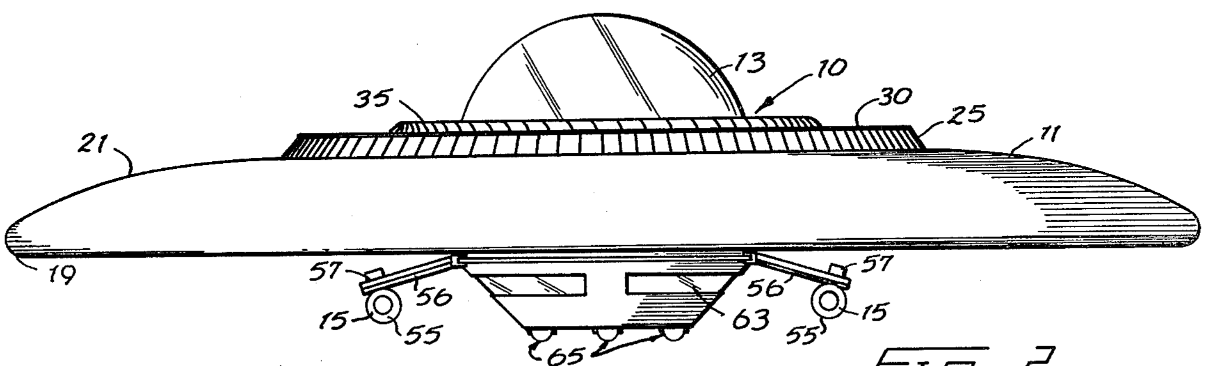


Fig 2

Fig 3

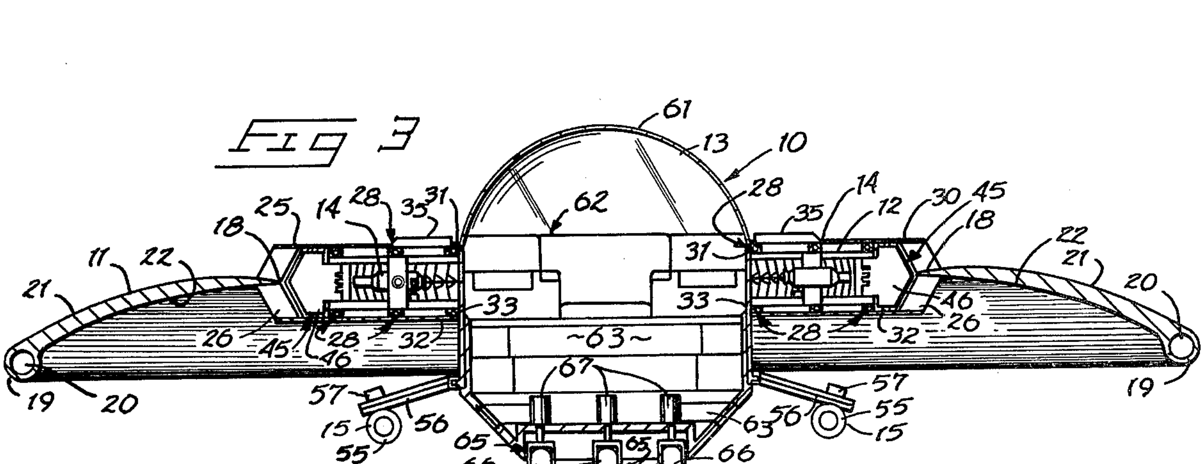


FIG 4

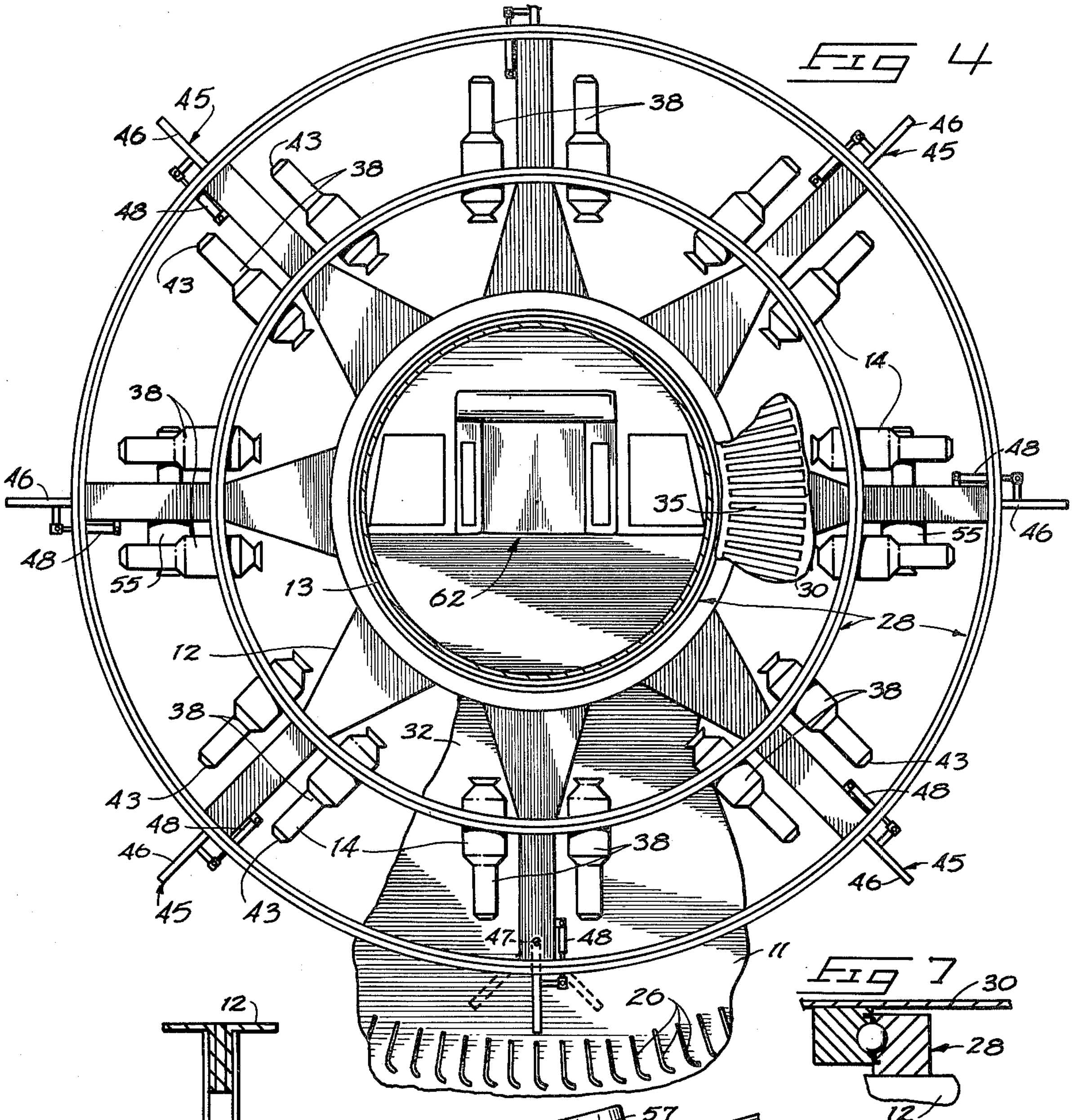


FIG 7

FIG 5

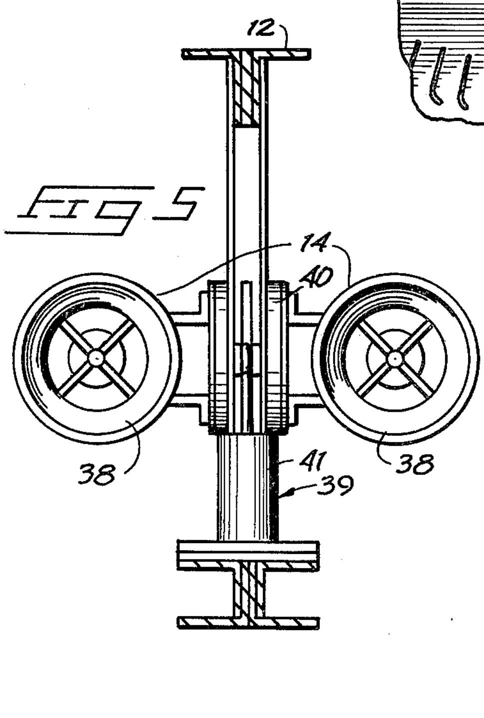
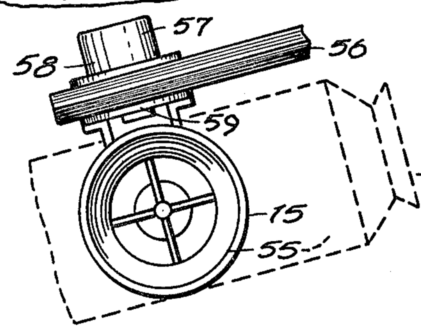


FIG 6



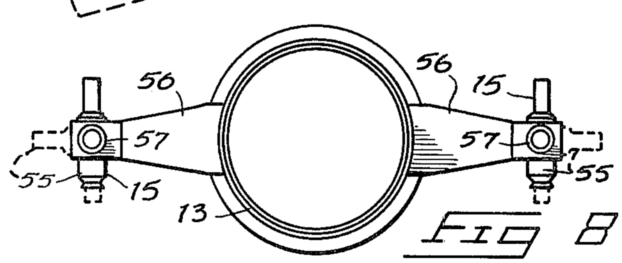


FIG 8

FLYING DISC

BACKGROUND OF THE INVENTION

The present invention is related to discoidal shaped aircraft.

The aerodynamic advantages of saucer shaped craft have been sought after in commerical, private and military aircraft design. A balanced spinning disc is capable of sustained flight as evidenced by the toy "frisbees" of current popularity. Discoidal flight is known and particular reference is made to it in U.S. Pat. No. 3,359,678.

This flight principle is claimed to be put to use in an invention disclosed in U.S. Pat. No. 3,946,970 in combination with vertical thrust means. The disclosure relates to a "gyroscopically stabilized vertical takeoff and landing aircraft". The craft includes an outer spinning ring that does not, of itself, produce vertical lift during takeoff or hovering of the craft. Instead, lift is provided by downwardly directed thrust produced by conventional jet or rocket engines. Part of the engine thrust is diverted through a complex ducting arrangement to produce rotation of the ring. Thus, the craft has the advantage of the spinning disk principle during horizontal flight but necessarily relies solely upon the downward thrust of its engines to accomplish vertical takeoff or for hovering.

U.S. Pat. No. 2,801,058 to C. P. Lent issued July 30, 1957 discloses a saucer shaped aircraft. Lent discloses the principle of forming a disc from a standard aircraft wing shaped configuration and producing thrust in radial directions about a central axis over the annular surfaces of the discoidal wing. The inventor claims that sufficient lift is provided by directing radial thrust across an annular ring to provide vertical takeoff and hovering capability. The nature of the craft, however, does not permit simultaneous rotation of the annular wing for a spinning disc effect, nor is additional thrust provided for lift during vertical takeoff or hovering situations.

Applicant has conceived of the unique combination of air foil configuration and the spinning disc principle that represents a substantial improvement over known forms of discoidal aircraft. Lift is produced both by the discoidal spinning wing moving through ambient air and by thrust from internal engines which is directed over the discoidal wing surface configurations and which also produces the wing rotation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a pictorial view of the present flying disc;

FIG. 2 is a slightly enlarged side elevation view;

FIG. 3 is a cross-sectional view of the present disc structure;

FIG. 4 is a plan fragmentary detail view illustrating the central support structure and thrust means along with associated elements;

FIG. 5 is an enlarged frontal view of a pair of thrust producing engines and mechanisms by which they are mounted to the central support structure;

FIG. 6 is a fragmentary view of a horizontal directional thrust producing engine and its associated mount;

FIG. 7 is an enlarged section view of a ring bearing situated between the discoidal wing and central support structure; and

FIG. 8 is a reduced diagrammatic plan view illustrating the pivotal mounting for the horizontal directional thrust producing engines.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

A flying disc embodying a preferred form of a present invention is illustrated in the accompanying drawings and is generally designated therein by the reference character **10**. The flying disc **10** basically includes a discoidal wing **11** that is freely rotatably carried on a central support structure **12**. A cockpit **13** is mounted to the central support structure **12** and is centered on an upright axis of rotation for the discoidal wing **11**. Lift is produced through a thrust means **14** situated within the central support structure **12**. Horizontal directional movement is achieved through a horizontal directional thrust means generally indicated at **15**.

The discoidal wing **11** is illustrated in some detail in FIG. 3. As shown, the discoidal wing is annular and includes an inner circular leading edge **18** and an outward concentric trailing edge **19**. An annular flotation ring **20** may be provided at the concentric upper trailing edge **19**. Joining the leading edge **18** and trailing edge **19** is a convex upper wing surface **21** and a concave lower surface **22**. These surfaces are joined by the edges **18** and **19** and, together, form the present wing cross-sectional geometry. The trailing edge **19** is situated elevationally below the leading edge **18** so as to produce a smooth curved upper surface across the entire disc body. Thus the entire disc of itself is formed in an airfoil configuration.

A first circular set of turbine blades **25** is mounted to the discoidal wing **11**. These turbine blades **25** are centered on the upright rotational axis of the disc and extend upwardly from the leading edge **18** above the convex upper surface **21**.

A second circular set of turbine blades **26** is provided. They are centered on the upright axis and are fixed to and extend downwardly from the lower concave surface **22** at the leading edge **18**.

As seen in FIG. 3, the two sets of turbine blades **25** and **26** are in substantial axial alignment. Each blade of either set is formed to receive and direct thrust from the thrust producing means **14** outwardly across the surfaces of the discoidal wing. They are also designed to produce rotation of the discoidal wing in response to thrust from the means **14**. Both sets are designed to produce rotation of the discoidal wing in a single direction.

The discoidal wing is rotatably mounted to the central support structure through a bearing means that is generally shown at **28** (FIGS. 3, 4 and 7). Specifically, an upper relatively horizontal cover surface **30** extends from upper ends of the first set of turbine blades **25** inwardly to a ring bearing **31** adjacent cockpit **13** on support structure **12**. A similar bottom cover surface **32** (FIG. 3) extends from bottom ends of the second set of turbine blades **26** to a second axially spaced ring bearing **33** that is also situated adjacent to the cockpit on the central support structure **12**. Additional sets of ring bearings may be provided as shown between the discoidal wing and central support structure to insure precise rotation of the discoidal wing about the central upright axis. Such bearings may also dissipate stresses that will occur between the discoidal wing and central support structure.

A typical cross section of the bearing means **28** is illustrated in FIG. **7**. It is to be understood, however, that various other forms of bearings may be utilized to reduce rotational friction between the rotating disc and relatively stationary central support structure and cockpit.

The upper cover surface **30** includes a circular set of compression blades **35**. The blades **35** are inclined toward the direction of rotation for the purpose of receiving and directing air forceably downward into the vicinity of the thrust means **14**. The compressor blades **35** may be formed integrally with the cover surface **30** or may be separate elements that are securely fixed to the cover for rotation therewith. As shown in FIG. **1**, the compressor blades are substantially radial with respect to the axis for the disc and are situated directly adjacent to the cockpit **13**. This places them radially inward of the first and second circular sets of turbine blades **25** and **26**. Air may be received from the compressor blades **35** and directed outwardly through the turbine blades **25** and **26**.

The thrust means **14** includes a number of thrust producing engines **38** (FIGS. **4** and **5**) that are situated angularly about the axis of the disc. The engines **38** are illustrated in FIGS. **3** through **5**. They are substantially radial and are situated radially between the circular set of compressor blades **35** and the sets of turbine blades **25** and **26**. They may therefore utilize air received from the compressor blades as combustion air, directing that air forceably outward through thrust ports **43** and against one or both sets of turbine blades.

A means **39** (FIG. **5**) is provided for angularly adjusting the thrust produced by the thrust means **14**. Means **39** may be utilized to direct thrust produced by the thrust means **14** upwardly over the first set of turbine blades or downwardly over the second set or horizontally over both sets. Means **39** include pivot mounts **40** that pivotally carry the thrust producing engines for selective pivotal movement about horizontal axes. FIG. **5** shows one of the pivot mounts **40** mounting two engines **38** in tandem to the central support structure **12**. A jack means **41** is provided interconnecting the central support structure and pivot means for pivoting the engines about the axis of the pivot mount **40**.

The radial thrust producing engines **38** comprise the thrust means **14** that are utilized for producing lift and for operating against the turbine blades **25** and **26** to rotate the discoidal wing **11**. The means **39** for adjusting the angular direction of the thrust controls the amount of lift produced. If the thrusting engines are inclined downwardly such that their thrust is directed solely through the lower or second set of turbine blades **26**, upward lift will be maximized. This position will be used for vertical takeoff and for hovering. The opposite position of the engines wherein the thrust is directed upwardly solely through the first set of turbine blades produces a downward force to cause rapid elevational descent of the disc. The position shown in FIG. **3** wherein the engines are substantially horizontal and the thrust is divided evenly over both surfaces of the discoidal wing produces a normal lift that may be utilized for maintaining the disc at a selected altitude while moving horizontally. Of course, an infinite variation between the angular positions described is possible through proper control of the jack means **41**.

It is understood that will be a tendency due to the rotation of the discoidal wing **11** for the central support structure and cockpit to also rotate. To counteract this and to selectively rotate the cockpit, I provide a thrust diverting, stabilizing means **45**. Means **45** is utilized for angularly deflecting the thrust produced by the thrust producing engines **38** to transmit some of the energy of the thrust into a corresponding amount of rotation of the central support structure and cockpit.

Means **45** basically includes a plurality of radial upright rudders **46**, one for each pair of engines **38**. The rudders **46** are pivoted at **47** (FIG. **4**) to the central support structure **12** about upright pivot axes (parallel to the central upright axis). Each rudder **46** is located radially outward and adjacent to a thrust port **43** of an adjacent thrust producing engine **38**. A jack means **48** is provided for each rudder **46** and is operative to pivot the rudder **46** about its upright pivot **47**. The jack means **48** may be utilized to pivot the rudders **46** slightly into the thrust of the adjacent engines in order to cause a very slight torsion about the central axis to offset the torsion in the opposite direction produced through the rotating discoidal wing **11** and friction through the ring bearings **31, 33**. In addition, the rudders may be pivoted further into the thrust produced by the engines to cause corresponding rotation of the cockpit and central support structures. This changes the direction of movement for the disc. This is so because the horizontal directional thrust means **15** is also connected to the central support structure and will rotate therewith.

The horizontal directional thrust means **15** is comprised of thrust producing engines **55**. There are a pair of the engines **55** mounted to diametrically opposed angular engine mounting struts **56**. The struts extend angularly downward from the central support structure and cockpit to mount the engines **55** equidistant from the central rotational axis and elevationally below the outward trailing edge **19**.

The engines **55** shown in FIGS. **2, 3** and **8** are parallel and operate in unison to cause motion of the disc in a straight path determined by the direction of thrust. However, means is provided at **57** for varying the positions of the engines to correspondingly vary the direction of thrust produced thereby. Such means **57** may be utilized to completely rotate the engines 180° simultaneously and in opposite directions so that forward motion of the disc may be slowed, brought to a stop, and reversed. Likewise, the engines may be pivoted 90° from the position shown in FIG. **8** to the dashed line positions. In these positions the engines **55** assist in producing lift. Horizontal directional force components are cancelled by the opposed engines **55**, but since thrust from both is directed downwardly, an upward resultant is produced that increases the upward lift produced through the internal engines **38**.

It is understood that the thrust producing engines **55** may be of the variety including thrust reversing mechanisms whereby full 180° rotation of the engines is not required. However, provision of the engine position varying means **57** will still be beneficial to assist in lift during takeoff and hovering. Means **57** may, if necessary, perform some of the steering functions and augment the stabilizing function of the thrust deflecting means **45**. Control of each engine independently in a steering mode, where the engines would pivot independently, in response to a steering control could augment or in emergency, replace the steering capability of stabilizing, diverting means **45**.

Means **57** is illustrated in FIG. **6** where a drive mechanism **58** is shown attached to a thrust producing engine **55**. Mechanisms **58** impart rotation to the engines **55** about axes that converge with the axis of rotation for the discoidal wing. The mechanisms **58** may be appropriate forms of motors connected to the associated engine through a pivot **59**. The axes of the pivots are perpendicular to the angles of inclination for the engine mounting struts **56**. The engines **55** may thus be freely rotated about the axis of the pivots **59** in arcs of 180°. Appropriate control (not shown) may be provided as indicated above to pivot the engines in unison in opposite directions or independently, depending on the mode of operation.

FIGS. **3** and **4** best illustrate the cockpit structure **13** and adjacent portions of the central support structure **12**. The cockpit may include a spherical transparent bubble **61** protruding upwardly above the compressor blades **35**. The clear bubble **61** allows a full field of vision for a pilot who may sit within the cockpit at a seat and control console **62**. It is noted that the illustrated example of my invention shows a seat and control console **62** for carrying a single rider. It is envisioned, however, that the scale of the disc may be varied according to the use and load requirement.

Below the seat and control console **62** is a lower cockpit housing **63**. This area may include various provisions for fuel, fuel supplying, controls, etc., which are known in the aeronautical and related industries.

A set of landing gear **65** is provided at a bottom side of the lower cockpit housing **63**. The landing gear includes at least three wheels **66** mounted to vertically extensible jacks **67** for extension and retraction of the wheels relative to the cockpit housing **63**. The jacks are operable to lower the wheels and are retractable into a recess formed within the lower cockpit housing **63**.

From the above technical description, operation of the invention may now be understood.

Flight is initiated by starting and controlling the thrust of the thrust means **14** to include a downward thrust component. This is done by operating the means **39** to adjust the thrust angle of the engines **38** downwardly through the lower, second set of turbine blades **26** and toward the ground surface. An upward force is thereby produced and since the engines **38** are diametrically opposed in relation to the axis of the disc, the upward lift is produced along a vertical line. The thrust produced also acts against the second set of turbine blades **26** to initiate rotation of the discoidal wing. As the engine thrust lifts the disc upwardly, the discoidal wing will come to full rotating speed.

If additional upward thrust is required, the engines **55** may be pivoted to the opposed thrusting positions (dashed lines in FIG. **8**) so their thrust will add to the upward lift component produced through the engines **38**. As sufficient altitude is gained, the engines **55** may be pivoted about the axes of their pivots **59** to produce a horizontally directed thrust. This thrust will serve to move the flying disc in a horizontal direction while the remaining engines **38** may be operated at lower power to merely maintain the altitude of the disc. This is so because the air foil shape of the disc as it moves horizontally also serves to produce a certain amount of lift, thereby reducing the demands upon the engines **38**. Of course, the air pressure above the convex surface **21** is reduced while the discoidal wing is rotating due to action of the compressor blades **35**. They serve to draw air downwardly from above the discoidal wing and into the confines of the central support structure. This air is used for combustion air for engines **38** and is directed outwardly through the turbine blades **25** and **26** to produce lift and rotation.

Directional change is made simply by controlling the thrust diverting and stabilizing means **45**. The radial upright rudders **46** are pivoted by the jack means **48** selectively to react against the thrust produced by engines **38** and cause pivotal movement of the cockpit and central support structure about the central axis of the disc. This causes corresponding pivotal movement of the horizontal thrust producing engines **55**, and, as a result, direction of the disc movement is abruptly changed. Turns may be performed without banking of the disc, although such tilting may be preferred and can be initiated by varying the angular relationships of the horizontal thrust producing engines.

Altitude may be varied somewhat by simultaneously pivoting the horizontal thrust producing engines in opposite directions about their inclined axes. Primary altitudinal changes, however, are made by pivoting the engines **38** up or downwardly relative to the concave and convex surfaces of the discoidal wing.

Slowing or stopping midflight may be accomplished by either reversing direction of the horizontal thrust producing engines to cause a halt to forward movement of the disc or providing the engines **55** with thrust reversing mechanisms by which the forward velocity of the disc is slowed to a stop. Appropriate controls may then be operated to increase the thrust component in a downward direction through the engines **38** and, if required, the engines **55** may be pivoted to the dashed line position (FIG. **8**) to assist in producing vertical lift. Such hovering may be utilized during slow vertical descent of the disc toward a landing surface to accomplish takeoff or midflight at relatively any selected altitude.

Should the disc lose power because of mechanism failure or lack of fuel, the discoidal wing will continue rotating about its axis on the bearings and the disc can be safely landed in an upright position at a distant location through the free flight advantage produced by the spinning discoidal wing. Enough thrust may be produced solely by the compressor blades **35** over the turbine blades **25** and **26** to continue rotation of the discoidal wing during descent. This may allow also for some manual control of the thrust diverting and stabilizing devices **45** to prevent undesirable rotation of the central support structure and cockpit area.

It is to be understood that the above description and attached drawings are given by way of example merely to set forth a preferred form of my invention. The following claims set forth the scope of my invention.

What I claim is:

1. A flying disc, comprising:

a central support structure including an upright axis;

a discoidal wing having a convex upper surface and a concave lower surface centered about the upright axis;

bearings mounting the wing and support structure to one another for free independent rotation about the upright axis;

a first circular set of turbine blades centered on the upright axis and mounted on the wing to project upwardly on the convex upper surface thereof;

a second circular set of turbine blades centered on the upright axis and mounted on the wing to project downwardly on the concave lower surface thereof;

said turbine blades of both sets being arranged to impart rotational motion of said discoidal wing about the upright axis in response to fluid thrust directed against them from within the central support structure;

thrust means within the support structure for producing an outwardly directed thrust against the turbine blades;

means for angularly adjusting the thrust produced by the thrust means so it may be directed upwardly against the first set of turbine blades or downwardly against the second set of turbine blades, or horizontally against both sets of turbine blades equally;

thrust diverting means mounted on the central support structure and positioned between the thrust means and turbine blades for angularly deflecting thrust to cause a resultant rotation or stabilization of rotation of the central support structure relative to said discoidal wing; and

horizontal directional thrust means mounted on the central support structure for producing directional thrust to move the disc horizontally during flight.

2. The flying disc as defined by claim **1**, further comprising:

a circular set of compressor blades centered on the upright axis and mounted on said discoidal wing along the convex surface thereof;

said compressor blades being arranged substantially radially with respect to the upright axis and spaced above and radially inward of said turbine blades; and

wherein said thrust means is comprised of a plurality of thrust producing engines equally spaced about the upright axis with thrust ports directed radially outward from the upright axis and with intake ports situated adjacent to said compressor blades.

3. The flying disc as defined by claim **1** wherein the horizontal directional thrust means is comprised of at least one horizontal thrust producing engine mounted to the central support structure below the concave surface of said wing.

4. The flying disc as defined by claim **3** further comprising means for pivoting the horizontal thrust producing engine about an axis that is inclined relative to the upright axis.

5. The flying disc as defined by claim **1** further comprising annular flotation means along the circular periphery of said discoidal wing.

6. The flying disc as defined by claim **1** wherein the thrust diverting means for angularly adjusting the thrust produced by the thrust means is comprised of:

a plurality of normally radial upright rudders pivoted to the central support structure about upright axes between the thrust means and sets of turbine blades; and

means for selectively pivoting said rudders about their axes from their normally radial positions.

7. The flying disc as defined by claim **1** further comprising a domed cockpit centered on the upright axis and mounted to the central support structure, projecting upwardly above the convex surface.

8. The flying disc as defined by claim **1** wherein said thrust means is comprised of a plurality of thrust producing engines that are equally spaced about the upright axis with thrust ports directed radially outward from the upright axis;

and wherein said horizontal directional thrust means is comprised of at least one thrust producing engine mounted to the central support structure below the concave surface.

9. The flying disc as defined by claim **1** wherein said bearing includes a pair of ring bearings mounted between the central support structure and discoidal wing with one ring bearing of the pair being centered on the upright axis and operatively mounted between the upper convex surface and the central support structure and with the remaining ring bearing being centered on the upright axis and operatively mounted between the lower concave surface and the central support structure.

10. The flying disc as defined by claim **1** further comprising means for selectively varying the directional thrust produced by the horizontal directional thrust means.

11. The flying disc as defined by claim **10** wherein the horizontal directional thrust means is comprised of a pair of thrust producing engines mounted by substantially radial engine struts to the central support structure, the engines being spaced on opposite sides of the upright axis and at equal distances therefrom.

12. The flying disc as defined by claim **11** wherein the means for varying the directional thrust produced by the horizontal directional thrust means includes pivot mechanisms mounting the thrust producing engines to the engine struts for selective pivotal movement thereon about axes spaced outwardly of the upright axis.

13. The flying disc as defined by claim **12** wherein the engine pivot axes are inclined at equal angles in regard to the upright axis.

14. A flying disc, comprising:

a central support structure including an upright axis;

a cockpit centered within the central support structure on the upright axis;

a discoidal wing having a convex upper surface and a concave lower surface;

the upper and lower surfaces being joined at a circular leading edge and a concentric outward trailing edge, both edges being centered on the upright axis;

bearing means mounting the discoidal wing to the central support structure for free rotation about the upright axis;

a first circular set of turbine blades centered on the upright axis and mounted to the discoidal wing along the upper convex surface adjacent the circular leading edge;

a second circular set of turbine blades centered on the upright axis and mounted to the discoidal wing along the lower concave surface adjacent the circular leading edge;

the first and second sets of turbine blades being positioned on the discoidal wing to impart rotation to the discoidal wing about the upright axis in response to fluid thrust directed against them from within the central support structure;

thrust means within the central support structures for producing an outwardly directed thrust against the sets of turbine blades;

means for angularly adjusting the thrust produced by the thrust means so it may be selectively directed against the first set of turbine blades or against the second set of turbine blades or against both sets of turbine blades;

means for selectively stabilizing the central support structure and cockpit against rotation about the upright axis; and

horizontal directional thrust means mounted on the central support structure for producing directional thrust for moving the disc horizontally during flight.

15. The flying disc as defined by claim **14** wherein the concentric trailing edge is spaced elevationally below the circular leading edge and the second circular set of turbine blades.

16. The flying disc as defined by claim **14** wherein the thrust means is situated radially between the cockpit and leading edge and further comprising:

an upper cover surface extending inwardly from the first set of turbine blades toward the cockpit.

17. The flying disc as defined by claim **16** further comprising a set of compressor blades on the upper cover surface radially inward of the sets of turbine blades, for receiving and directing air downwardly to the thrust means and sets of turbine blades.

18. The flying disc as defined by claim **16** further comprising a bottom cover surface extending inwardly from the second set of turbine blades toward the cockpit.

19. The flying disc as defined by claim **16** wherein the bearing means is comprised of a ring bearing rotatably mounting the upper cover surface to the cockpit and central support structure.

20. The flying disc as defined by claim **14** wherein the means for selectively stabilizing the central support structure and cockpit is comprised of a plurality of normally radial upright rudders pivoted to the central support structure about upright axes between the thrust means and sets of turbine blades; and

means for selectively pivoting the rudders about their axes from their normally radial positions.

21. The flying disc as defined by claim **14** wherein the horizontal directional thrust means is comprised of at least one thrust producing engine mounted to the central support structure below the trailing edge of the discoidal wing.

22. The flying disc as defined by claim **21** further comprising means for pivoting the engine about an axis relative to the cockpit that is inclined with respect to the upright axis.

23. The flying disc as defined by claim **14** wherein said thrust means is comprised of a plurality of thrust producing engines that are equally spaced about the upright axis with thrust ports directed radially outward from the upright axis; and wherein said horizontal directional thrust means is comprised of at least one thrust producing engine mounted to the central support structure below the concave surface.

24. The flying disc as defined by claim **14** wherein the thrust means is comprised of a plurality of thrust producing engines spaced equiangularly about the upright axis and the means for angularly adjusting the thrust produced by the thrust means is comprised of pivot mounts for the engines enabling pivotal movement of the engines about horizontal axes and jack means between the engines and the central support structure for selectively pivoting the engines about the horizontal axes.

* * * * *

United States Patent [19]

Bostan

[11] **4,312,483**

[45] **Jan. 26, 1982**

[54] **AIRCRAFT WITH CIRCULAR WING**

[76] Inventor: **Nicolae Bostan**, 2344 Kingsland Ave., Bronx, N.Y. 10469

[21] Appl. No.: **951,198**

[22] Filed: **Oct. 13, 1978**

[51] **Int. Cl.**³ **B64C 29/04;** B64C 17/06

[52] **U.S. Cl.** .... **244/12.2;** 244/23 C; 244/39; 244/52

[58] **Field of Search** 244/12.1–12.5, 244/23, 39, 52

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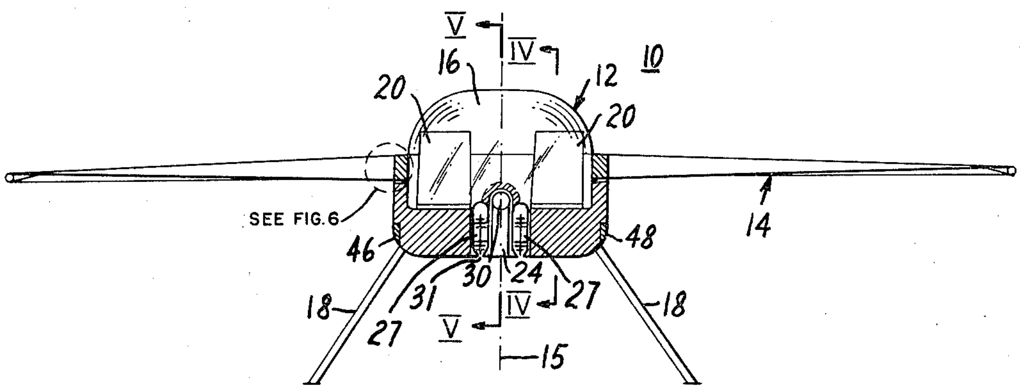
Primary Examiner—Galen L. Barefoot
Attorney, Agent, or Firm—Brumbaugh, Graves, Donohue & Raymond

[57] **ABSTRACT**

An aircraft is provided with a circular wing member which is rotatably mounted to a fuselage member. The circular wing member provides lift for horizontal flight and also provides gyroscopic stabilization of aircraft attitude. The circular wing member is substantially free of aerodynamically active flight control or propulsion members and, in a preferred embodiment, has a concentration of mass at its outer rim. The fuselage is provided with propulsion means for effecting and controlling vertical and horizontal flight. The propulsion means provides horizontal or vertical thrust along vectors which pass through the aircraft center of mass.

5 Claims, 7 Drawing Figures



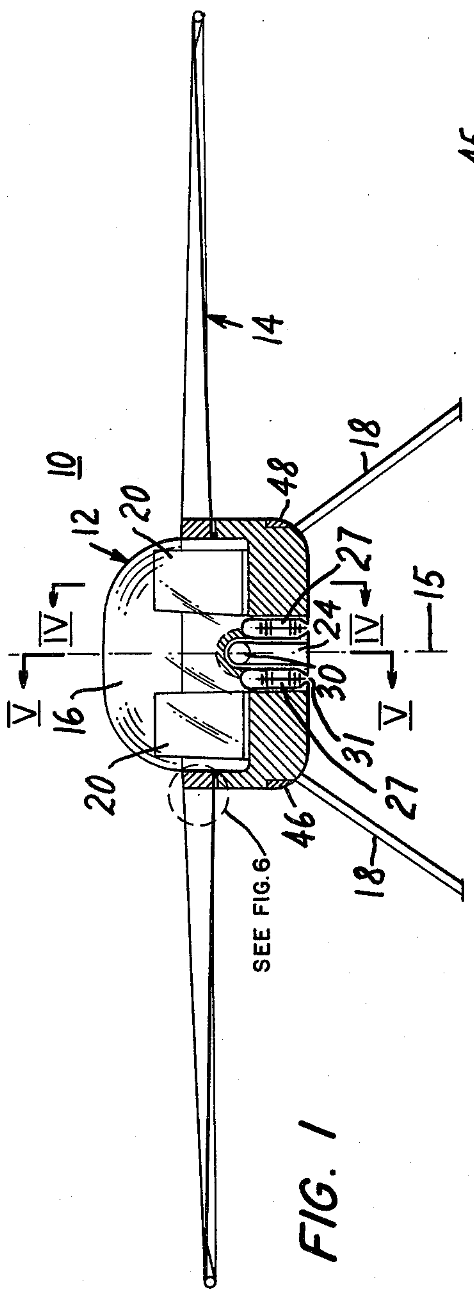


FIG. 1

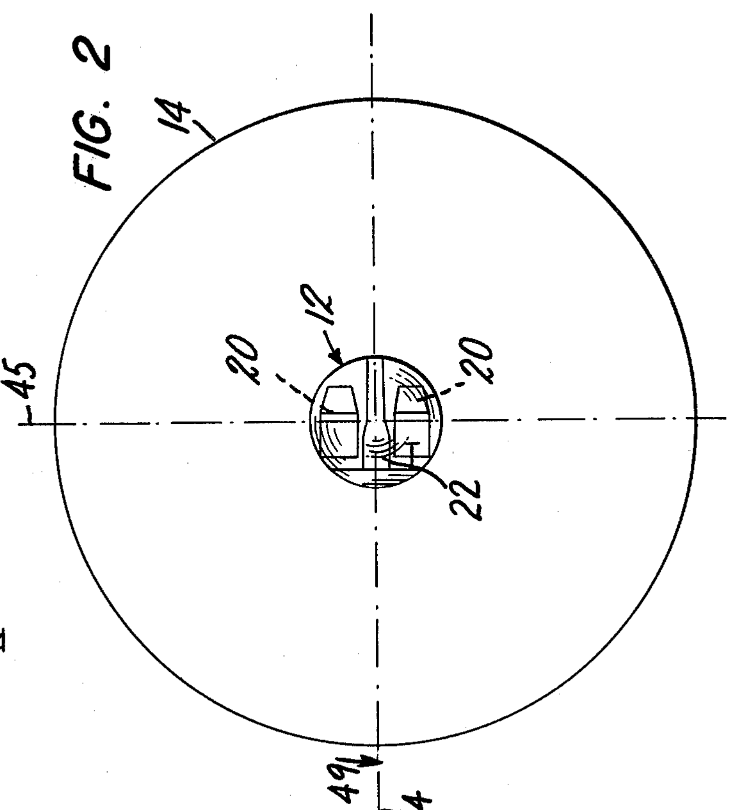


FIG. 2

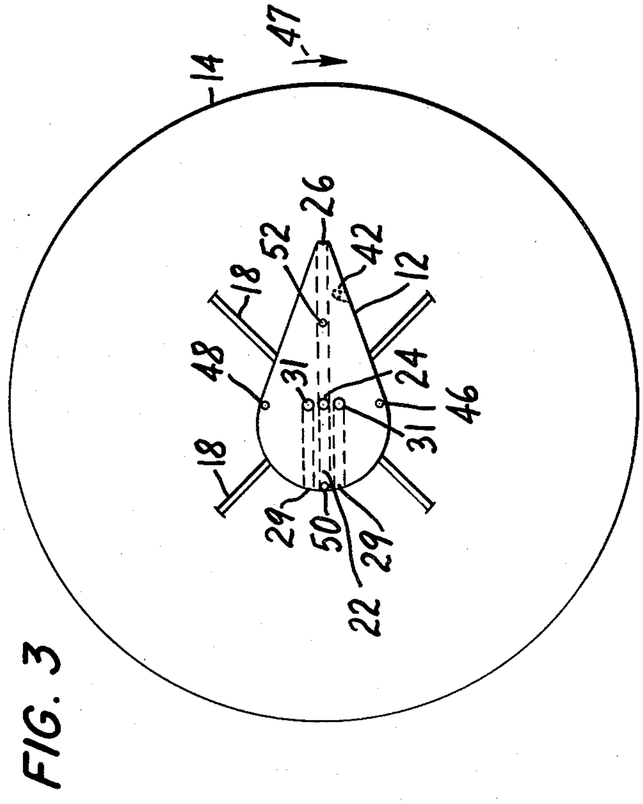


FIG. 3

FIG. 4

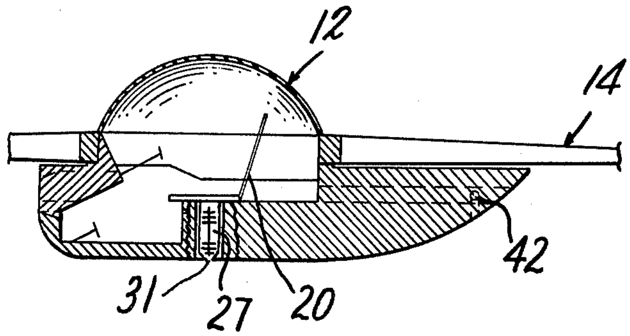


FIG. 6

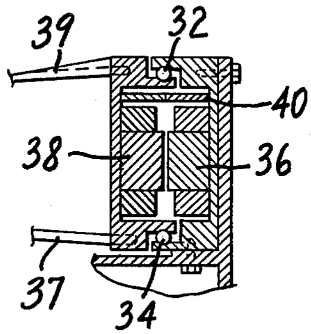


FIG. 5

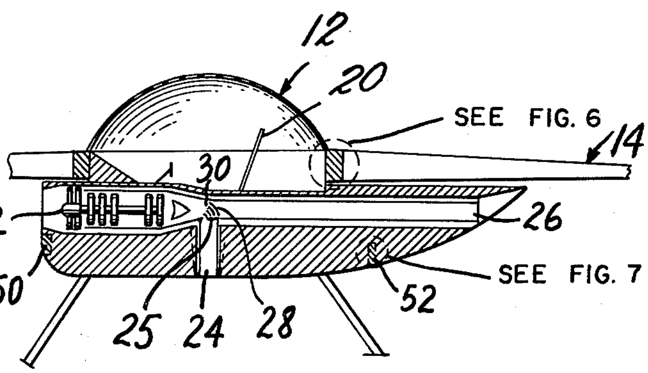
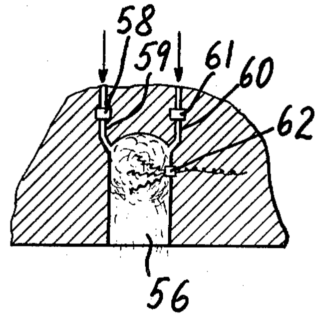


FIG. 7



AIRCRAFT WITH CIRCULAR WING

BACKGROUND OF THE INVENTION

This invention relates to powered aircraft and particularly to aircraft having a circular wing member.

Several prior-art patents, including U.S. Pat. Nos. 2,939,648, 3,067,967, 3,503,573, 3,514,053, 3,519,224, and 3,946,970, disclose aircraft with a circular wing member arranged to rotate about the aircraft fuselage and thereby provide gyroscopic stabilization of aircraft attitude. All of these prior-art aircraft are provided with some aerodynamically-active components on the circular wing member for assisting or controlling aircraft flight. In particular, the rotating wing members are most often provided with wing-shaped fins, channels, grooves, or thrust members for providing aircraft lift.

It is an object of the present invention to provide a new and improved aircraft having a circular wing member which is substantially free of aerodynamically-active members.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided an aircraft which includes a fuselage member centrally mounted in a wing member. The fuselage member includes propulsion means, flight-control means, and means for operating the propulsion and flight-control means. The wing member comprises a disk with a substantially vertical axis. The disk is arranged for rotation about the axis with respect to the fuselage and is substantially free of aerodynamically-active flight-control or propulsion members. Means is provided for rotating the disk with respect to the fuselage thereby to gyroscopically stabilize the attitude of the aircraft.

The propulsion means on the fuselage is a jet engine which is arranged to provide thrust with a first thrust component along the disk axis and a second thrust component substantially perpendicular to the disk axis. The operating means controls the relative magnitude of the first and second thrust components. The fuselage may be additionally provided with attitude control means comprising reaction motors. The reaction motors may be activated to exert a torque on the fuselage about an axis perpendicular to the disk axis and thereby cause gyroscopic precession of the disk axis and a consequent change in the attitude of the aircraft. Enhanced stabilization of the aircraft can be provided by a concentration of the mass of the wing member at the circumferential edge of the circular wing. This concentration of mass increases the gyroscopic moment of the rotating wing member in relation to overall vehicle weight and rotational speed of the wing member. In accordance with another aspect of the invention, the propulsion means are arranged to provide said first and second thrust components along vectors with directions passing substantially through the center of mass of the aircraft.

For a better understanding of the present invention, together with other and further objects, reference is made to the following description, taken in conjunction with the accompanying drawings, and its scope will be pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front view, partially in cross-section, of an aircraft in accordance with the present invention.

FIG. **2** is a top view of the FIG. **1** aircraft.

FIG. **3** is a bottom view of an aircraft similar to the FIG. **1** aircraft.

FIG. **4** is a longitudinal cross-section view of the FIG. **1** aircraft.

FIG. **5** is a central longitudinal cross-section view of the FIG. **1** aircraft.

FIG. **6** is a detailed cross-section of the bearing by which the wing of the FIG. **1** aircraft is mounted to the fuselage member.

FIG. **7** is a cross-sectional view of an attitude control reaction motor of the type used in the FIG. **1** aircraft.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. **1** through **5** show a two-seat utility aircraft **10** constructed in accordance with the present invention. The illustrated utility aircraft **10** is described for purposes of illustration only, and it should be recognized that the advantages inherent in the present invention are equally applicable to aircraft of larger or smaller size and having different configurations and uses; in fact, some advantages, to be described further below, are most important in aircraft having significantly larger sizes.

The aircraft **10** includes a fuselage **12** and a circular air foil or wing member **14**. The fuselage **12** includes a cockpit **16** within which seats **20** are provided to accommodate the aircraft pilot and another passenger. Fuselage **12** is also provided with landing gear **18** which comprises struts upon which the aircraft rests when on the ground.

Since the aircraft **10** is capable of vertical takeoff and landing, struts **18** need not be of strong construction to withstand forces of a rolling takeoff or landing, and therefore can have a small aerodynamic cross-section. Struts **18** are retractable into the fuselage to reduce aerodynamic drag during horizontal flight.

A principal propulsion engine **22** of a conventional jet engine design is provided centrally mounted toward the forward end of the fuselage. Engine **22** is used to provide thrust along a vector having a direction along the vertical axis **15** of wing **14** by exhaust of combustion gases through nozzle **24**, or alternatively provide thrust in a direction substantially perpendicular to the axis **15** of wing member **14** by exhaust which is directed through nozzle **26**. Two control members **25** and **28**, visible in FIG. **5** are provided between engine **22** and exhaust nozzles **24** and **26**.

When the aircraft has substantially zero horizontal speed, exhaust gases from engine **22** are directed by vanes **28** primarily or exclusively through nozzle **24** to generate thrust along a vector having a direction vertically downward along the axis **15** of the circular wing **14**. This axis, and hence the thrust vector, passes substantially through the aircraft center of mass **30**.

When the aircraft is to undergo horizontal flight, vanes **28** are retracted into the tube leading to nozzle **24**, and some or all of the thrust-producing exhaust gases from engine **22** are directed to exhaust nozzle **26** to produce a horizontal thrust along a vector which is perpendicular to the axis **15** of wing member **14** and passes through the aircraft center of mass **30**. When valve **25** is closed, all the thrust from engine **22** is provided to nozzle **26**.

Generally, it will be necessary to provide an engine capable of producing a thrust substantially in excess of the aircraft weight in order to effect satisfactory vertical climb and a satisfactory rate of slowing of vertical descent. Preferably, the thrust of engine **22** should be 30% in excess of the weight of the vehicle. This amount of engine thrust is not required during horizontal flight. It may therefore be advantageous to provide auxiliary engines for use only during hovering and vertical flight and a main engine for use during all aerial maneuvers. FIGS. **1** and **3** show such an arrangement wherein three engines are provided, a main engine **22** which can provide either vertical or horizontal thrust and auxiliary engines **27** having intakes **29** and downward-pointing exhaust nozzles **31** for use in supplying the necessary excess thrust for vertical takeoff, hovering and landing.

As previously noted, wing member **14**, which is symmetrical about vertical axis **15**, is rotatably mounted on fuselage **12** so that the axis **15** of the wing member passes through the aircraft center of mass **30**. Wing **14** is mounted for rotation with respect to the fuselage by the provision of bearings **32** and **34**, shown in FIG. **6**. It will be recognized that other bearing arrangements may be utilized. In order to cause the relative rotation between the fuselage and the wing member, electromagnetic motor poles and coils **36** and **38** are arranged between bearings **32** and **34** so that electric current may be used to counterrotate the two aircraft portions **12** and **14**. The motor also includes brush holder and armature assembly **40**. A reaction motor **42** is provided on fuselage **12** to provide counterrotational torque and compensate for the tendency of the aircraft fuselage **12** to rotate in opposition to the rotation of wing member **14**.

As an alternative to the use of coils **36** and **38** for producing relative rotation between fuselage member **12** and wing member **14**, the wing member may be provided with tangentially oriented reaction motors for inducing wing rotation and for acting in opposition to fuselage stabilizing reaction motor **42**.

An important feature of the present invention resides in the fact that the wing member **14** provides gyroscopic stabilization of aircraft attitude and is substantially free of aerodynamically active flight control or propulsion members. In the embodiment illustrated in FIGS. **1** through **5**, wing member **14** has no aerodynamically active member. Wing member **14** naturally takes part in the flight dynamics of aircraft **10** providing drag during vertical flight and lift, depending on wing shape and aircraft pitch during horizontal flight, but wing **14** does not include any members for affecting the speed or direction of vertical or horizontal flight. Thus, the rotation of wing member **14** is not used to induce any substantial downward thrust for assisting the vertical flight of the aircraft. Likewise, even in an embodiment having reaction engines on wing member **14** for causing rotation of the wing member, the reaction motors are substantially neutral with respect to the aircraft center of mass and provide no propulsion or control of the vertical or horizontal flight of aircraft **10**.

As previously noted, a principal function of wing member **14** is to provide gyroscopic stabilization of the attitude of aircraft **10**. For this purpose, the mass of wing member **14** is largely concentrated at the outer rim of the wing member. In one embodiment, the outer edge of wing **14** is fabricated out of a 50 milimeter pipe or a wire-wound rim, bent to form the wing edge 6.5 meters in diameter. The wing edge is supported by spoke-like structural members which are covered by sheet metal or other suitable material to form the airfoil surfaces **37** and **39** of the wing. For an aircraft having a 6.5 meter wing diameter and 700 kilograms maximum takeoff weight, the wing might weigh a total of 150 kilograms of which 115 kilograms is concentrated in the circumferential edge.

For the two-passenger aircraft **10** shown in FIGS. **1** through **5**, the wing member is rotated at a speed of 1,000 to 1,500 rpm to generate the required gyroscopic stabilization moment. Such high-velocity rotation is facilitated by the fact that the wing member is free of aerodynamically-active flight-control or propulsion members, particularly in the embodiment illustrated, wherein coils **36** and **38** form an electric motor which induces the rotation.

In accordance with the principals of gyroscopic stabilization, any force which tends to rotate the aircraft around an axis perpendicular to the axis of rotation **15** of wing member **14** will cause precession of the axis of rotation about the third perpendicular axis. Thus, a force which is asymmetrical about the aircraft roll axis **44** such as may be caused by one of the reaction motors **46** or **48** will cause precession of rotation axis **15** around pitch axis **45**. Thus, for rotation of wing **14** in the direction indicated by arrows **47** and **49**, activation of reaction motor **46** will cause an increase in the aircraft pitch angle, and activation of motor **48** will cause a decrease in the aircraft pitch angle. Likewise, activation of motors **50** and **52** to provide a torque around pitch axis **45** will cause precession of rotational axis **15** around roll axis **44**, and consequent tilting of the roll angle of the aircraft. Yaw control and despinning of the fuselage member are both provided by reaction motor **42**.

Those familiar with aircraft control will recognize that control of the aircraft may be provided by a conventional stick and rudder type control. The yaw jet **42** can be controlled in the same manner as a rudder and the roll and pitch jets **46**, **48**, **50**, and **52** can be controlled using a stick operated by the pilot. Automatic attitude and direction stabilization can be provided by an automatic control circuit responsive to gyroscopic sensors.

Since the air frame of aircraft **10** is free of control surfaces or stabilizers, flight control and maneuvering are different from those of conventional aircraft. Banking (i.e., precession of the rotational axis **15** around the roll axis **44**) causes side-slip without yaw change. Turns can be made without banking by changing the yaw of the fuselage and consequently the direction of thrust.

As an alternative to providing multiple control jets **46**, **48**, **50**, and **52**, it is possible to provide a single jet mounted to provide thrust in any direction to control aircraft pitch and roll. Such a single jet is preferably mounted pivotably on the axis **15** of wing **14** at a distance from the center of gravity **30**.

FIG. **7** is a detailed cross-sectional view illustrating an auxiliary reaction motor which may be used for any of control motors **42**, **46**, **48**, **50**, or **52**. The motor includes a combustion chamber **56** to which compressed air is supplied over conduit **59** and fuel is supplied over conduit **60**. Air and fuel supplies are controlled by valves **59** and **61**. Ignition means **62** is provided to ignite the fuel-and-air mixture in combustion chamber **56** and thereby cause a thrust to be generated by the exiting combustion gases.

Typical specifications for a two passenger aircraft **10** in accordance with the invention are as follows:

Wing Diameter: 6.5 m.
Cockpit Diameter: 1.2 m.
Height (excluding landing gear): 1.05 m.
Fuselage length: 2.5 m.
Fuselage width: 1.35 m.
Weight empty: 405 kg.
Payload: 295 kg.
Maximum Takeoff Weight: 700 kg.

Those skilled in the art will recognize that the principles of the present invention can advantageously be applied to aircraft having larger dimensions and different functions. The aircraft described can achieve the high air speed characteristic of fixed-wing jet aircraft and is capable of vertical takeoff and landing characteristic of rotary wing aircraft. Further, the aircraft has high stability and maneuverability thereby making it most suitable for many military missions such as close tactical support.

While the preferred embodiments of the invention have been described, it will be recognized that other and further modifications may be made thereto without departing from the spirit of the invention, and it is intended to claim all such modifications as fall within the true scope of the invention.

I claim:

1. An aircraft for vertical, horizontal, or stationary flight, comprising a wing member and a fuselage member centrally mounted in said wing member, said fuselage member including propulsion means, aerodynamically active flight control means, and means for operating said propulsion and flight control means, said wing member comprising a disk substantially larger than said fuselage and having a substantially vertical axis, said disk being arranged for rotation about said axis with respect to said fuselage, said disk and propulsion means being arranged so that said disk has substantially neutral lift characteristics when rotated, said disk being substantially free of aerodynamically active flight control or propulsion members, whereby said disk provides substantially no lift or thrust during said vertical or stationary flight and means for rotating said disk relative to said fuselage, thereby to gyroscopically stabilize the attitude of said aircraft, said propulsion means comprising a reaction motor having a first exhaust opening for providing a first thrust component along said disk axis and a second exhaust opening for providing a second thrust component substantially perpendicular to said disk axis, said first and second exhaust openings comprising tubular passages, said passages meeting substantially at the center of gravity of said aircraft, and said operating means including means for controlling flow of reaction motor exhaust gases through said exhaust openings thereby to control the relative magnitude of said thrust components.

2. An aircraft as specified in claim **1** wherein the relative mass of said disk is greater in the region near the circumferential edge of said disk than in the adjacent radially inner regions of said disk.

3. An aircraft as specified in claim **2** wherein said disk includes a relatively massive ring forming the circumferential edge of said disk.

4. An aircraft as specified in claim **1** wherein said means for effecting relative rotation comprises an electric motor.

5. An aircraft as specified in claim **4** wherein said electric motor has ring shaped pole members surrounding said fuselage member at the junction of said fuselage member and said wing member.

* * * * *

United States Patent [19]

Eshoo

[11] **4,326,681**

[45] **Apr. 27, 1982**

[54] **NON-RIGID AIRSHIP**

[76] Inventor: **Fredrick Eshoo,** 66 Cleary Ct., Apt. 1304, San Francisco, Calif. 94109

[21] Appl. No.: **77,188**

[22] Filed: **Sep. 20, 1979**

[51] **Int. Cl.**3 .... **B64B 1/58**

[52] **U.S. Cl.** .... **244/30;** 244/23 C; 244/97; 244/128

[58] **Field of Search** .... 244/23 C, 24, 25, 26, 244/27, 28, 29, 30, 31, 96, 97, 98, 125, 128

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Primary Examiner—Charles E. Frankfort

Attorney, Agent, or Firm—Hill, Van Santen, Steadman, Chiara & Simpson

[57] **ABSTRACT**

A lighter-than-air saucer or disc-shaped non-rigid airship is disclosed. A saucer-shaped flexible envelope is provided within which an annular pressurized tube is positioned so as to maintain the flexible envelope in a saucer shape when inflated. Walls within the envelope from a central chamber and a plurality of outer chambers symmetrically disposed around the central chamber. Typically a load such as a gondola is suspended beneath the central chamber. To maintain level horizontal flight stability, differential forces are developed by preferably providing the central chamber with heated air and the outer chambers with a lighter-than-air gas such as helium providing greater lift than the central chamber. Propulsion units are preferably arranged at opposite peripheral side edges of the envelope and maneuvering of the saucer-shaped airship is accomplished by rotating the airship.

8 Claims, 11 Drawing Figures

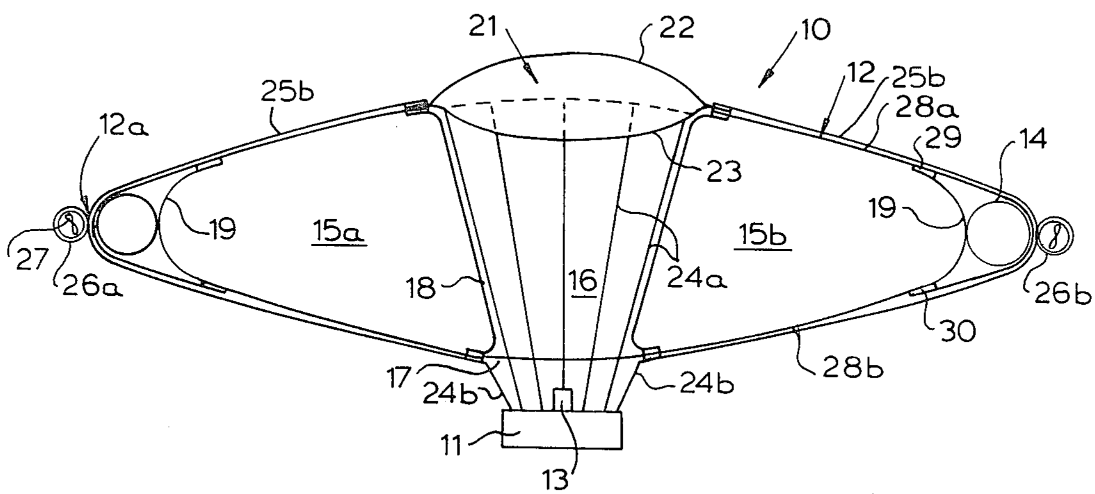


FIG. 1

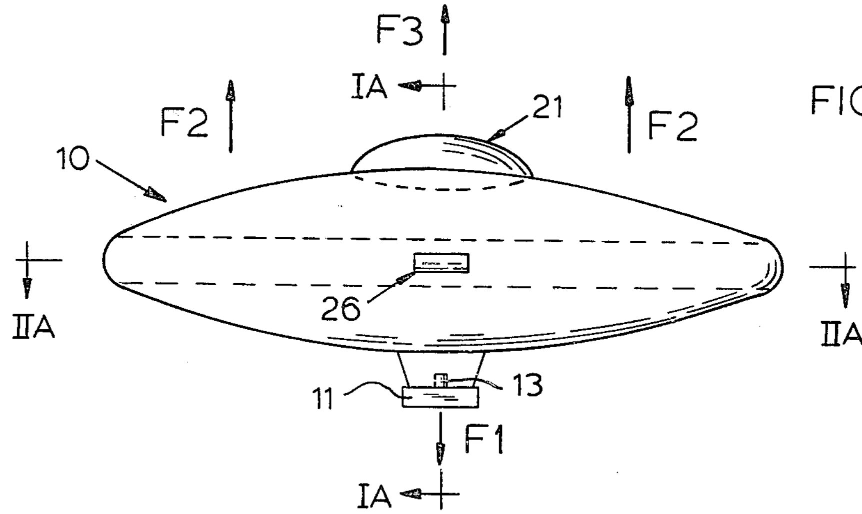


FIG. 1A

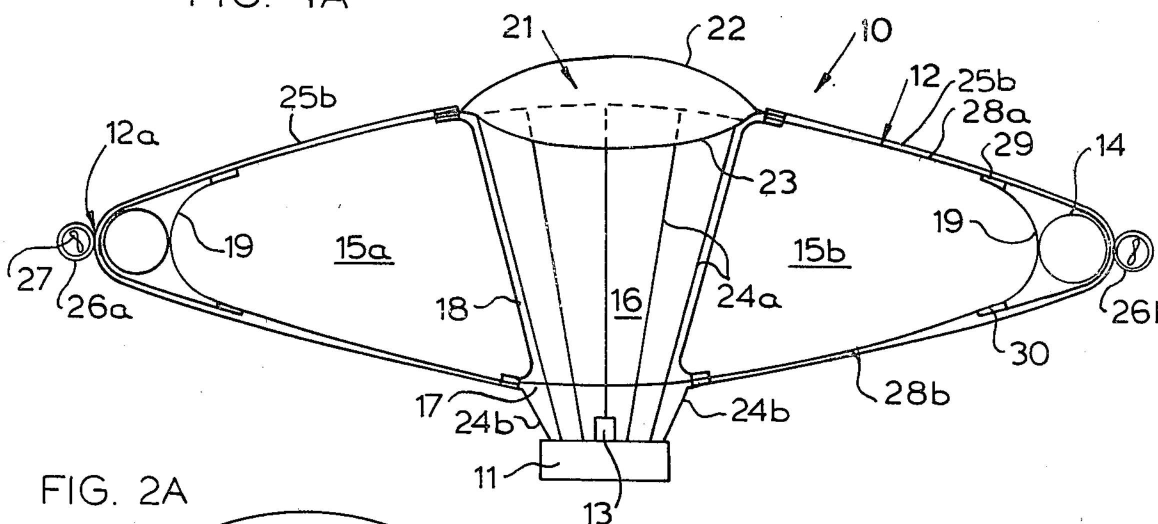


FIG. 2A

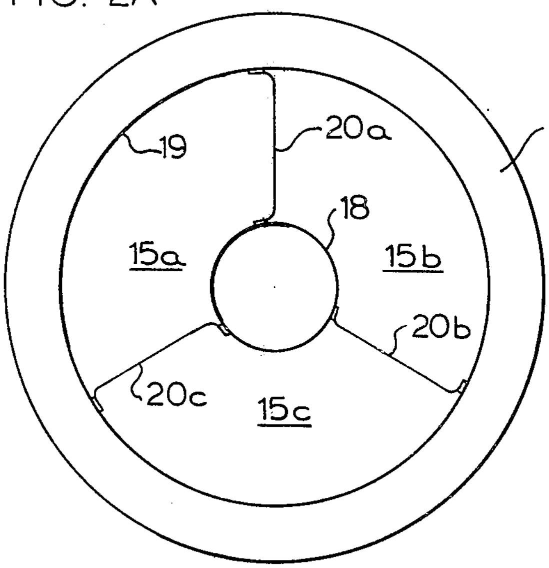


FIG. 3

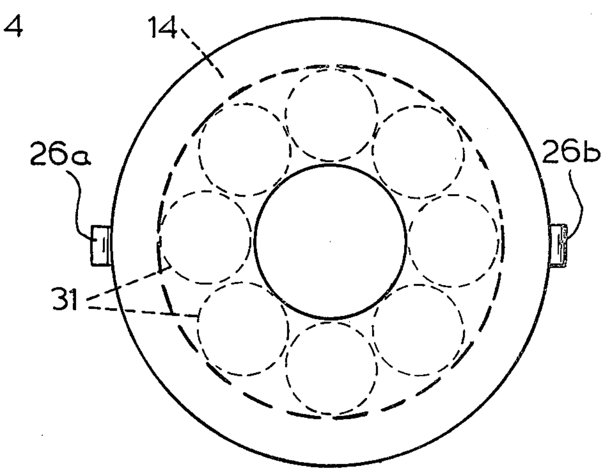


FIG. 2

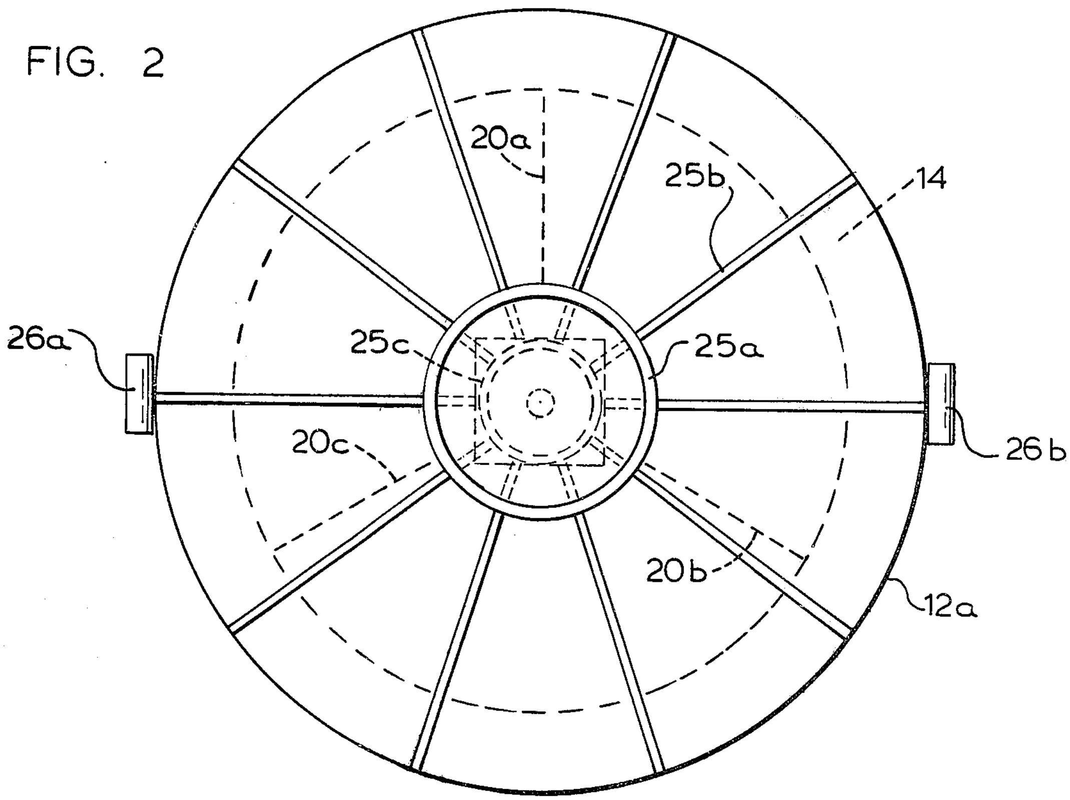


FIG. 4

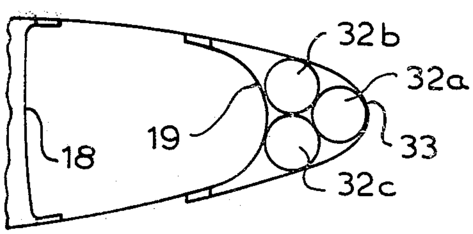


FIG. 5

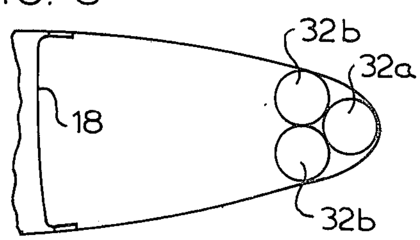


FIG. 6 $T_1 \gg T_2$

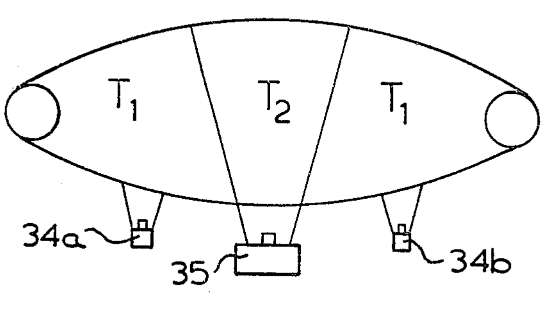


FIG. 7 $T_1 \gg T_2$

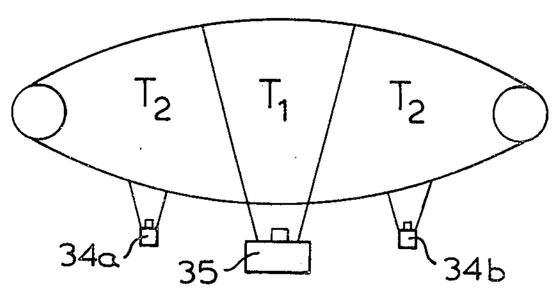


FIG. 8

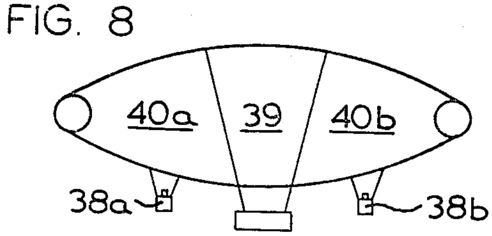
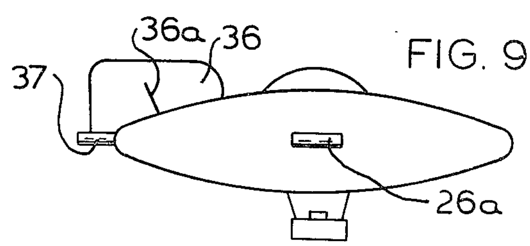


FIG. 9



NON-RIGID AIRSHIP

BACKGROUND OF THE INVENTION

Non-rigid and/or lighter-than-air airships are known such as gas balloons which have been provided in many shapes and sizes. Known designs are extremely bulky and have considerable drag if the motor is used for lateral propulsion. It would be advantageous to build a gas balloon or other type of airship which is more suited by its shape to be propelled with less drag. Such a shape would be streamlined by comparison with known balloon shapes and is preferably, therefore, of small dimensions in one coordinate direction such as a thin cross-section. It is, however, very difficult to construct from a soft fabric a balloon which will retain such a shape when inflated. More particularly, if the shape chosen is that of a disc or "flying saucer" shape, it is difficult to maintain a thin cross-section when the envelope is inflated.

It has also been previously known to provide lighter-than-air airships which can be propelled in a given direction and which are streamlined to promote propulsion in a given direction but which have fins or other guide surfaces to maintain stability. If a turn to the left or right is desired, it is usually necessary to bank one fin lower than the lower to initiate a turn. Consequently, sharp turns cannot be achieved.

It is known that a "flying saucer" shape is a desirable shape since it is streamline in all horizontal directions. However, up until now it has not been known how to maintain such a saucer-like shape in level flight.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a saucer-shaped airship which is aerodynamically stable and which will assume a level flight even in the presence of various wind currents which might temporarily effect level flight of the airship.

It is another object of this invention to provide a non-rigid lighter-than-air airship which will maintain a disc or saucer-like shape after inflation.

It is a further object of this invention to provide an airship which can be turned without the need for banking and which can execute turns over a very small area.

According to a preferred form of the invention, a lighter-than-air saucer-shaped non-rigid airship is provided wherein a saucer-shaped flexible envelope is provided within which an annular pressurized tube is positioned at an outer peripheral edge portion of the saucer-shaped envelope so as to maintain the saucer-shape when the envelope is inflated. Within the envelope a central chamber and an outer chamber system surrounding the central chamber is provided. In the central chamber heated air or a lifting gas is provided and in the outer chambers a lifting gas or heated air is also provided but wherein the lift provided in the outer chamber system is greater than the central chamber. With a load suspended beneath the central chamber, aerodynamic stability is attained for level or horizontal flight since the lifting force provided by the central chamber is less than the symmetrical force surrounding the central chamber.

In another form of the invention, a plurality of gas bags are provided surrounding the central chamber. Also, lifting gases such as helium may be provided throughout the airship and the use of hot air eliminated so long as a differential lift is created within the airship so as to maintain aerodynamic stability as explained above. Additionally, the lifting force provided by the central chamber might be greater than the lifting forces provided by the outer chambers and thus also achieve aerodynamic stability in this manner.

Although in the preferred form the balloon is in the shape of a "flying saucer", other shapes may be employed while still retaining the aerodynamic stability indicated previously.

Preferably the outer chamber system includes a plurality of chambers symmetrically disposed around the central chamber and during normal flight transfer of gas from one chamber to the other is prevented so that in the event of a temporary tilting of the airship gas will not flow from one side to the other. However, valves may be provided for selectively transferring gas from one chamber to another.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of the improved airship of this invention;

FIG. **1A** is a cross-sectional view taken along line *Ia*—*Ia* of FIG. **1**;

FIG. **2** is a top view of the saucer-shaped airship of this invention;

FIG. **2A** is a simplified cross-sectional view showing placement of chamber dividing walls taken along line II*a*—II*a* of FIG. **1**;

FIG. **3** is a top cross-sectional view of an alternate embodiment of the airship of FIG. **1**;

FIG. **4** is an alternate embodiment of a frame supporting tube system at peripheral edges of the saucer-shaped airship of FIG. **1**;

FIG. **5** is another alternate embodiment of the frame system of FIG. **4**;

FIGS. **6**, **7** and **8** are simplified side cross-sectional views illustrating various lifting gas arrangements in alternate embodiments of the invention; and

FIG. **9** is a side view of the airship of this invention showing alternate embodiments employing stabilizing fins and pusher-type propulsion units.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIG. **1**, in accordance with the invention an improved non-rigid saucer-like shaped airship is provided generally indicated at **10**. Preferably such an airship utilizes a lifting gas such as heated air, helium, or the like. The airship may support a load **11** such as a gondola carrying a pilot. A hot air generator **13** is preferably mounted on the gondola so as to direct a stream of heated air upwardly through an aperture **17** more clearly shown in FIG. **1A** into the airship. Such hot air generators are well known and include propane burner systems.

The airship is formed of an outer envelope **12** of saucer or disc-like shape and preferably comprising nylon or plastic materials such as used in hot air and gas balloons. In order to maintain the saucer-like shape, an annular pressurized tube **14** generally known as an "inner tube" shape is provided at an outer peripheral edge **12***a* of the airship. With the annular tube **14** positioned within the outer envelope **12** and pressurized with air or with helium, when the outer envelope **12** is inflated the saucer-shape is maintained since the annular tube **14** serves as a frame member. As shown in FIGS. **1A**, **2**, and **2A**, the outer envelope **12** is comprised of a top envelope section **28***a* and a bottom envelope section **28***b*. A central or inner chamber is formed within the envelope **12** by providing an inner chamber wall **18** surrounding a vertical central axis of the airship. The inner chamber wall **18** is slanted so as to form an upside down truncated conical shaped central chamber **16** which approximates the shape of known hot air balloon designs. Exterior to the central chamber **16** a plurality of outer chambers **15***a,b,c* are distributed around the central chamber in symmetrical fashion. Preferably three or a multiple of three of such chambers are provided. These chambers **15***a,b,c* are formed by providing chamber dividing walls **20***a,b,c* which radially extend from the inner chamber wall **18** out towards the peripheral edge **12***a* of the airship. These dividing walls are provided in a symmetrical pattern such as shown in FIG. 2A so that the volumes of the outer chambers **15***a,b,c* will be substantially equal. An outer chamber wall **19** may be provided to segregate the annular tube **14** from each of the outer chambers or to provide a well defined sealed interior for each of the chambers **15***a,b,c.*

A dome chamber **21** is positioned above the central chamber **16** and provides a supporting roof above the central chamber **16**. This chamber is formed of an upper wall **22** and a lower wall **23**. Load cables **24***a* which are preferably nylon may extend from the top of the central chamber **16** down to the gondola **11** and additional load cables **24***b* may extend from the bottom of the outer envelope **12** adjacent the aperture **17** to the gondola.

To provide further envelope support and load lines for the gondola, an upper circular load tape **25***a* as shown in FIG. 2 may be provided around the dome **22**. Longitudinal load tapes **25***b* extend around the outer envelope in a symmetrical pattern down to a lower circular load tape **25***c* around the aperture **17**.

Propulsion units **26***a,b* are provided for movement of the airship during flight. These propulsion units are preferably placed at the peripheral edge **12***a* of the saucer-shaped airship and at opposite sides thereof. Each of these propulsion units may contain a small propeller **27** driven by a low horsepower electric motor.

As shown in FIG. 1A, the outer wall **19** may be an extension of the lower envelope section **28***b* which is sewn to the upper envelope section at **29**. Similarly, the upper envelope section **28***a* may extend around the annular tube **14** so as to form the peripheral edge **12***a* and then be sewn to the lower envelope section **28***b* at **30**.

In the preferred embodiment of the invention, the central chamber **16** is filled with heated air and the outer chambers **15***a,b,c* are filled with helium. Also, to insure adequate lift, it is preferable to pressurize the annular tube **14** with helium. When a load is applied such as the gondola **11**, a downward force **F1** is created as shown in FIG. **1**. This force is balanced by the forces F2 plus F3. Horizontal equilibrium of the airship is maintained during flight since the symmetrical forces F2 surrounding the central axial force F3 are greater than F3. Consequently, if an air current temporarily tilts the airship, the airship will automatically reassume a horizontal flight plane. In other words, since the density of air decreases with increasing elevation above the ground, if a left side of the saucer tips upwardly the surrounding air will be less dense than at the right side of the airship where the air is more dense. Consequently, a differential will be created such that the lift on the right side of the airship will exceed the lift on the left side of the airship and bring the airship back to a horizontal equilibrium position. This horizontal aerodynamic stability is therefore achieved with the invention through a differential lift system contained within an outer envelope. Preferably there is no gas transfer between the outer chambers so that when one side of the airship is higher than the other there is no flow of gas to the higher portion of the airship. However, valves may be provided to selectively transfer gas to balance lift.

By filling the dome chamber **21** with helium, the top of the dome is self-supporting even without the addition of hot air. The dome may also be pressurized with air.

The altitude of the airship may be controlled by the temperature of the hot air within the central chamber **16**, thus controlling the lift.

With the invention, in order to change the flight direction of the aircraft, it is not necessary to bank such as in prior art airship designs. Rather, one simply creates greater propulsion from one of the two propulsion units so as to rotate the saucer-shaped airship substantially about its vertical central axis and then resume level flight in the new direction by applying substantially equal thrusts from each of the propulsion units **26***a,* **26***b.*

The aerodynamic characteristics of the airship are superior to previous designs due to the relatively small vertical height relative to the diameter of the airship.

Also, by providing the lower envelope section **28***b* continuous to the junction point **29**, gas seepage is minimized.

Also, it is possible to provide the differential lift concepts of this invention in a non-rigid airship of shape other than circular although the circular shape provides the direction change advantages previously described.

Further embodiments of the invention are shown in FIGS. **3** through **9**. In FIG. **3** rather than providing dividing walls in order to form the outer chambers, a plurality of closed lifting gas bags **31** are provided between the annular tube **14** and the central chamber **16**. These bags **31** should be distributed substantially evenly around the central chamber **16** and are preferably filled with helium.

As shown in FIG. **4**, rather than providing a single annular tube **14**, three or more small annular tubes such as **32***a,* **32***b* and **32***c* may be provided in the triangular pattern such that one of the tubes **32***a* forms a narrow, sharp, aerodynamically smooth peripheral edge **33** for the airship.

As shown in FIG. **5**, it is possible to eliminate the outer chamber wall **19** provided that the dividing walls and inner chamber wall **18** are provided for the formation of outer chambers.

As shown in FIG. **6**, the central chamber may be heated with a hot air generator **35** while outer chambers may be heated with additional hot air generators **34***a,* **34***b* and **34***c* (not shown). Preferably the temperature **T1** in the outer chambers exceeds the temperature **T2** in a central chamber so as to create the differential lift aerodynamic stability described previously.

Alternatively as shown in FIG. **7**, the temperature in the outer chambers may be less than the temperature in the central chamber so as to have a greater force in the center and lesser forces surrounding the central force. This arrangement will also result in aerodynamic stability through differential lift.

In FIG. **8** the central chamber **39** is filled with a lifting gas other than air such as helium whereas the outer chambers **40***a,b,c* are provided with heated air by use of hot air generators **38***a,b,c.* Here again the differential lift aerodynamic stability is achieved so long as the forces between the central chamber and the outer chambers differ.

Finally, in FIG. 9 the addition of a vertical stabilizing fin **36** is shown attached at one side of the airship and supported by a support cable **36***a*. Also, a pusher type propulsion unit **37** may be provided as an alternative or in addition to the propulsion units **26***a,b* previously described.

Although in the preferred embodiment of this invention a circular disc or saucer-shape is employed, the principle of differential lift for stability may also be employed with other shapes of airships such as a cigar shape in which case chambers with greater lift can be provided at the front and rear of the airship symmetrical to a central load so that the front and tail portions of the airship will remain in a substantially horizontal plane although such an arrangement may not maintain rotational stability about a longitudinal axis of the airship.

Although various minor modifications may be suggested by those versed in the art, it should be understood that I wish to embody within the scope of the patent warranted hereon, all such embodiments as reasonably and properly come within the scope of my contribution to the art.

I claim as my invention:

1. A non-rigid lighter-than-air airship employing differential lift for stabilization, comprising:

a saucer-shaped envelope having a central chamber and a plurality of separate outer chambers symmetrically arranged around the central chamber;

means supported below the central chamber of the envelope for generating heated air;

a lighter-than-air medium other than heated air in the outer chambers and the central chamber having an opening in a bottom thereof dimensioned to permit heated air to enter from the means for generating heated air, the medium in the outer chambers providing a lifting force arranged symmetrically about the central chamber which is greater than that provided by the central chamber when filled with heated air;

the other chambers being separate from one another so as to prevent shifting of the lighter-than-air medium when the saucer-shaped envelope is tilted relative to level flight; and

the outer chambers being designed to provide the symmetrical lifting force so as to maintain the airship in a horizontal attitude as an equilibrium state to which the airship returns when deflected.

2. The non-rigid airship of claim **1** wherein an annular pressurized tube is positioned within the envelope along a circular periphery of the envelope to maintain a circular shape of the envelope.

3. The non-rigid airship of claim **1** wherein the plurality of outer chambers are provided by dividing walls extending from the central chamber to the outer periphery of the airship, said dividing walls being symmetrically arranged around the central chamber.

4. The non-rigid airship of claim **1** wherein propellors are arranged on opposite sides of the airship at a periphery thereof.

5. The non-rigid airship of claim **1** wherein a domed chamber closes the top of the central chamber.

6. A method for stabilizing a non-rigid airship by differential lift, comprising the steps of:

providing an envelope having a central chamber with an opening at the bottom and a plurality of enclosed outer chambers arranged symmetrically about the central chamber in a horizontal plane;

introducing heated air through the opening in the central chamber generated by a hot air generator suspended below the central chamber and providing a lighter-than-air medium other than heated air in each of the outer chambers;

loading the airship below the central chamber; maintaining the airship in a horizontal attitude which is an equilibrium state to which the airship returns when deflected, said equilibrium state being a result of outer peripheral lift forces created by the outer chambers being symmetrically arranged about a lesser lift force created by the heated air in the central chamber; and

preventing a shift of the medium in the outer chambers when the airship is tilted relative to level flight by providing the medium in said enclosed outer chambers which are separate from one another.

7. The method of claim **6** including the further step of maintaining a shape of the airship by pressurizing an annular tube within the envelope positioned along a circular periphery of the envelope.

8. A non-rigid lighter-than-air airship employing differential lift for stabilization, comprising:

a circular saucer-shaped envelope having a central chamber and a plurality of separate equal volume outer chambers symmetrically arranged around the central chamber;

a load supported below the central chamber of the envelope;

a same lifting gas provided in all of the outer chambers and also a lifting gas in the central chamber, the lifting gas in all the outer chambers providing a total lifting force arranged symmetrically about the central chamber which is greater than that provided by the lifting gas in said central chamber;

the outer chambers of equal volume being separate from one another so as to prevent shifting of the lifting gas therein when the saucer-shaped envelope is tilted relative to level flight; and

the outer chambers being designed to provide the symmetrical lifting force so as to maintain the airship in a horizontal attitude as an equilibrium state to which the airship returns when deflected.

* * * * *

United States Patent [19]
Jordan

[11] 4,387,867
[45] Jun. 14, 1983

[54] FLYING CRAFT

[75] Inventor: Heinz Jordan, Carinthia, Austria
[73] Assignee: Technische Gerate-u Entwicklungsgesellschaft m.b.H., Wolfnitz/Klagenfurt, Austria

[21] Appl. No.: 267,493
[22] Filed: May 27, 1981

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 956,005, Oct. 30, 1978, Pat. No. 4,273,302.

[30] **Foreign Application Priority Data**

Oct. 31, 1977	[AT]	Austria	7749/77
Jun. 13, 1978	[AT]	Austria	4309/78
Jun. 13, 1978	[AT]	Austria	4310/78
Feb. 1, 1980	[AT]	Austria	537/80

[51] Int. Cl.³ B64C 29/00; B64C 39/06
[52] U.S. Cl. .... 244/12.2; 244/23 C
[58] Field of Search .... 244/12.1-12.5, 244/23 R-23 D, 73 B, 73 C, 34 A; 46/74 D, 75

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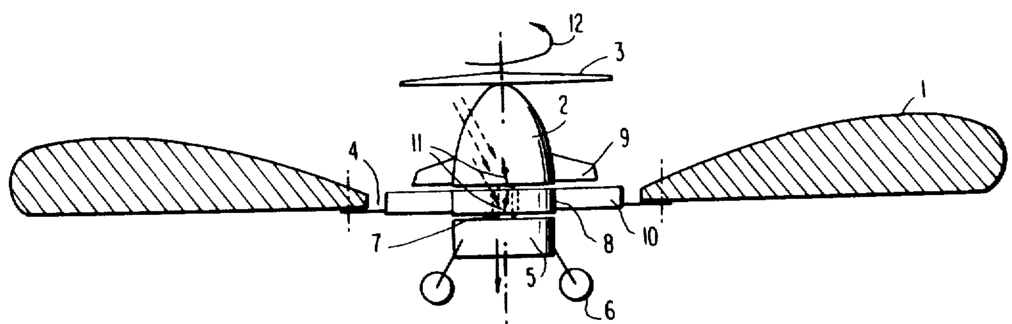
Primary Examiner—Charles E. Frankfort
Attorney, Agent, or Firm—Beveridge, DeGrandi & Kline

[57] **ABSTRACT**

A flying craft has a supporting element with an opening in it. A driving unit with a propeller drives air downwardly through the opening. Vanes mounted on the driving unit break up the circular component of the air velocity and also counteract the torque on the driving unit. The downwardly moving air is formed into a laminar air stream by a second set of vanes which are connected to the supporting element for rotation therewith. The pitch of the vanes can be adjusted. Adjustment of the pitch of the second set of vanes may cause the supporting element to rotate and give the craft a gyroscopic stability. The craft is tiltable for maneuvering purposes.

5 Claims, 4 Drawing Figures



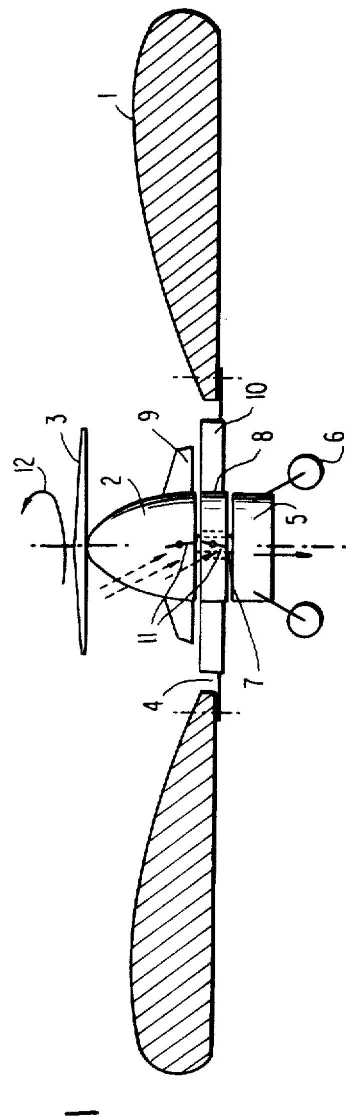


FIG.1

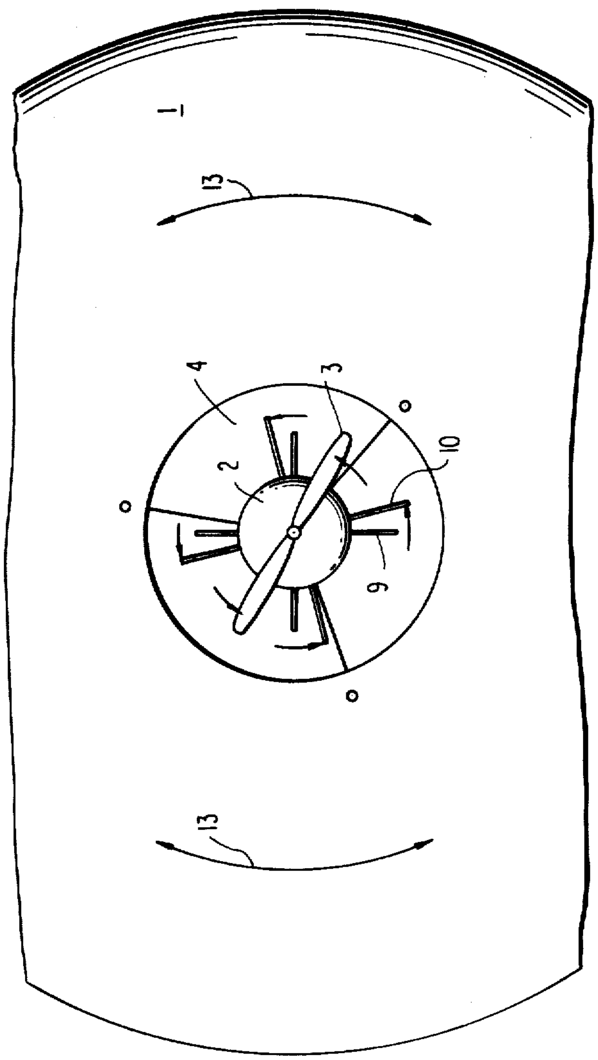


FIG.2

FIG. 3

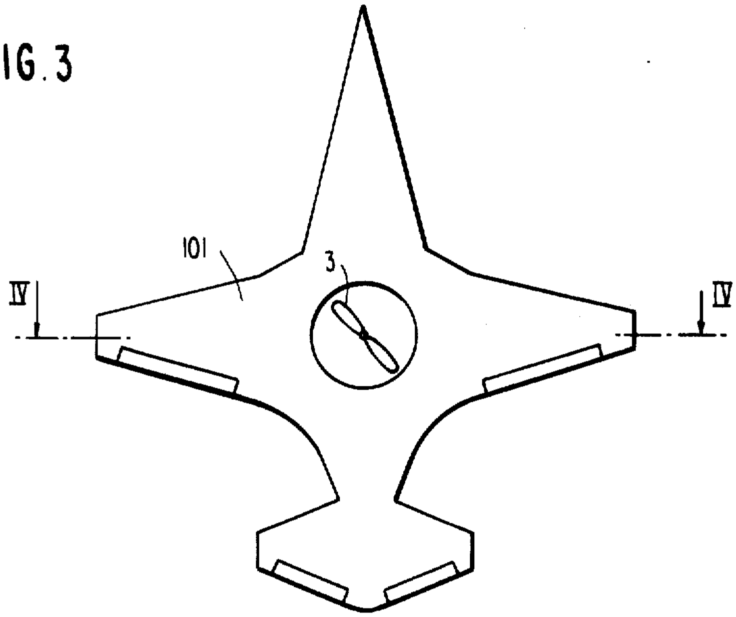
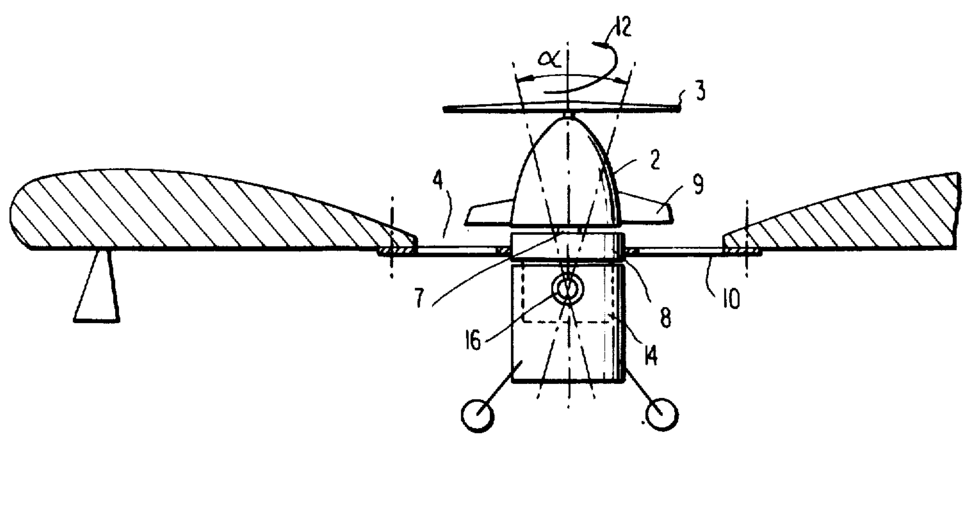


FIG. 4



FLYING CRAFT

REFERENCE TO RELATED APPLICATION

This is a continuation-in-part of U.S. patent application Ser. No. 956,005 filed Oct. 30, 1978 now U.S. Pat. No. 4,273,302.

BACKGROUND OF THE INVENTION

The invention relates to a flying craft with an outer supporting means, at least one driving means such as a driving motor with a propeller, preferably coaxially arranged in relation to the supporting means, a carrier which may be a cabin or steering means, and an annular gap for downward movement of an air stream between the supporting means and the driving means.

A flying craft of this type is disclosed in Austrian PS No. 353,105 and U.S. patent application Ser. No. 956,005 filed Oct. 30, 1978, which are incorporated herein by reference. In such craft, the driving unit is mounted on and rotates with the supporting means, and the steering means or cabin is rotatably mounted in relation to the supporting means and the driving unit. The supporting means has the shape of an airfoil profile and, in response to the counter torque of the driving unit, it counterrotes relative to the direction of propeller rotation.

It is the object of this invention to provide an improved flying craft which has a stonger aerodynamic lift, requires reduced mechanical effort and prevents carrier rotation by a simple and effective set of vanes.

SUMMARY OF THE INVENTION

The objects of this invention are achieved in a flying craft of the type initially mentioned by providing in the annular gap, or immediately above it, at least two sets of air deflecting vanes, each set including two or more vanes which preferably are angularly adjustable, and with the sets of vanes being spatially arranged one above the other.

According to this invention, the supporting means receives its lift primarily from the air stream generated by the driving means, not by the counter torque of the driving unit. Depending upon the inclination angle of the vanes, the supporting means can be rotationally driven in the same direction of rotation as the driving unit, or in a direction counter to the rotating direction of the driving unit. It is essential that the upper set of vanes neutralize the counter torque of the air stream by defecting the air stream to align it partially and direct it downwardly. Subsequently, the air stream is formed into a substantially laminar, downwardly directed air stream by the lower set of vanes. The carrier, i.e. the load-receiving or steering means of the flying craft, does not rotate during flight.

According to an embodiment of the invention, the vanes in both sets are pivotable, preferably together, around their essentially horizontally extending axes. This provides them with an adjustable inclination which can be controlled to vary the rate of rotation of the supporting means to increase or decrease the gyroscopic effect of the supporting means, thereby influencing the stability of the flying craft.

Since the cabin of the flying craft does not rotate during flight, it is possible to connect the driving unit and the cabin rigidly to one another, in particular by means of a shaft. This results in a particularly simple and stable construction.

In a preferred construction of the flying craft, the upper set of air deflection vanes is attached only to the driving unit and the lower set of air deflection vanes is attached to both the supporting means and to a supporting plate on which the driving unit is rotatably mounted.

It is also possible to provide the supporting means with a separate additional drive which, although not absolutely necessary, improves the steering of the flying craft.

In another embodiment according to the invention, the supporting means does not carry out a rotating motion around its axis during flight. In this embodiment of the invention, the flying craft and/or the driving unit is provided with at least one means for imposing a tilting force on the flying craft as, for example, by displacing the center of gravity of the flying craft. The supporting means receives its aerodynamic lift from the air stream generated by the driving unit and not from rotation produced by counter torque from the driving unit. The supporting means can be steered by tilting, remaining stationary in air space during flight, i.e. not rotating around its axis. The upper set of steering vanes neutralizes the counter torque received by the driving unit and partially aligns the air stream and directs it downwardly, while the lower set of steering vanes subsequently generates a largely laminar, downward-directed air stream. The load-receiving cabin and/or the steering means of the flying craft do not rotate during flight.

In this latter embodiment, the means for imposing a tilting force may be a gyroscopic means rotatably mounted in relation to the driving unit, it may comprise two or more steering nozzles arranged on the supporting means, or it may be means for tilting the cabin to shift the center of gravity of the craft.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be explained in detail with reference to the drawings which show two embodiments of the invention.

FIG. **1** is a diagrammatic sectional view of a flying craft according to the invention;

FIG. **2** is a top view of the craft of FIG. **1** partially broken away;

FIG. **3** is a top view of a flying craft according to another embodiment of the invention; and

FIG. **4** is a section along line II—II of FIG. **3** in enlarged scale, partially broken away.

DETAILED DESCRIPTION OF THE INVENTION

The flying craft illustrated in FIGS. **1** and **2** comprises a ring-shaped supporting means **1**, having rotational symmetry, and a driving unit **2** with a propeller **3**. As can be seen from the figures, the ring defines a normally horizontal opening which extends vertically through the supporting means **1**. Propeller **3** is mounted with its axis of rotation colinear with the axis of rotational symmetry of the supporting means **1**. The driving unit **2** is arranged coaxially within the supporting means **1**. An annular gap **4** is formed between the supporting means **1** and the driving unit **2**. The supporting means **1** viewed in cross section preferably has the form of an airfoil profile, but it may be of any other given shape. The driving unit **2** could have the form of counterrotating double propellers or of a radial-flow turbine, and it could be arranged outside axis of the supporting means **1**. Connected to the driving unit **2** is a carrier which may be either a load-receiving cabin **5** having a landing gear **6**, or a steering means for the flying craft. This connection between the driving unit **2** and the cabin **5** is effected by means of a shaft **7** which is perpendicular to and extends through a mounting means such as a supporting plate **8** for the driving unit **2**. The supporting plate **8** is arranged below and is rotatable relative to the driving unit and forms the inner circumference in the lower part of the annular gap **4**. the propeller **3** is spaced above the upper side of the supporting means **1**.

A first set of air deflection vanes **9** is arranged immediately above the annular gap **4**, and a second set of air deflection vanes **10** is arranged in the annular gap **4** below the first set of vanes **9**. The upper set of vanes **9** is attached to the driving unit **2** only at its inner circumference, while the lower set of vanes **10** is attached to and supported by both the supporting means **1** and the supporting plate **8** for the driving unit **2**. As can be seen in the figures, each set of vanes **9** and **10** includes a plurality of steering vanes, flaps, blades or baffles **11** which are pivotable around essentially horizontal axes and extend into a vertical cylindrical space which is coaxial with and radially coextensive with the annular gap **4**. The vanes **11** are adjustable jointly or individually, to control their pitch, by means of an adjusting means (not shown in detail). This may be an electrically or hydraulically operated means for rotating a vane around its axis. In particular, the vanes of each set can be pivoted jointly. The upper set of vanes **9** has a smaller outer diameter than the lower set **10**, but this is not essential. The dimensions may be either reversed or they may be equal. It would also be possible to use sets of vanes with unadjustable rigidly attached vanes.

The supporting plate **8** may be replaced by any other type of supporting structure such as a frame, casing or the like; and, it may rotatably support the shaft **7** by means of bearings.

The flying craft functions as follows:

Air is drawn off from the upper side of the supporting means **1** by the propeller **3** and guided downwardly toward the annular gap **4**. This generates a highly turbulent, downwardly circular motion in the air. The circularly moving air stream encounters the first upper set of vanes **9** which neutralize the torque and guide the air partially downwardly. The air stream then strikes the second lower set of vanes **10**. These vanes form the stream into a downwardly-directed, largely laminar air stream, which is oriented perpendicular to the supporting means. This results in very strong aerodynamic lift, as the air stream extends practically vertically. The motor or drive **2** and the cabin **5**, which are fixed to one another by means of the rigid shaft **7**, do not rotate. The direction of rotation of the propeller is indicated by arrow **12**. The direction of rotation of the supporting means **1**, indicated by arrow **13**, can be in the same or opposite direction as the propeller, depending on the angular position of the vanes **11** in set **10**.

The vanes in set **10** on the supporting plate **8** and the supporting means **1** allow a variation of the number of revolutions of the supporting means **1**. An increase of the gyroscopic effect can be achieved by increasing the number of revolutions of the supporting means **1**, thereby enhancing the stability of the craft.

During flight, the cabin **5** including the steering means does not rotate. This feature is of particular importance if the device is to be used for conveying passengers.

The transmission of the steering functions is facilitated by the rigid connection of the driving unit and the cabin to the steering means by means of shaft **7**.

Since the rotationally symmetrical air foil **1** is rotatably mounted on this rigid shaft, the mechanical effort is negligible.

The flying craft illustrated in FIGS. **3** and **4** comprises in the top view an arrow-shaped supporting means **101** with air foils and a driving unit **2** with a propeller **3**.

Essentially, the lift producing means of the first embodiment are used in this embodiment, including driving unit **2**, propeller **3**, deflection vanes **9**, **10**, and shaft **7**. However, since the supporting means **101** in this embodiment need not be rotationally symmetrical, it may be non-rotationally connected, via plate **8** and shaft **7**, to driving unit **2** and cabin **5**.

Connected to the driving unit **2** is a gyroscopic means **14** for imposing a tilting force on the flying craft. In addition, steering nozzles **15** are arranged on the airfoils. These means are essentially equivalent and may optionally be employed jointly or separately. Tilting may also be produced by displacing the center of gravity by means of a pivoting device **16** which produces pivotal movement of the cabin **5** about a horizontal axis in relation to the supporting means **101**, as shown in dotted lines in FIG. **4**. The pivoting range is indicated by means of angle α.

Persons familiar with the field of the invention will recognize that the invention may be utilized in a variety of flying craft other than the two embodiments disclosed herein. Therefore, it is emphasized that the invention is not limited solely to the disclosed embodiments but is embracing of variations thereto and modifications thereof which fall within the spirit of the following claims.

I claim:

1. A flying craft, comprising, an outer supporting means which has an annular airflow opening extending vertically therethrough, at least one driving means supported on the supporting means for propelling a stream of air downwardly through the opening, a carrier supported by the supporting means, an upper set and a lower set of air deflecting vanes, each set of vanes having at least two adjustable pitch vanes, said sets of vanes being spaced apart and located in the stream of air produced by the driving means, and a supporting member, said driving means being mounted on the supporting member, said upper set of vanes being fixed only to the driving means, said lower set of vanes each having one end attached to the supporting means and one end attached to the supporting member, said supporting member being rotatably mounted relative to the driving means.

2. A flying craft according to claim **1**, wherein the vanes in each set are pivotable about substantially horizontal axes.

3. A flying craft according to claim **1** or **2**, having a shaft which fixes together the driving means and the carrier.

4. A flying craft according to claim **1** or claim **2** wherein the upper set of vanes has a smaller diameter than the lower set of vanes.

5. A flying craft according to claim **1** having means for tilting the craft, said tilting means comprising two or more steering nozzles which are arranged on the supporting means.

* * * * *

United States Patent [19]

Carrington

[11] 4,433,819

[45] Feb. 28, 1984

[54] AERODYNAMIC DEVICE

[76] Inventor: **Alfred C. Carrington,** 33811 Morse St., Mt. Clemens, Mich. 48043

[21] Appl. No.: **345,788**

[22] Filed: **Feb. 4, 1982**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 22,068, Mar. 19, 1979, abandoned.

[51] **Int. Cl.**[3] **B64C 29/00; B64C 39/06**

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

[58] **Field of Search** .... 244/12.1, 12.2, 12.4, 244/23 R, 23 C, 23 A, 17.11, 17.19, 29, 52; 416/20 R, 21, 22; 60/39.34

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1129038	3/1958	France	244/23 C

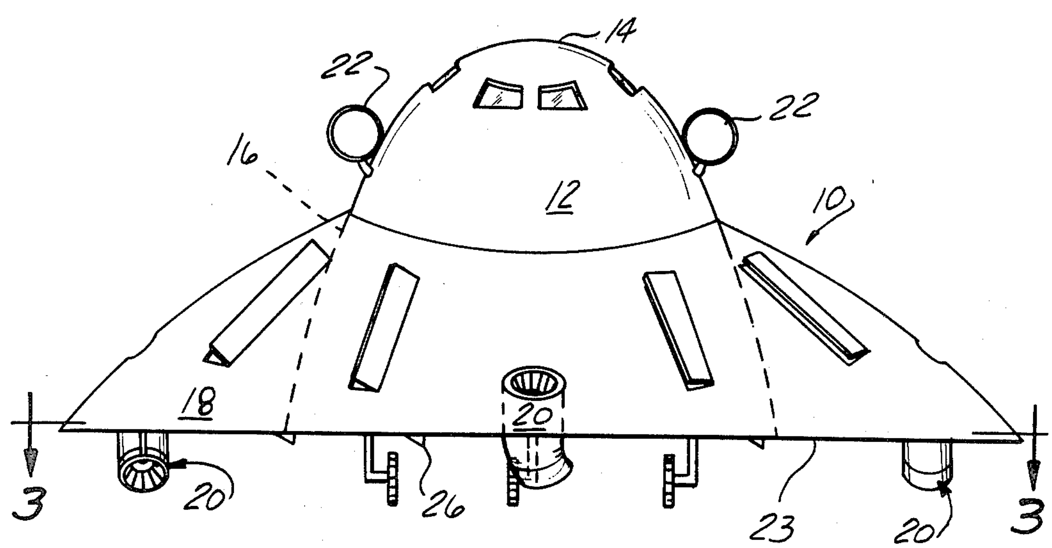
Primary Examiner—Galen L. Barefoot

Attorney, Agent, or Firm—Basile, Weintraub & Hanlon

[57] **ABSTRACT**

An aerodynamic device which can take off and land vertically is disclosed. The device comprises a non-rotating central body surrounded by an outer rotating disc concentric with the central body. A plurality of jets affixed to the disc are selectively vectorable between a vertical, tangential, or radial direction. One or more reaction jets are affixed to the central body and vectored to counteract a torque generated by the rotating disc. The jets affixed to the central body so that as the disc rotates relative to the body the jets are rotated in a counter direction to have a common longitudinal axis with the central body. Pairs of radial vanes disposed along the upper and lower walls of the disc are hinged to their respective walls, and when open impart a lifting action to the disc. The pairs of upper and lower vanes are interconnected by a slot which makes the lifting action of the vanes aerodynamically more effective. The slots also serve as a means for causing the disc to rotate relative to the central body in the event of a total power failure and give the device a degree of stability and control during a non-powered decent.

7 Claims, 8 Drawing Figures



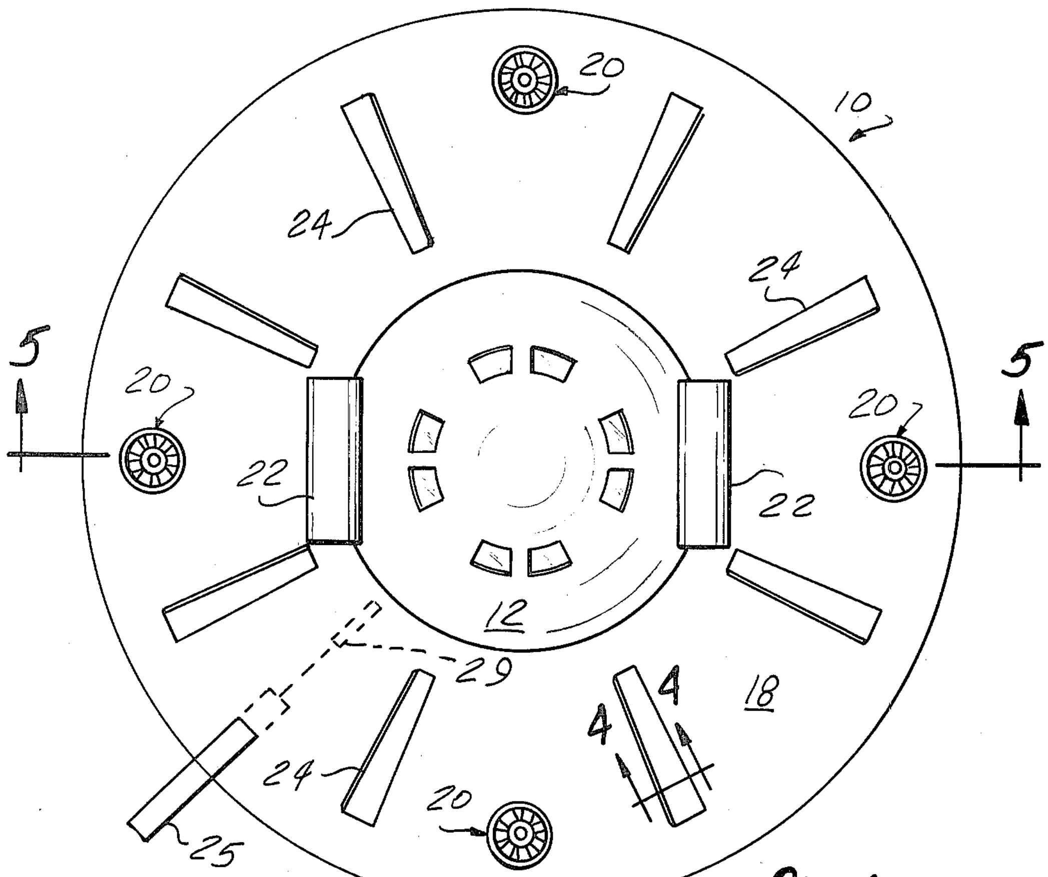

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Fig-1

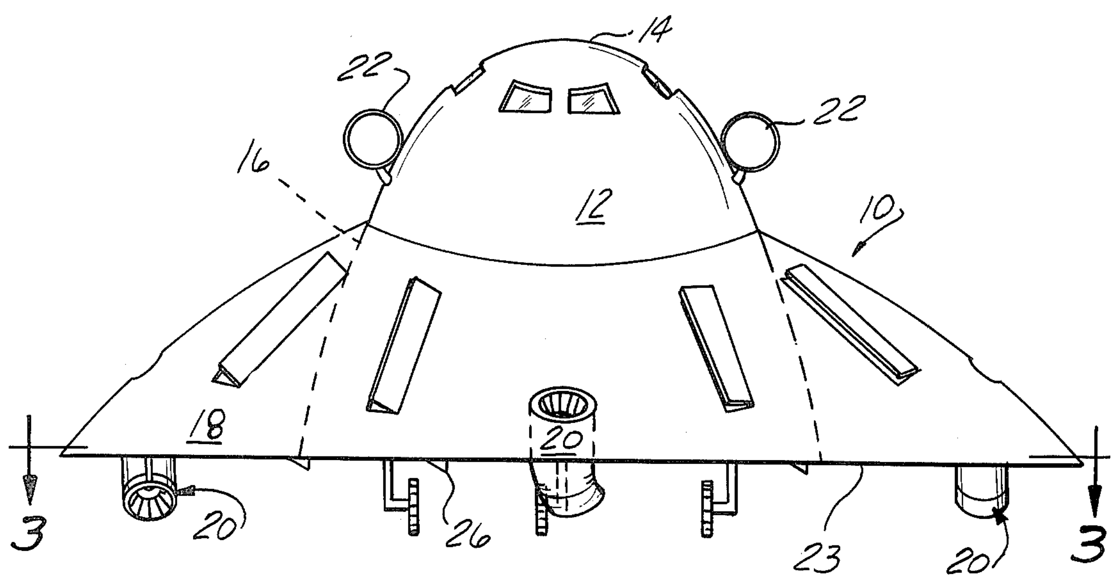
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Fig-2

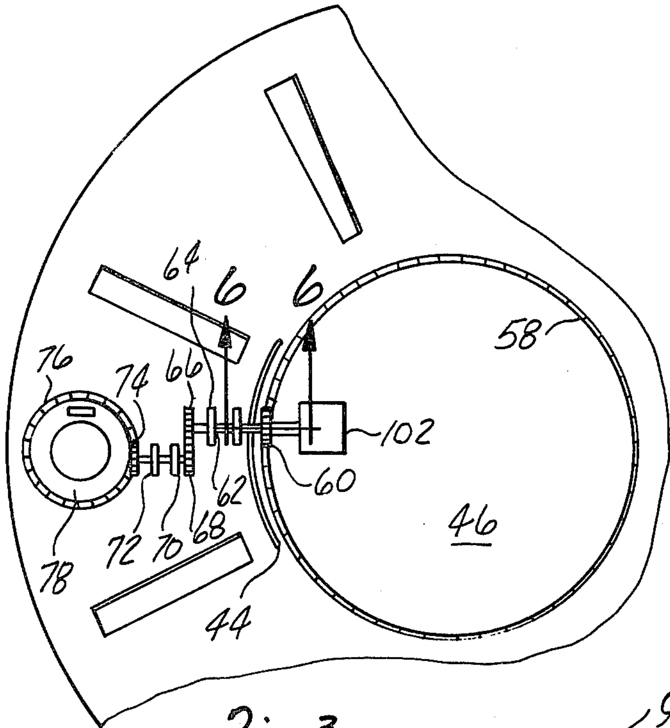

Fig-3

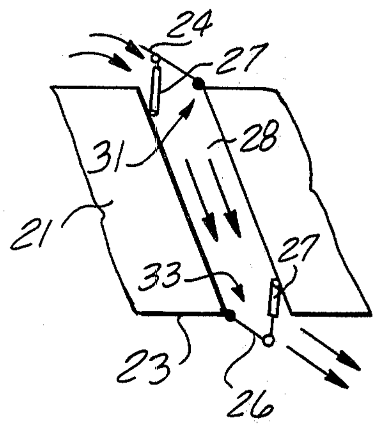

Fig-4

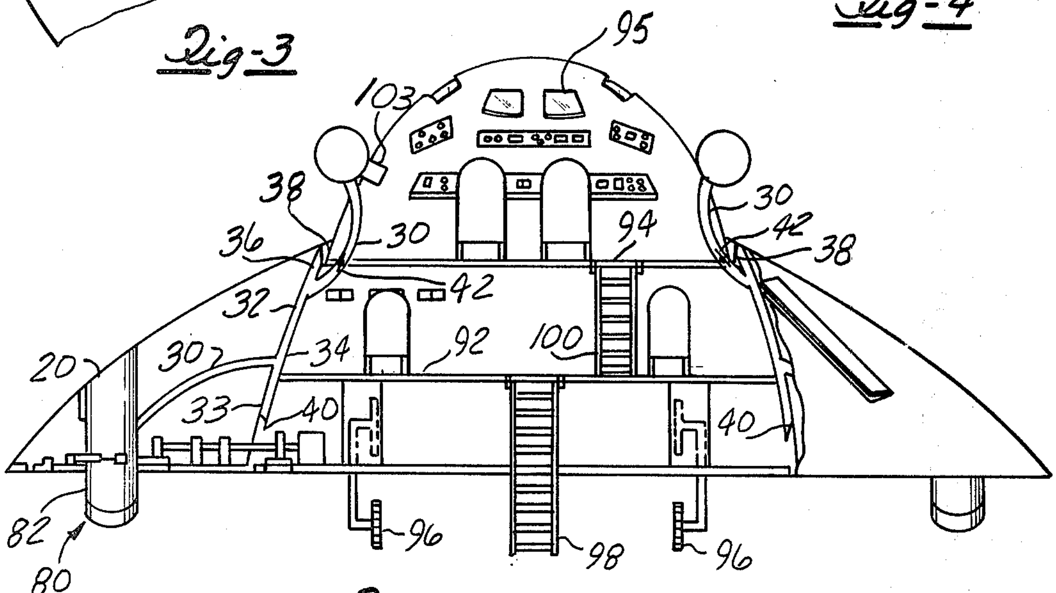

Fig-5

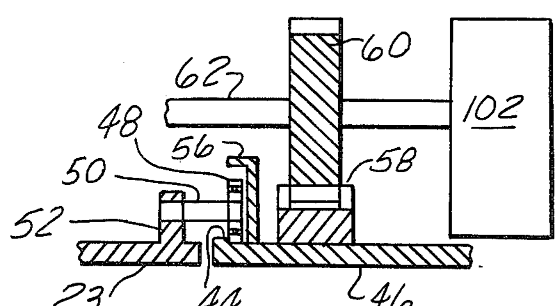

Fig-6

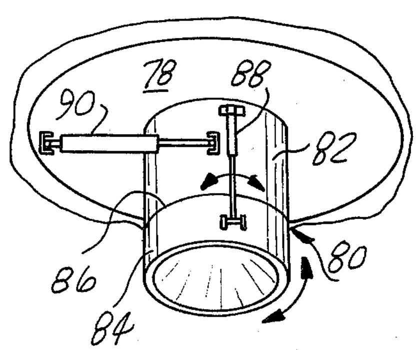

Fig-7

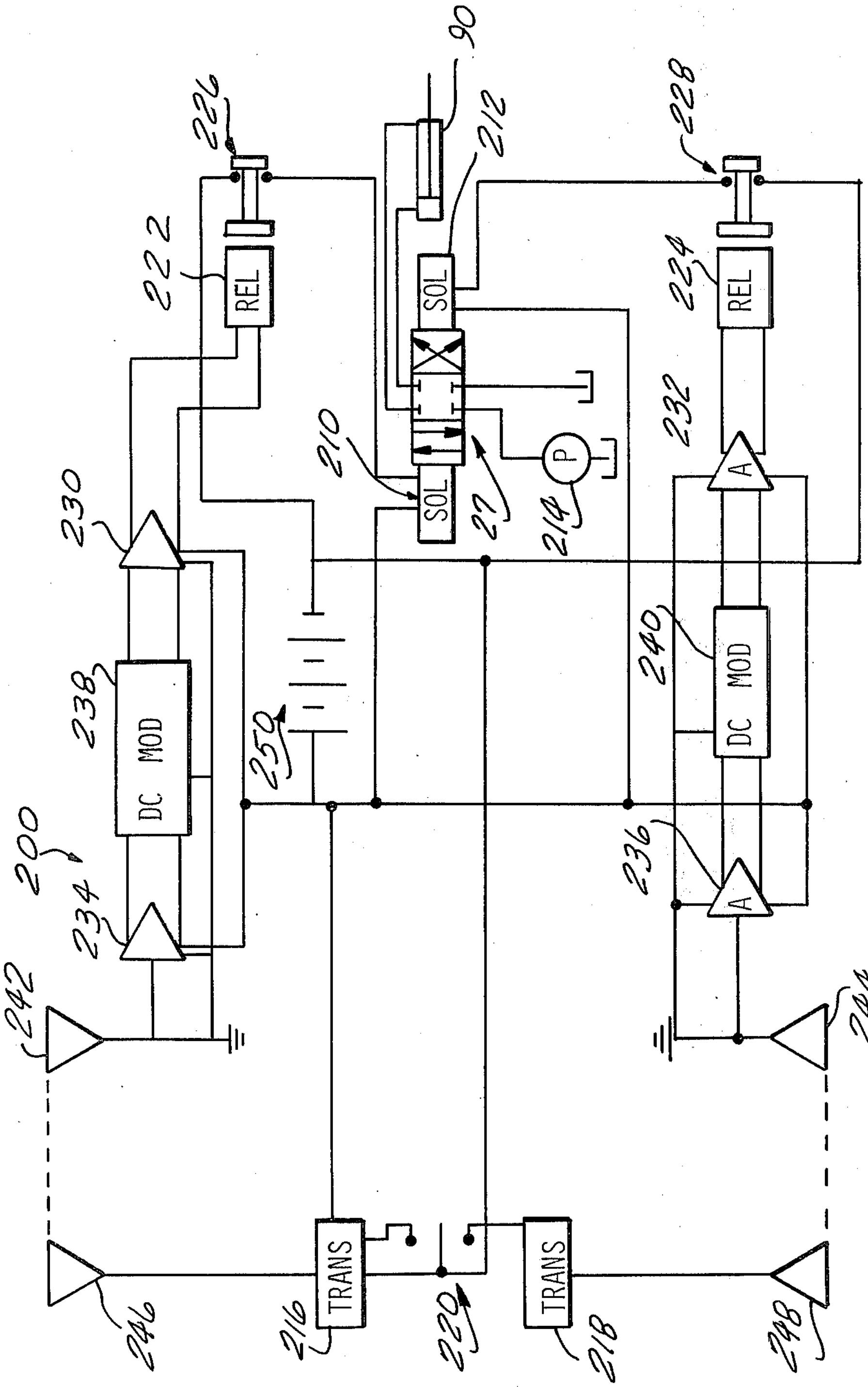
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Fig-8

AERODYNAMIC DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of application Ser. No. 022,068 filed Mar. 19, 1979 entitled "Aerodynamic Device", now abandoned.

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates to the field of aerodynamic devices and in particular to the field of aerodynamic devices capable of vertical take off and landing. Even more particularly the present invention relates to the field of aerodynamic devices that are disc shaped and capable of vertical take off and landing having an outer disc which rotates relative to the central portion of the device and is powered by jets.

II. Prior Art Statement

Disc shaped aerodynamic devices have long been known. U.S. Pat. Nos. 2,949,693; 3,109,256; 3,204,891; 3,394,906; 3,477,168; 3,508,360; 3,568,358; and 4,065,873 are typical of prior art devices employing a rotatable disc for aerodynamic stability.

U.S. Pat. Nos. 2,949,693; 3,204,891; 3,394,906; 3,477,168; 3,568,358; and 4,065,873 all employ a power plant of the internal combustion engine type which drives a rotating propeller directing air downward, producing an upward reaction force to lift the device into the air. A torque reaction by the propeller causes the outer disc of the device to rotate in a direction counter to the propeller. Vanes or blades rotatable with the disc are employed to impart further lift to the device as the disc rotates.

U.S. Pat. Nos. 3,109,256 and 3,508,360 disclose an aerodynamic device which is jet powered as in the present invention. While these disclosures employ a rotating disc which is powered by a jet, they do not disclose a central body which does not rotate and is prevented from rotation by one or more reaction jets. None of the aforementioned disclosures include means for vectoring the jets which rotate with the disc to direct a thrust along a common vector.

The above listed U.S. patents constitute the entire art known to the applicant.

SUMMARY OF THE INVENTION

The present invention discloses an aerodynamic device comprising: a non-rotating central body including a vertical axis; an outer disc rotatably supported by the central body encircling the central body; a plurality of jets affixed to the disc along a bottom wall thereof, the jets selectively vectorable between a vertical, tangential, or radial direction; one or more reaction jets affixed to the central body are vectored to counteract a torque generated by the disc; and means is provided for vectoring the jets in a common direction.

A plurality of conduits interconnect a high pressure chamber of each jet and reaction jet to a plenum. The plenum, serves as a reservoir of fluid pressure for distributing the jet flow evenly throughout the various jets and reaction jets as needed for proper control of the device. A variable restriction within each conduit serves as a device for controlling the distribution of the compressed fluid. A ring gear driven by hydraulic motors causes the outer disc to rotate to create lift and stability.

One or more pairs of vanes comprising an upper vane and a lower vane are radially aligned and hinged to selectively open or cover a plurality of openings in the disc. The upper vanes are radially aligned and hinged to selectively open or cover an upper opening in the disc upper wall. The lower vanes are radially aligned and hinged to selectively open or cover a lower opening in the disc bottom wall. A pair of spaced apart vertical walls enclosed by a pair of end walls from a slot which interconnects the upper opening and the lower opening. The vanes are hinged along a radial edge to produce lift when the disc rotates. Cylinders are provided to selectively open and close the vanes. The vanes co-operating with the slots provide additional lift when the disc is rotating. In the event of a power failure the vanes and slots co-operate to provide a spinning motion to the disc as the device decends enabling the device to be controlled and produce a soft landing.

For a more complete understanding of the present invention, reference is made to the following detailed description and accompanying drawings.

Other advantages and applications of the present invention will become apparent to those skilled in the field to which this invention pertains, when the accompanying description of the best mode contemplated for practicing the invention is read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings like reference numbers refer to like parts throughout the several views and wherein:

FIG. **1** illustrates a top view of a device embodying the teaching of the present invention;

FIG. **2** illustrates a side view of the device of FIG. **1**;

FIG. **3** illustrates a vertical sectional view of the device of FIG. **1** taken along the lines **3**—**3** of FIG. **2**;

FIG. **4** illustrates a cross-sectional view of the slots in the disc taken along the lines **4**—**4** of FIG. **1**;

FIG. **5** illustrates a cross-sectional view of the device of FIG. **1** taken along the lines **5**—**5** of FIG. **1**;

FIG. **6** illustrates a cross-sectional view taken along the lines **6**—**6** of FIG. **3**;

FIG. **7** illustrates a partial perspective view of the vectoring device of the jets; and

FIG. **8** illustrates a circuit for the remote control of the various hydraulic cylinders for control of the device.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and in particular to FIGS. **1** and **2** wherein there is illustrated at **10** a preferred embodiment of the present invention comprising an aerodynamic device comprising a central body **12** having a vertical axis. The central body **12** has a dome shaped top **14** which joins downward and outward sloping sides **16** in the form of a truncated cone. An outer disc **18** encircles the central body **12** and is concentric therewith. The outer disc is rotatably supported by the central body **12** and mechanically rotated in a manner which will be more fully described hereinbelow.

A plurality of jets **20** affixed to the disc along a bottom wall thereof are selectively vectorable between a vertical, tangential, or radial direction. The means for vectoring the jets will be described more fully hereinbelow.

One or more pairs of radially aligned and hinged vanes including an upper vane 24 and a lower vane 26 which are disposed along an upper surface and a lower surface 23 of the disc 18. The upper vane is radially aligned and hinged to selectively open or cover an upper opening 31 in the disc upper surface. The lower vane 26 is hinged to open and close a lower opening 33 in the lower surface. A pair of spaced apart vertical walls enclosed by a pair of end walls form a slot 28 interconnecting the upper opening and the lower opening. The vanes are hinged along a radial edge and produce lift when the disc is rotating. A cylinder means 27 is provided for selectively opening and closing the vanes. The open vanes and the slot co-operate to form a means for increasing the lift of the device when the outer disc is rotating. Should the power fail during flight of the device, opening the vanes 24 and 26 allows air to flow along the slots 28 causing the disc 18 to rotate and enhance the stability and lift of the device 10 which enables a soft landing. Rotation of the disc 18 provides stability in a manner similar to the way a rotating bicycle wheel stabilizes a bicycle.

A plurality of conduits 30 (FIG. 5) interconnect a high pressure chamber (not shown) of each jet and reaction jet 22 to a plenum 32. The plenum 32 comprises an inner wall around an inner periphery of the disc formed by the downward and outward sloping portion 16 of the outer wall of the central body, an outer wall 33 spaced from the inner wall, an upper dynamic seal 38 between an upper end of the outer wall and the inner wall, and a lower seal 40 between a lower end of the outer wall and inner wall. A variable restriction 42 provides a means for controlling the flow of gas from the high pressure side of the jets to the plenum. The plenum 32 and the conduits 30 serve as a means for providing thrust to any of the various jets that might fail.

As shown in FIG. 6 of the drawing, the outer disc 18 is rotatably supported by the central body 12 by a "U" shaped ring 44 which defines the periphery of the bottom wall 46 of the central body 12. A plurality of antifriction bearings 48 engage the "U" shaped ring 44 and a plurality of shafts 50 engage a bore of the plurality of bearings 48. The shafts 50 extend radially outward and are supported by a plurality of support members 52 which are attached to a bottom wall of the disc 23. An inner leg of the "U" shaped ring projects upward a distance and then radially outward to form an upper wall 56 which overlays the upper portion of the outside diameter of the bearing 48 restricting the vertical movement of the bearing 48.

The rotation of the outer disc is achieved through a hydraulic motor 102 and gear assembly. The motor is connected to a pump 103 which drives the motor, the motor in turn, causes rotation of the disc through a gearing arrangement described as follows:

A first ring gear 58 is disposed around the periphery of the central body bottom wall 46 spaced in a distance from the outer edge thereof (FIGS. 6 and 7). An input gear 60 is meshed with the ring gear 58, and the first gear is supported at the inner end of a shaft 62 which is fixedly attached to the gear 60 for rotation therewith (FIG. 3). The shaft 62 is rotatingly driven by an hydraulic motor 102 which is powered by a first engine driven hydraulic pump 103 which is mechanically driven by a gear box of reaction jets 22. Jets 22 produce a controllable thrust in opposed tangential directions to counter the rotation of the outer disc 18 and keep the central body 12 pointed in the desired direction. The shaft 62 extends radially outward and is rotatingly supported by a pair of spaced apart pillow blocks 64 affixed to the disc bottom wall 21. An outer end of the shaft 62 is affixed to a second gear 66 which rotates with the input gear 60. A third gear 68 is meshed with the second gear 66 which is fixedly attached to a shaft 70 for rotation therewith. The shaft 70 extends radially outward and is rotatingly supported by a second pair of pillow blocks 72 which are affixed to the bottom wall of the disc 21. The outer end of the shaft 70 has affixed thereto a fourth gear 74 which rotates with the third gear 68 and the shaft 70. The fourth gear 74 meshed with the drives a second ring gear 76 which is affixed to the periphery of a jet support platform 78 for rotation therewith. The ratio of the gears is configured to create for each revolution of the disc 16 relative to the central body 12, a counter revolution of the jet platform 78 relative to the central body 12 as the disc rotates orienting a vector of the jet engine attached to the platform 78. Thus all jets affixed to the disc are vectored in a common direction relative to the central body 12 as the disc rotates. The jets 22, in addition to providing hydraulic power through the gear box (not shown) also provide electrical power for the central body 12 and a jet reaction force to control the direction of the central body.

While a plurality of jets 20 are used in the present invention and distributed around the perimeter of the disc 18, the control and vectoring of only one jet will be described herein for the sake of brevity and clarity. Each jet 20 has affixed thereto a rotatable swiveling nozzle 80 (FIG. 7) comprising a vertical conduit 82 affixed to the jet support platform 78, and a swiveling nozzle 84 joined to the conduit by a sphere and sperical socket joint 86 which allows the swiveling nozzle 84 to direct the output of the jet at a variable angle with respect to the vertical conduit 82. A cylinder means 88 is swively attached at the cylinder end to the jet platform 78 and at the rod swively attached to the swiveling nozzle 84. Extension of the rod of the cylinder 88 directs the jet toward a vertical vector and the retraction of the rod of the cylinder 88 directs the jet toward a horizontal vector. The vertical conduit 82 is rotatable about an axis of the jet platform 78. A second cylinder means 90 has its cylinder end pivotally attached to an outer surface of the conduit 82. Extension of the rod of the cylinder 90 rotates the conduit 82 in a first direction and retraction of the rod of the cylinder 90 rotates the conduit 82 in a second direction. As is understood by the skilled artisan, manipulation of the cylinder means 88 and 90 selectively directs the vector of the jet in a desired direction.

A second hydraulic pump is driven by the jet 20 by either electrical mechanical, or air turbine means and the hydraulic power generated is used to operate the cylinders 88 and 90, as well as the cylinder means of the vanes 24, 26. Hydraulic directional valves 27 are remotely operated to control the cylinders 88 and 90 in response to a command signal generated by the operator of the device. The command signal is transmitted to the hydraulic valves by the circuit 200 as shown in FIG. 8 of the drawing.

In the circuit 200 the hydraulic directional valve 27 is a double solenoid spring centered valve. When a first solenoid 210 is energized the cylinder 90 is caused to retract its rod. When the solenoid 212 is energized the cylinder **90** is caused to extend its rod. Hydraulic power for operating the hydraulic cylinder **90** provided by a pump **214** which may be either electrically or mechanically driven. Circuit **200** includes a pair of transmitters **216, 218** tuned to their individual frequencys to operate a receiver without interference from one another. A switch **220** is employed to selectively activate either the transmitter **216** or the transmitter **218**. Normally open relays **222, 224** are employed to selectively energize either solenoid **210** or **212** respectively by means of normally open relay contacts **226, 228**. The coil of the relay **222, 224** is selectively energized by the output of audio amplifiers **230, 232** which is turn are connected to a tuned radio frequency amplifier **234, 236** and a demodulator **238, 240**. A pair of antennas **242, 244** are connected to tuned radio frequency amplifiers **234, 236**, and receive a radio frequency signal from the transmitters **216, 218** by means of transmitter antennas **246, 248**.

In operation the operator moves switch **220** to activate one of the transmitters **216, 220**. For reasons of simplicity let us assume the operator has moved the switch **220** to activate transmitter **216**. A modulated radio frequency signal will be transmitted by antenna **246** which will be picked up by the receiving antenna **242** and amplified by the tuned radio frequency amplifier **234**. The output of the amplifier **234** is demodulated by the modulator **238** and the signal is amplified by the audio amplifier **230** and is transmitted to the relay **222** which closes contacts **226** and activates solenoid **210** porting oil to the rod end of cylinder **90** forcing the rod of the cylinder **90** to retract. Moving the switch **220** to a position activating transmitter **218** causes relay **224** to close contacts **228** energizing solenoid **212** which ports hydraulic oil to the piston end of the cylinder **90** causing the rod of the cylinder to extend. A battery **250** provides the electrical energy for operating the circuit **200**. The battery is kept charged by a generator driven by the jet **20**.

A horizontal deck **92** is spaced from and parallel to the bottom wall **46** of the central body **12** (FIG. **5**). The deck **92** extends to the walls of the central body **12** providing structural support. The space between the deck **92** and the bottom wall **46** accommodates fuel tanks, controls, and the mechanism and wheel wells for a retractable landing gear **96**. A command deck **94** is spaced above the engineering deck **92** extending between the outer walls of the central body **12** providing a compartment for the operator of the vehicle. A plurality of windows **95** provide a view of the surrounding area. The reaction jets **22** operate hydraulic pumps and generators for generating the necessary electrical and hydraulic power for operating the controls, and for retracting or extending the landing gear, as well as power for operating the restriction **42**. Access hatches are provided between decks and a retractable latter **98** provides a means for access from the ground to the engineering deck **92**. A stationary ladder **100** provides access from the engineering deck **92** to the command deck **94**.

In operation the reaction jets **22** are first started which provides electrical power and pressure to the plenum **32**. Batteries are provided to supply the necessary cranking power to first start the engines **22**. Pressure from the plenum **32** is directed by means of the conduits **30** to the plurality of jets **20**. Pressure from the plenum **32** provides the cranking energy necessary to initiate the starting of the jets **20**. When all jets are operating properly the operator increases jet thrust and directs hydraulic oil to the hydraulic motor **102** causing the disc **18** to rotate. The vanes **24** and **26** are then opened to provide additional lift and the device lifts from the ground. Once airborne the nozzles **84** are vectored to move the vehicle laterally and the lateral motion induces an aerodynamic lift due to the air passing over the top of the device reaching a higher velocity than the air passing there under which produces a lower pressure at the top of the device than at the bottom in a well known aerodynamic manner. When a desired altitude has been reached the vanes **24** and **26** are closed reducing the amount of drag generated by the vehicle outer surface, and high speed lateral motion can be achieved. The thrust and direction of the jets is controlled by the speed of the jet **20** and the direction of the nozzle **84** giving the operator complete control over the device.

In the event of an engine failure the vanes **24** and **26** are opened and a soft decent of the device under controlled conditions is possible due to the rotation of the disc **18** induced by the slots and the vanes. Electricity can be drawn from the batteries for control purposes in the event the jet powered generators fail. With the disc **18** rotating about the central body **12**, the ring gear **58** drives the input gear **60** and shaft **62**. A generator and hydraulic pump can alternately be driven by the shaft **62** to provide electrical and hydraulic power in the disc during flight.

To improve the air inlet efficiency of the jets **20**, scoops (not shown) can be affixed to the upper end of the jets to use the rotary motion of the disc **18** to direct air into the jets. Alternately, the jets **20** can be disposed along a horizontal axis with the swiveling nozzles **84** selectively directed downward for vertical lift.

During lift off and vertical decent a plurality of retractable helicopter type blades **25** (FIG. **1**) can be employed along the perimeter of the disc **18**. An extending cylinder **29** is employed to extend or retract the blades which are slidingly supported by the disc **18**.

A horizontal projected area of the outer wall **33** is created by its downward and outward projections. The pressure in the plenum **32** on the horizontal area causes an upward force on the disc **18** resulting in a lifting action. The lifting action reduces the downward load that the weight of disc imposes on the bearings **48** (FIG. **6**).

While a manned aerodynamic device is described herein employing turbojet engines, it is obvious to the skilled artisan that a toy device can be devised from the above described device by using a charged cartridge of CO_2 or similar gas to provide the energy for the jets. Fixedly orienting the jets along a predetermined vector can be selectively cause lateral or vertical flight or a flight path in between vertical or lateral.

Having thus described my invention what I claim is:

1. An aerodynamic device comprising:

a central body including a vertical axis, an outer wall and a bottom wall;

an outer rotatable disc concentric with the central body axis, including an upper wall, and a bottom wall;

a plurality of jets affixed to the disc bottom wall selectively vectorable between a vertical, tangential or radial direction;

one or more reaction jets affixed to the central body vectored to counteract a torque generated by the disc;

means for vectoring the jets in a common direction;

means for rotatably supporting the disc with the central body; and

means for rotating the outer rotatable disc.

2. The aerodynamic device as defined in claim 1 wherein the means for vectoring the jets comprises:

a first ring gear proximate the periphery of the central body;

an input gear rotationally affixed to the disc bottom wall meshing with the ring gear

a second gear spaced from the first gear joined thereto by a first common shaft for rotation therewith;

a third gear meshed with the second gear;

a fourth gear spaced from the third gear and joined thereto by a second common shaft for rotation therewith;

a plurality of pillow blocks affixed to the disc bottom wall to support the gears;

a jet support platform proximate the periphery of the disc rotatable about an axis spaced from and rotatable about the vertical axis, and supported by the disc bottom wall;

a second ring gear proximate the periphery of the jet support platform meshed with the fourth gear, the ratio of the gears configured to create for each revolution of the disc relative to the central body a counter revolution of the jet support platform; and

a rotatable swiveling nozzle comprising, a vertical conduit affixed to the jet support platform, a swiveling nozzle joined to the conduit by a sphere and sperical socket joint, a first cylinder means to direct a jet between a vertical and a horizontal vector relative to the jet support platform, and a second cylinder means for rotating the vertical conduit relative to the jet support platform.

3. The aerodynamic device as defined in claim 1 wherein the means for rotatably supporting the disc to the central body comprises:

a "U" shaped ring around the periphery of the central body;

a plurality of anti-friction bearings nestingly engaging the ring, the bearings including a radial axis intersecting the vertical axis;

an upper wall spaced from and overlaying the bearing outer diameter; and

a plurality of shafts engaging the bearing bores, the shafts fixedly supported by a support attached to the disc bottom wall.

4. The aerodynamic device as defined in claim 1 further comprising:

a plurality of conduits interconnect a high pressure chamber of each jet and reaction jet to a plenum;

the plenum comprises, an inner wall around an inner periphery of the disc formed by a downward and outward sloping portion of the outer wall of the central body, an outer wall spaced from the inner wall, an upper dynamic seal means between an upper end of the outer wall and the inner wall, and a lower dynamic seal means between a lower end of the outer wall and the inner wall; and

a variable restriction in each conduit.

5. The aerodynamic device as defined in claim 1 further comprising:

one or more pairs of vanes including an upper vane and a lower vane;

the upper vane radially aligned and hinged to selectively open or cover an upper opening in the disc upper wall;

the lower vane radially aligned and hinged to selectively open or cover a lower opening in the disc bottom wall;

a pair of spaced apart vertical walls enclosed by a pair of end walls forming a slot interconnecting the upper opening and the lower opening;

the vanes hinged along a radial edge to produce lift when the disc rotates; and

means for selectively opening and closing the vanes.

6. The aerodynamic device as defined in claim 1 wherein the plurality of jets and the reaction jets are axial flow turbojet engines.

7. An aerodynamic device comprising:

(a) a central body including a vertical axis, an outer wall and a bottom wall;

(b) an outer rotatable disc concentric with the central body axis, including an upper wall and a bottom wall;

(c) a plurality of jets affixed to the disc bottom wall selectively vectorable between a vertical, tangential or radial direction;

(d) means for counteracting the torque generated by the disc;

(e) means for vectoring the jets in a common direction;

(f) means for rotatably supporting the disc with the central body;

(g) means for rotating the outer rotatable disc.

* * * * *

United States Patent [19]
Everett

[11] **4,452,410**
[45] **Jun. 5, 1984**

[54] **IN-LINE GYRO TYPE AIRCRAFT**

[76] Inventor: **Robert A. Everett,** 704 S. 142 E. Ave., Tulsa, Okla. 74108

[21] Appl. No.: **332,319**

[22] Filed: **Dec. 18, 1981**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 177,094, Aug. 11, 1980, abandoned, and Ser. No. 971,783, Dec. 21, 1978, abandoned.

[51] **Int. Cl.**3 .... **B64C 27/00;** B64C 39/06
[52] **U.S. Cl.** .... **244/12.2;** 244/23 C; 416/23
[58] **Field of Search** .... 244/6, 8, 12.1, 12.2, 244/12.3, 23 R, 23 B, 23 C, 39, 217; 46/74 D, 75; 416/23, 24, 144

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Primary Examiner—Charles E. Frankfort
Attorney, Agent, or Firm—Robert A. Everett

[57] **ABSTRACT**

An aircraft containing aerodynamic and gyroscopic stability that has a high angle of take-off and landing capabilities, with high speed horizontal powered flight, but is also able to sustain power-off flight with autorotation of its multiple extending airfoils. The fuselage has the shape of an inverted saucer with aerodynamic configuration and has an open circular track at its periphery; and riding in this track is a rotary frame and extended airfoil assembly that isin-line with the fuselage. Each extending airfoil contains solid weighted bodies at their tips and this rotary frame and extended airfoil assembly is rotated on the track by an internal power unit. The extending airfoils taper toward their tips and these tips have a knife sharp edge for penetrating the air resistance. Special flaps on the airfoils function for creating additional lift in the downwind quadrant, but in the power-off flight mode, when the rotary frame and extending airfoil assembly is disengaged; the dual purpose flap and trap flap combine to function to trap the slip-stream causing the rotary frame and extended airfoil assembly to rotate. Mounted to the surface of the fuselage are forward thrust engines with rearward extending booms on which are located the tail assembly with flight control surfaces.

6 Claims, 11 Drawing Figures

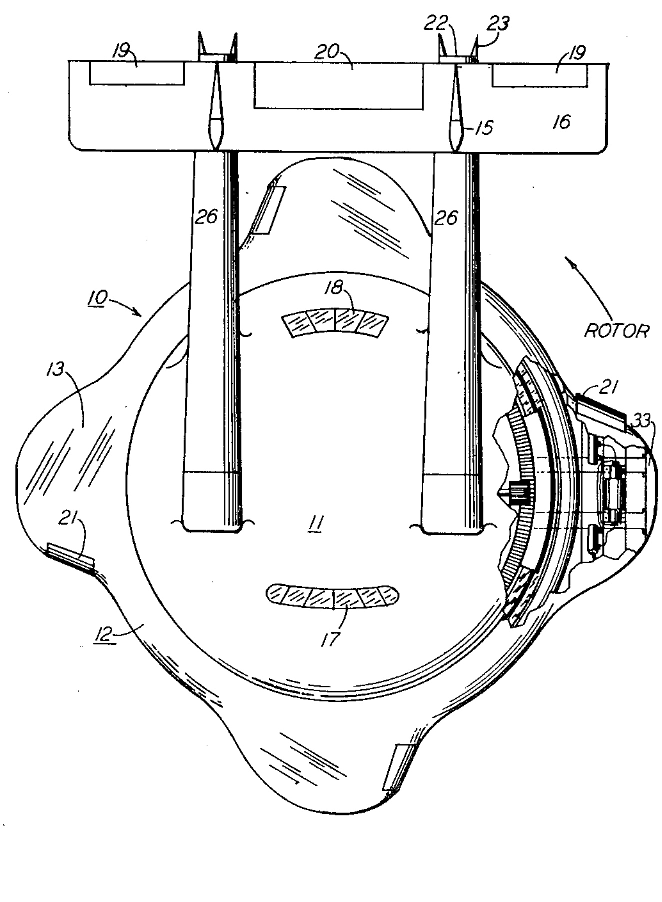
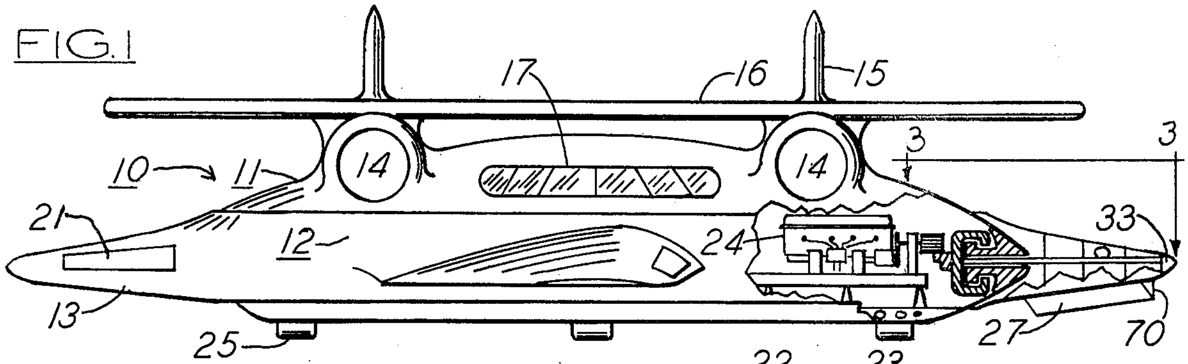


FIG. 1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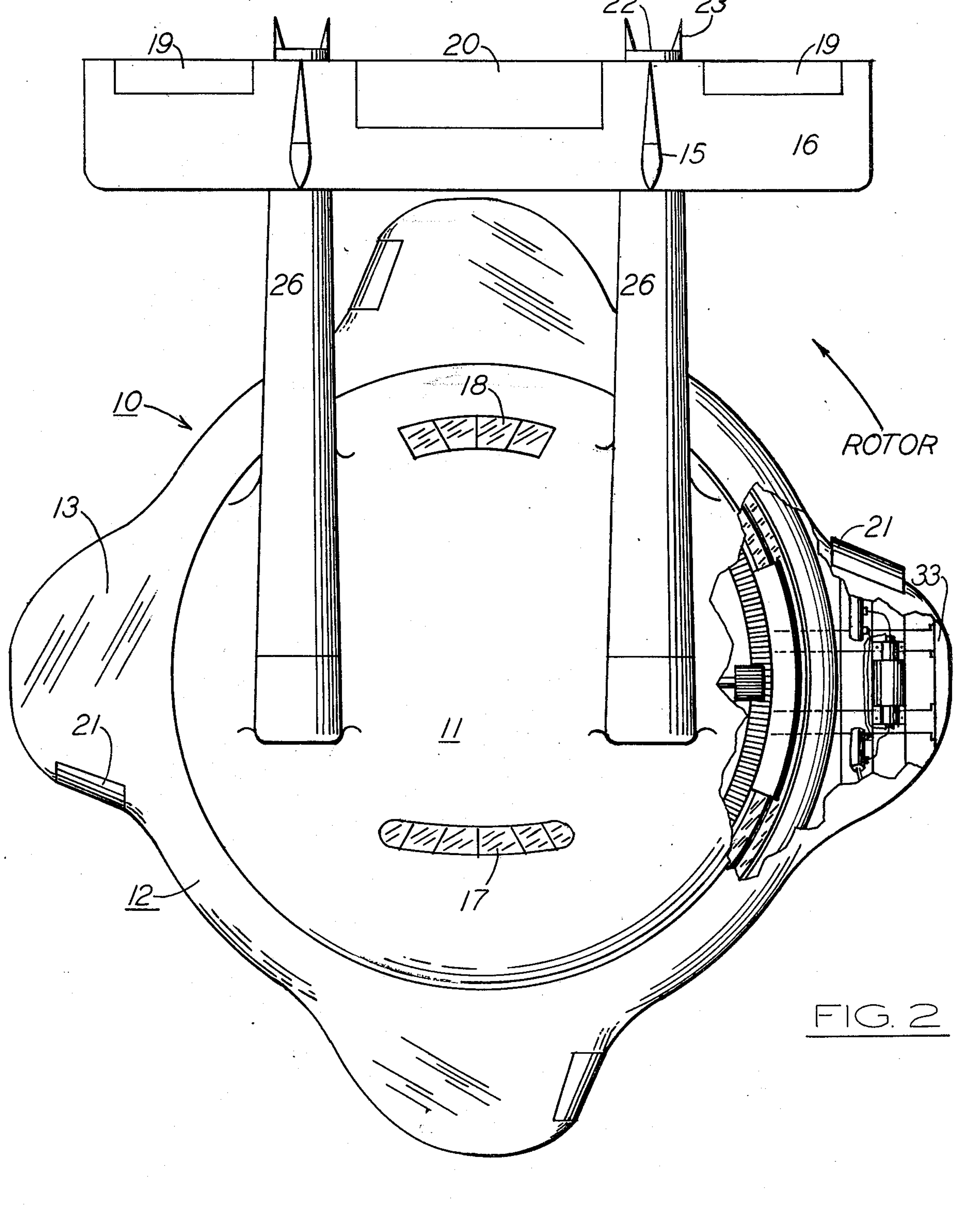
22
23
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16
26
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10
18
ROTOR
13
21
33
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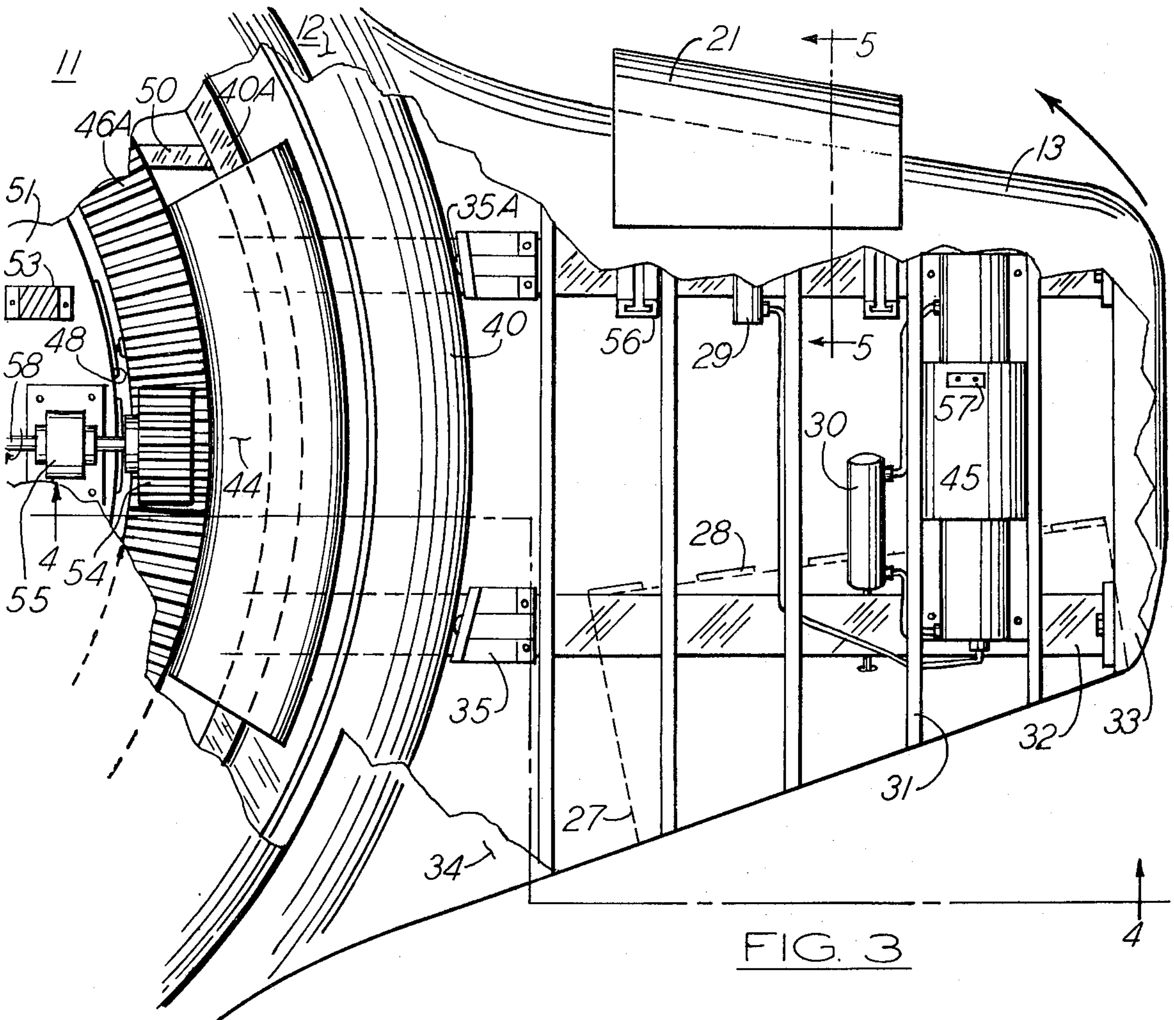
21
12
17

FIG. 2



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12
21
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50
40A
46A
51
35A
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48
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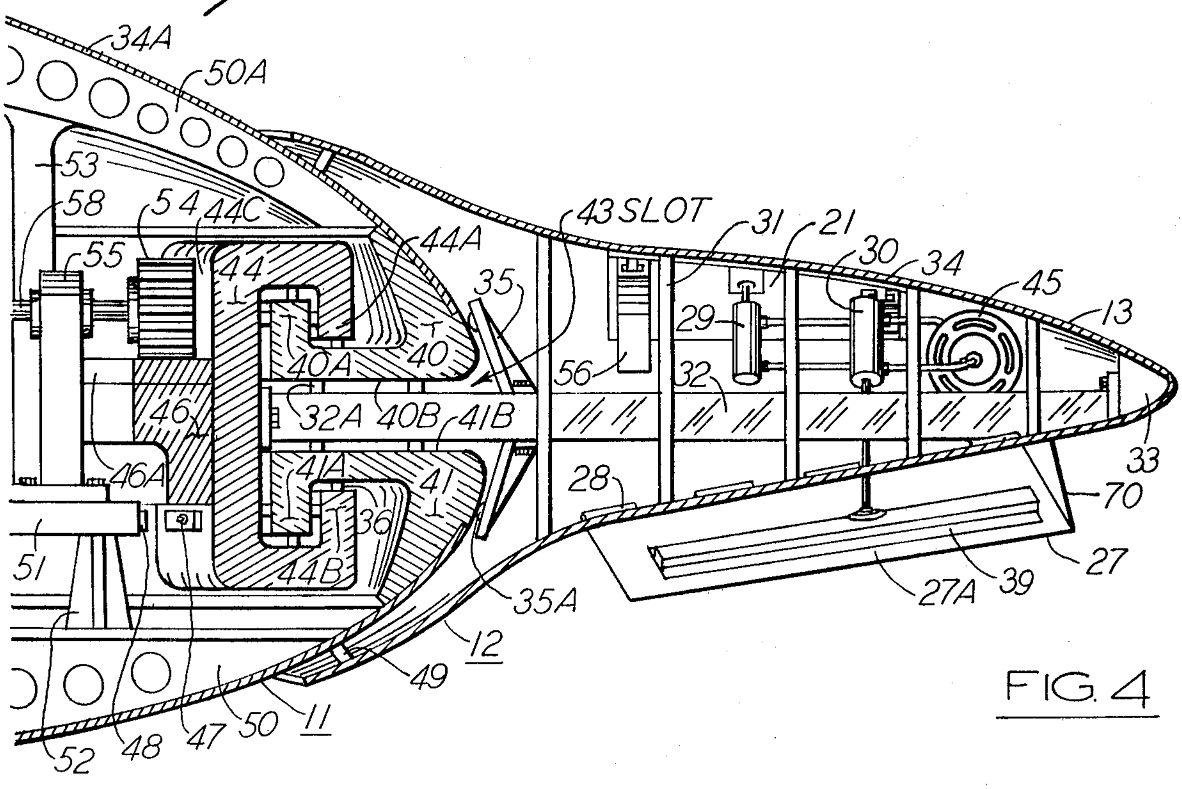
FIG. 3



34A
50A
53
58
55
54
44C
43 SLOT
31
21
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34
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44A
44
40
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29
13
40A
56
32
32A
40B
41B
33
46
46A
41A
41
28
70
51
36
44B
35A
27
27A
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12
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11

FIG. 4

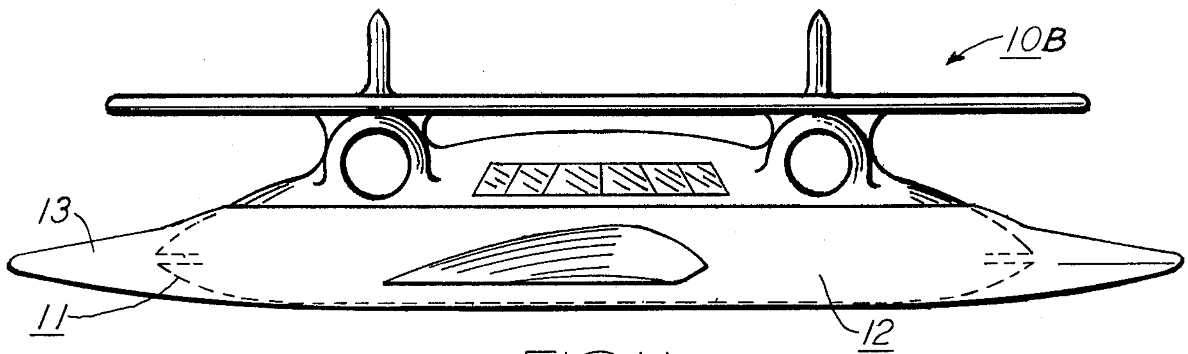

FIG. 11

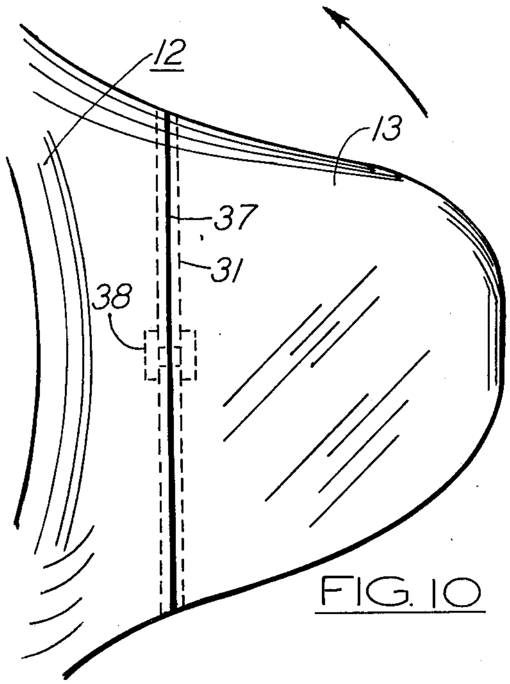

FIG. 10

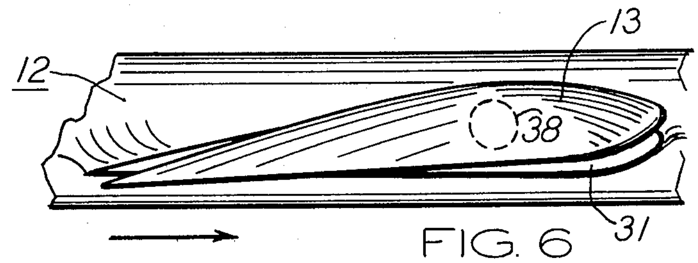

FIG. 6

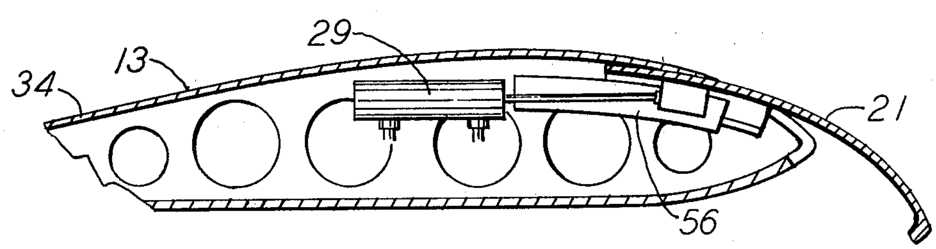

FIG. 5

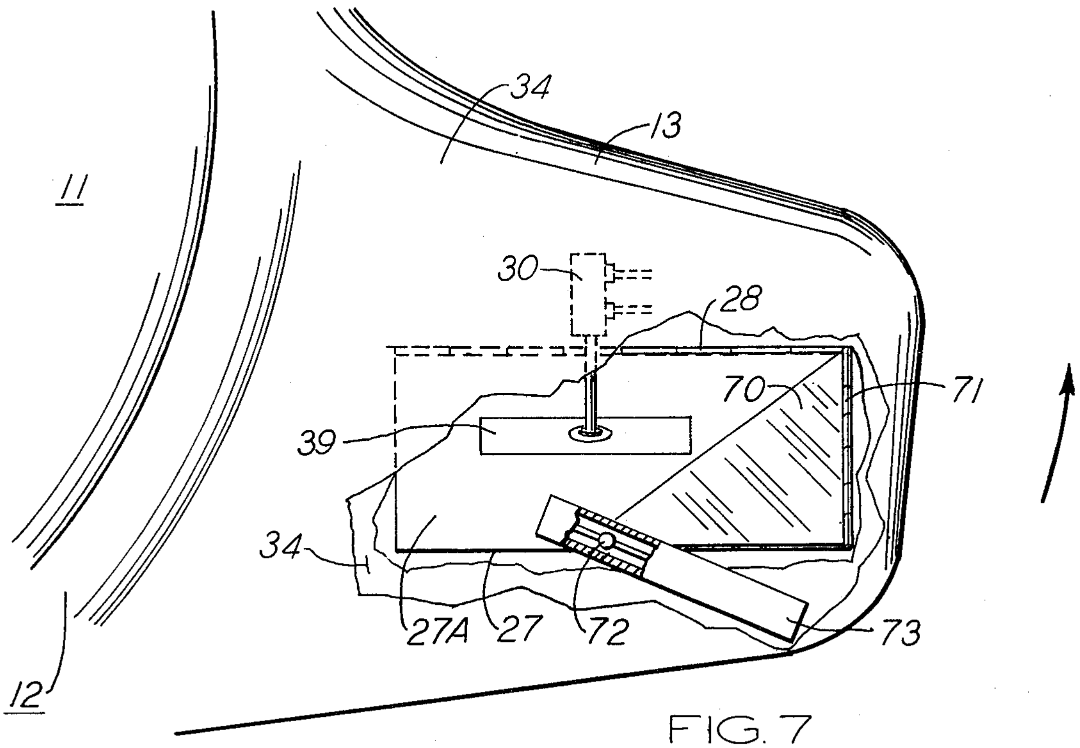

FIG. 7

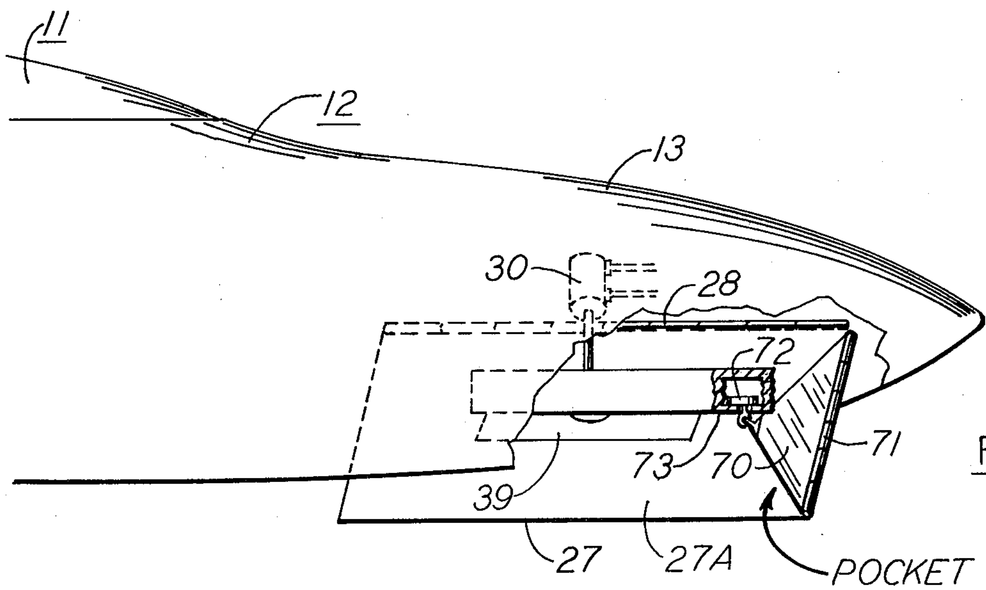

FIG. 8

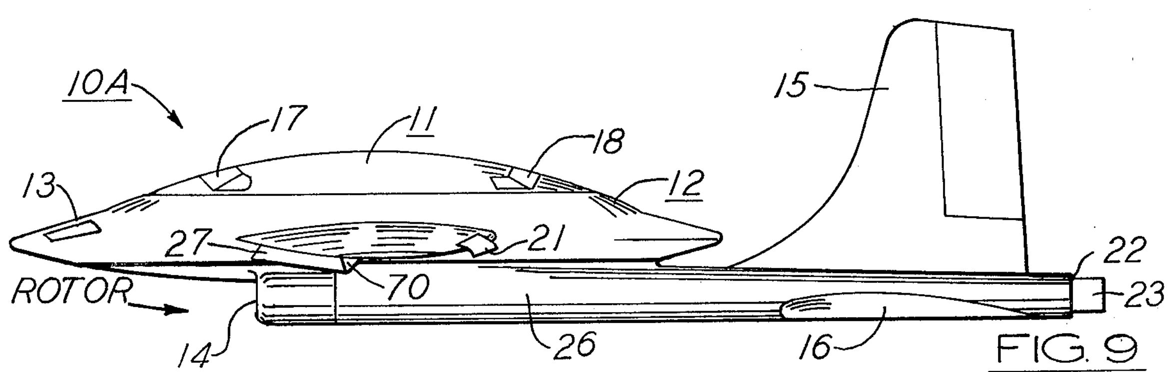

FIG. 9

IN-LINE GYRO TYPE AIRCRAFT

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to rotor wing aircraft that generate vertcal lift along with horizontal flight with gyroscopic stability and back up flight feature of flying horizontally in a power-off mode. This unique type flight without mechanical power source, is due to the aircraft's saucer design configuration. Thus the fuselage also becomes a formidable lift body that is encompassed by a rotating frame and multiple extending airfoils that also form and function as a segmented gyroscope assembly, which permits mass storage of energy. This storage of energy combined with other means that allow this gyro type aircraft to fly horizontally from a high altitude with no fuel consumption and no converting structures for vertical or horizontal flight.

2. Description of prior art

Todays fixed wing aircraft are limited to the amount of lift forces that they can create, do to their design features, power and lift means. So they use a tremendous amount of power and fuel with long run-ways just for take-off and in horizontal flight. Other so called convertiplanes have been invented to overcome this waste of fuel and long take-off area, by using vertical lift for take-off and then using converting means for forward flight. There have been many of these aircrafts and too many to mention here. The well known helicopter has been the most successful and has no converting structures, yet it contains limitations as to forward speed and lift forces.

It is desirable to mention at this time a rotor invention that is capable of modifying a fixed wing aircraft to give it high lift capabilities and which is my own U.S. Pat. No. 3,900,176. It is also necessary to mention three of my aerial toy inventions that are similar to this present invention; U.S. Pat. Nos. 3,613,295; 3,852,910 and 4,157,632. These toy inventions have been tested in flight, which is the basis for this present invention. These inverted saucer shaped aerodynamic aerial toys do fly, even though with some imbalance as part of their flight characteristics, but they fly without the benefit of the use of spoilers, flaps etc. to correct the inherent imbalance feature. Many flight tests have revealed that its combination flywheel and gyroscopic forces are due to its weight distribution that stores up energy and produces angular momentum to a degree; depending on body mass, how fast it turns and how the mass is distributed. This results in extra long flights when hand launched at ground level; therefore a gyro type of aircraft design configuration will also contain these same inherent forces that are condusive in sustaining horizontal flight.

SUMMARY OF THE INVENTION

The primary object of this present invention is to provide an aerodynamic and gyroscopic stable saucer shaped aircraft that has a high angle of take-off and landing capabilities as well as stable high speed horizontal powered flight and also containing structures to allow horizontal flight with out a mechanical power source and no fuel consumption, from a high altitude.

Another object is that the aerodynamic saucer shaped fuselage provides a mounting for the forward thrust engines, tail assembly and landing gear. The fuselage also contains a rigid horizontally mounted rotary frame with multiple horizontal extending airfoils that encompasses the fuselage at its periphery and functions in creating lift forces when spinning.

A further object is that this gyro type of aircraft by its very design configuration, presents a large aerodynamic surface area that includes not only the multiple airfoils, but the fuselage itself that combines to enhance the aircraft's ability to develope a long glide ratio.

A still further object of this invention is that it contains solid weighted bodies at the extreme tips of the airfoils and in contour shape of the airfoils, for creating a positive gyroscopic force and stored energy in a horizontal plane, with a low center of gravity.

Another object is that the multiple extending airfoils' top surface tapers towards its outer tip edge to form a thin edge, for the purpose of penetrating the wall of air in front of the forward moving aircraft and presenting a streamline type of nose area as the extending airfoils pass in the forward quadrant of the fuselage.

A further object is that each extended airfoil contains special flaps for equalizing lift forces on each side of the forward moving gyro type aircraft, they also function in trapping air pressure in the downward quadrant and using this resistance for spinning the rotary frame and extending airfoil assembly in horizontal power-off flight.

A still further object is that this gyro type aircraft's size can include large cargo or passenger capacity, due to its simplicity in design, strength, flight stability and buoyancy, coupled with its ease in converting its mechanical power source into an abundants of lift forces; which makes it ideal for the do-it-yourself plane builders, because it is also highly suitable to mass production of the smaller aircraft even more.

Another object of this invention is that it is not totally dependent upon the special flaps for the equalizing of the lift forces of this gyro type aircraft, but the rotary frame and extended airfoil assembly contains the well known Kruger Flap located in the leading edge of the extended airfoils and made to function automatically in only the downwind quadrant, if necessary for more lift force. It is also obvious by means known to the art, that the extended airfoils can by means, pitch only in the downward quadrant for also equalizing lift forces on this forward moving gyro type aircraft.

Another further object of this invention is to provide a means to correct for any torque created by the friction from the spinning rotary frame and extended airfoil assembly around the stationary fuselage, at the contact bearing points located in replete numbers along the periphery of the fuselage surface and track.

BRIEF DESCRIPTION OF THE DRAWINGS

Many objects and advantages of the present invention will become readily apparent to those skilled in the art as a detailed description of the various embodiments of the present invention unfolds, when taken in conjunction with the appended drawings wherein like reference numerals denote like parts and in which:

FIG. 1 is a frontal elevation view of an in-line gyro type aircraft;

FIG. 2 is a top plan view of an in-line gyro type aircraft;

FIG. 3 is a top plan view of a partial fuselage and rotary frame and one extended airfoil in the downwind quadrant with the top surface skin cut away exposing internal construction and components;

FIG. 4 is a cross-sectional view taken along line 4—4 of FIG. 3 showing the vertical view of the partial fuselage, rotary frame and extended airfoil;

FIG. 5 is a vertical sectional end view showing a Kruger Flap in a simplified form, taken along a sectional line 5—5 of FIG. 3;

FIG. 6 is a vertical end view of an alternate structure showing an extended airfoil pitched to create lift, in the down wind quadrant;

FIG. 7 is a top plan view of an extended airfoil in the upwind quadrant, with a cut away surface showing a dual purpose flap and a trap flap in a closed position;

FIG. 8 is a rear elevation view of an extended airfoil in the downwind quadrat, with part of the skin surface removed to show the dual purpose flap and trap flap in the open or extended position, and forming a pocket;

FIG. 9 is a vertical side view showing an alternate mounting of the forward thrust engines and showing the dual purpose flap, trap flap and the Kruger Flap in an open or extended position while in the downwind quadrant.

FIG. 10 is a top plan view alternate structure shown in FIG. 6;

FIG. 11 is a frontal elevation view of an alternate in-line gyro type aircraft with the fuselage bottom housed inside the rotary frame and multiple extended airfoil assembly, in which this assembly becomes the segmented gyroscope.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, there is shown a frontal elevation view and FIG. 2 which shows a top plan view of an In-Line Gyro Type Aircraft 10, with a pilot compartment 17 and a passenger space 18 all located within the aerodynamic fuselage 11. Attached to the fuselage 11 are twin forward thrust engines 14 mounted within rear extending twin booms 26 with a tail assembly that contains a horizontal stabilizer 16, ailerons 19, twin vertical fins and rudders 15 and tail flap 20 with all control members mounted in the tail area of the twin booms 26. These control members located in the tail area function to control the aircraft 10 in flight, similar to that of the normal fixed wing aircraft. Also located at the tail area are the thrust engines exhaust ports 22, and mounted to them are deflecting vanes 23. These deflecting vanes 23 or similar means, function to correct the torque that is created by the friction between the multiple bearing members that are located in the periphery of the stationary fuselage 10 and the rotary frame 12 and the extended airfoils 13 assembly as it spins in one direction.

Most single rotor type aircraft must contain some type of component to equalize the lift on the rotor blades when the blades spin into the downwind quadrant of rotation of its 360 degrees of rotation (i.e. where the rotor blade's leading edge is facing in the opposite direction of the aircraft's forward flight). This present invention is no exception, since the extended airfoils 13 also face in the opposite direction when in the downwind quadrant of the forward moving aircraft 10 and airfoils 13 having no angle of incidence thus has less lift imbalance.

In the present invention, by its very configuration it is able to contain one or several types of compensating lift devices in a combination use of them in order to produce the desired results to equalize the lift forces on each side of the fuselage of the forward moving aircraft 10. In FIGS. 3 and 4 are partial views of the construction of the fuselage 11, and the rotary frame 12 with its extended airfoils 13. Mounted to each multiple extended airfoil's 13 bottom surface is a dual purpose flap 27 shown in an open or extended position and is attached by a hinge 28 means along its front edge and the hydraulic cylinder and linkage 30 actuating unit. This dual purpose flap 27 drops down to function in the slipstream automatically and in the downwind quadrant only, of the forward moving aircraft 10 as the rotary frame 12 and extended airfoil 13 assembly spins. As the extended airfoils 13 spin into the downwind quadrant of the forward moving aircraft 10, this also spins the inside mounting ("C" shaped bracket 44) of each extended airfoil 13 which has electrical contact 47 and makes contact with a stationary electrical switch 48 located inside of the stationary fuselage 11. These electrical contacts 47 and 48 energize the hydraulic motor unit 45 at the wired contact point 57 causing the hydraulic cylinder and linkage 30 to extend the dual purpose flap 27, and as the spinning extended airfoils 13 moves out of the downwind quadrant, the electrical contacts 47 and 48 are broken and then recontacted, causing the hydraulic motor unit 45 to reverse and retract the dual purpose flap 27. This action of each dual purpose flap 27 of each extended airfoil 13 is actuated in each complete 360 degree cycle, and automatically dropping the dual purpose flap 27 into the slip-stream only in the downwind quadrant. This function causes a creation of lift in the downwind quadrant to equal the lift being created by the forward moving extended airfoils 13 in the upwind quadrant on the opposite side of the fuselage 11, thereby creating equal lift on both sides of the forward moving aircraft 10. This aforesaid operation is performed exactly in the same manner in the case of power failure, except the power source to actuate the hydraulic motor unit 45 can be furnished by auxiliary batteries and means (not shown) may be disengaged to eliminate the friction from the power off internal engine 24 in FIG. 1.

An alternate flap that can be used in place of or in combination with the dual purpose flap, is the Kruger Flap 21 shown in a top plan view in FIG. 3 and in a side view in FIG. 5. FIG. 3 and FIG. 5 shows this said flap 21 connected to and extending from the leading edge of an extended airfoil 13 while in the downwind quadrant. This said flap 21 which is attached by a slide T-slot bracket 56 and hydraulic cylinder and linkage 29 and functions in extending only in the downwind quadrant and thus creating equalizing forces of the forward moving aircraft 10. So these two said flaps 21 and 27 can mount within the same extended airfoils 13 and can operate simultaneously if desirable. Both aforesaid flaps 21 and 27 have their separate hydraulic cylinder and linkage 29 and 30, but can use the same hydraulic motor unit 45 electrical contacts 47 and 48 to function in extending and retracting these two aforesaid flaps 21 and 27 shown in FIGS. 3 and 4 in their downwind extended position. Referring to FIG. 2 which shows a top plan view of the Kruger Flaps 21 in the four different quadrants. But only in the downwind quadrant does the Kruger Flap 21 actually function and that is when it extends itself from the airfoil's leading edge to create lift. In the other three quadrants, the Kruger Flap 21 remains stored in the leading edge of the extended airfoils 13.

Shown in FIGS. 6 and 10 which shows still another type lift equalizing wing pitch-pivot 38 means that can also be used in conjunction with the other aforesaid flaps 21 and 27 if desirable. This wing pitch-pivot 38 can function in using the same operating components as used by the two aforesaid flaps 21 and 27, such as the same hydraulic motor unit 45, but with its own hydraulic cylinder, linkage and lines (not shown) to function in pitching the extended airfoils 13 around its pitch-pivot axis 38 at the slip separation 37, between the two reinforced ribs 31. This same pitch means is known to the art, and will also function to equalize the lift forces of the gyro type aircraft only in the downwind quadrant, automatically.

The special dual purpose flap 27 contains a safety feature that can be used for power-off horizontal flight in which the dual purpose flap 27 is used as the means for the auto-rotation of the rotary frame 12 and extended airfoil 13 assembly. With the drive-shaft 58 and drive gear 54 in FIGS. 3 and 4 which are held in alignment by a drive shaft support 55 and are disengaged by means (not shown) for power-off horizontal flight. When the dual purpose flap 27 drops down into the slip-stream in the downwind quadrant only, it will cause air pressure to push against the back surface 27A of the dual purpose flap 27; causing the complete rotary frame 12 and extending airfoils 13 assembly to continue its spin as long as the aircraft 10 is moving forward in flight. The back surface 27A of the dual purpose flap 27 has a reinforcing bar 39 for added strength and attaching of the hydraulic cylinder and linkage 30 assembly.

Referring to FIGS. 7 and 8 there is shown a triangular shaped trap flap 70 assembly which functions in aiding the dual purpose flap 27 when it is open and extended. The trap flap 70 is connected to the outboard edge of the dual purpose flap 27 and pivots open and closed by action of the dual purpose flap 27 when it opens and closes. The trap flap 70 is attached at one end by a pivot means 71 along the outboard edge of the dual purpose flap 27, with its opposite end connected to the bottom surface of the extended airfoils 13 via T-linkage and swivel means that slides inside a T-slot track 73. When the dual purpose flap 27 opens by moving downward into the slip-stream, it also moves the outboard edge of the trap flap 70 downward and forcing its opposite T-linkage and swivel 72 end, to slide towards the outboard side in its T-track 73 and forcing the trap flap 70 to open up to an almost 90 degree vertical position. The trap flap 70 when in the open or extended position forms a pocket at the outboard edge of the dual purpose flap 27 and its back surface 27A and the bottom surface of the extended airfoils 13. Without the trap flap 70 installed, the air pressure from the slip-stream will slide out and off of the dual purpose flap 27 and its back surface 27A almost instantly along the outboard open end, with every slight degree of rotation made by the rotary frame 12 and extended airfoil 13 assembly. But with the trap flap 70 attached and in operation then in the down-wind quadrant, causes the slip-stream to build up air pressure for a longer period (i.e. through more degrees of rotation) thus giving the rotary frame 12 and extended airfoil 13 assembly a more positive rotational force means, when the rotary frame 12 and extended airfoil 13 assembly is put into its auto-rotational mode. The closing operation of the trap flap 70 is actuated by the closing action of the dual purpose flap 27, that forces the T-linkage and swivel 72 to move inboard, because of the outboard end of the T-track 73 is closed and will only permit the trap flap 70 to open to a few degrees less than a full vertical 90 degrees. This slight inboard tilt (less than 90 degrees) of the T-linkage and swivel 72 causes it to slide inboard when closing and not lock up, accidently.

In FIGS. 3 and 4 shows a partial cut away view showing an extended airfoil 13 that contains a solid weighted body 33 in the contoured shape of the airfoil tip, that functions in all of the extended airfoils 13 for storage of energy and gyroscopic stability with a low center of gravity. Attached to the airfoil's solid weighted body 33 are twin spars 32 and mounted to the spars 32 and ribs 31 with metal skin covering 34 that fastens to the ribs 31. The metal skin 34 completely covers the extended airfoils 13 and the rotary frame 12 and the compound multiple curves that makes for a light weight, but very strong rotary frame 12 and extended airfoil 13 assembly that spins around its vertical axis in a horizontal plane, at the periphery of the fuselage 11.

The root ends of the twin spars 32 penetrate through a 360 degree horizontal open slot 43 and attach to an elongated "C" shaped bracket 44 as shown in FIG. 4. Each elongated "C" shaped bradket 44 has two 90 degree angle lips 44A and 44B that engage with two 90 degree angle lips 40A and 41A of the parallel tracks 40 and 41, with contacts between the two pairs of aforesaid lips 44A, 44B and 40A, 41A by multiple bearings 36 that serves to interlock all the said lips together in a free sliding movement, to the parallel tracks 40 and 41 which in turn mounts 360 degrees horizontally at the periphery of the fuselage 11. The slot 43 has an upper slot surface 40B and a lower slot surface 41B in which the spars 32 travel with multiple spar bearing members 32A that make the only contact with the slot surfaces 40B and 41B. On the external side of the parallel tracks 40 and 41 are located multiple bearing members 35A mounted to the spar bearing support 35 that fastened to the spars 32 and these external mounted bearing members 35A coupled with the internal mounting gives the added stability to the extended airfoils 13 as they spin almost frictionless around the horizontal open slot 43 of the mounted parallel tracks 40 and 41 at the periphery of the fuselage 11. Other bearing members 49 that are located throughout the rotary frame 12 and extended airfoil 13 assembly and parallel tracks 40 and 41 are to facilitate the spinning function and support.

On the most inward vertical side 44C of each elongated "C" shaped bracket 44 is mounted a 360 degree horizontal ring flange 46 and ring gear 46A shown in FIG. 4. The ring flange 46 and ring gear 46A locks together, all moving internal components of each extended airfoil 13 and rotary frame 12 into one complete rotating assembly that spins inside and outside of the stationary fuselage 11 and along on the parallel tracks 40 and 41. The ring gear 46A is the means by which the complete rotating assembly is driven by power means with the drive gear 54 turning and meshing with the horizontal 360 degree ring gear 46A and in turn, spinning the entire rotating assembly along the horizontal 360 degree parallel track 40 and 41.

The fuselage 11 has its upper fuselage spars 50A connected to the lower body through vertical fuselage beams 53 to the fuselage floor 51 and floor supports 52 to the lower fuselage spars 50 and with the upper and lower body covered by a metal skin 34A thereby making it one complete stationary fuselage assembly 11.

In FIG. 9 is shown a side view of an alternate in-line gyro type aircraft 10A design with all the aforesaid mentioned components, but with the forward thrust engines **14** in an underslung mounting. Also shown in FIG. **9** is a dual purpose flap **27** and trap flap **70** with both being in an open and extended position, while in the downwind quadrant. Also shown in an open and extended position is a Kruger Flap **21**, in the downwind quadrant.

In FIG. **11** is a frontal elevation view of another alternate in-line gyro type aircraft **10B**. This design also contains all the aforementioned operating components, but without landing gear and with the bottom fuselage area inside the rotary frame **12** and extended airfoil **13** assembly.

A brief flight procedure of this in-line gyro aircraft would be similar to the following description: As the aircraft sets on the airport ramp, it is noticed that the perfectly balanced rotary frame and extended airfoil assembly is being slowly rotated by a gentle breeze, since it is in a auto-rotating mode. As the pilot prepares for take-off, the pilot engages the rotary frame and extended airfoil assembly with the internal power means and advances the vertical lift throttle until the gyro aircraft slowly lifts vertically with all downwind components operating automatically in their calculated slow rotational speed mode. As the aircraft clears the airport vertically at about 150 feet the pilot advances the vertical lift throttles until they engage the forward thrust throttles as the lift speed increases greatly at the same time the forward thrust is accelerated. The gyro-aircraft then really zooms out and away at approximately 60 degrees vertically with the gyro-aircraft still remaining in a horizontal attitude. The gyro-aircraft with its spinning rotary frame and extended airfoil assembly which is disturbing the solid wall of air ahead of its line of flight, reaches a high altitude at a very fast rate of climb with very little fuel consumption. At approximately 35,000 feet, the pilot cuts back all the way on both power sources and proceeds to maneuver the aircraft by the tail control surfaces that takes a little time, since the gyrodynamic forces are keeping the gyro-aircraft in a normal flat horizontal attitude. The forward thrust momentum keeps the gyro-aircraft in forward flight until the pilot is able to lower the nose into the proper downward shallow flight angle by using the large control surfaces of the tail assembly. With the gyro-aircraft in the proper downward flight angle and the rotary frame and extended airfoil assembly is put into its auto-rotational mode, then the gyro-aircraft is flying on its own in an undulating manner. Thus the force of gravity becomes its source of power means until it reaches its destination with no fuel consumption. Upon reaching its destination the pilot uses the reverse procedure of that used in take-offs and lands at a high angle, using mostly its rotary frame and extended airfoil assembly's power to set the gyro-aircraft down. Since this gyro-aircraft may have no landing gear, it can then use a special wheeled dolly to land on with the aid of the ground crew or it is possible to use any suitable body of water as a landing site.

The gyro-aircraft is highly suitable for mass production for many of its components, such as segments of the rotary frame and airfoils. Sections of the rotary frame and extended airfoil assembly can be stamped out, which would be ideal in producing the many identical compound curves that maintain aerodynamics, strength and rigidity. The identical parallel tracks can be cast into segments and bolted or welded together to form its 360 degree upper and lower parallel tracks and then placing them on a grinding jig to finish the race surface etc. as one unit, to exactness and balance. These mass produced units would be ideal for the do-it-yourselfers, who would be relieved of the many hours of labor and less worries about safety in construction and airworthiness. Outward model changes would almost be nil, since aircraft are unlike automobiles that make outward costly style changes each year, whereas aircraft people are interested primarily in functional and safety improvement changes.

What is claimed is:

1. A fuselage body adapted for powered flight and sustained power-off flight with auto-rotation means, said fuselage body having the general shape of an aerodynamic inverted saucer, in which a continuous circular track is mounted at the periphery of said fuselage body, and mounted to and riding on bearings in said continuous circular track is a circular rotary frame;

said circular rotary frame including an extended airfoil assembly containing multiple airfoils extending from spaced locations around the periphery of said circular frame and radially therefrom, so as to engage the air and develope lifting forces as said extending airfoils rotate about said fuselage body;

said multiple airfoils contain solid weighted bodies within their extreme tips, said solid weighted bodies conforming to the shape of the airfoil tips, and having a density and balance that will produce inertial properties when spinning, to thus create a positive gyroscopic force with stored energy as in a segmented type of gyroscope;

first power means mounted inside the fuselage body and connected to said circular rotary frame and extended airfoil assembly for moving said frame and airfoil assembly along said circular track to create a lift force on said rotating multiple extending airfoils, and said first power means also containing means for the auto-rotation of said rotary frame and extended airfoil assembly;

second power means mounted on the fuselage body in twin booms that extended rearwardly from said fuselage body to provide forward thrust for horizontal flight, and attached to the tail exhaust of said twin booms are torque control vanes, also attached to the tail area of said twin booms beyond the outer circumference of the extending airfoil tips are a tail assembly and control surfaces for said fuselage body;

other control surface means are located on said extending airfoils, said other control surface means including dual purpose flaps which function by means in the downwind quadrant for additional lift forces, and attached to said dual purpose flaps on an outboard edge thereof are trap flaps, one end of each said trap flap being attached to its respective extending airfoil by a slide means and the other end being attached to said outboard edge of said dual purpose flap by a hinge means, that allows both the dual purpose flap and trap flap to open together and close automatically as a unit for trapping the slip-stream pressure, when open in the downwind quadrant, on and between a back surface of the dual purpose flap and a surface of the airfoils at right angle to the direction of flight of the fuselage body, to thus become the power means for auto-rotation of the circular rotary frame and multiple extended airfoils in poweroff flight; and

aerodynamic flap means in the form of a leading edge airfoil type flap mounted on the leading edge of each said extending airfoil by means which can extend said flap forward from the leading edge of said extending airfoil into the slip-stream to develope additional lift only as the extending airfoils pass into the downwind quadrant of said fuselage body.

2. The body of claim **1** in which,
the extending airfoils taper towards their tips, and terminate to a knife sharp tip edge for penetrating of air resistance.

3. The body of claim **1** including,
said rotary frame with the extending airfoils having a pitch means, that when pitched to a desired angle of attack, will create equalizing lift force in the downwind quadrant.

4. The body of claim **1** including,
a skin that covers the bottom of the rotary frame and extending airfoils, and also covers and encloses the fuselage inside of it, thus forming a supporting cradle for the fuselage, that produces a better lift surface and a sealed bottom for water landings.

5. The body of claim **1** in which,
said extending airfoils have the design of zero degrees of incidence.

6. The body of claim **1** in which,
the weighted bodies in the airfoil tips are located in such a manner, as to produce an extreme low center of gravity, such as in airfoils having a negative degree of dihedral.

* * * * *

United States Patent [19]

Andresevitz

[11] **Patent Number: 4,457,476**

[45] **Date of Patent: Jul. 3, 1984**

[54] **WINGLESS AIRCRAFT**

[76] Inventor: **Frank Andresevitz,** c/o 5th Assembly of God, 16215, Oreszaba St., Paramount, Calif. 90723

[21] Appl. No.: **323,269**

[22] Filed: **Nov. 20, 1981**

[51] **Int. Cl.**[3] **B64C 29/00**

[52] **U.S. Cl.** .... **244/23 C;** 244/52; 244/56; 60/39.34

[58] **Field of Search** .... 244/12.2, 236, 52, 66, 244/56, 12.4, 12.3, 23 A; 60/39.34, 39.35, 39.14 M

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Primary Examiner—Galen L. Barefoot

Attorney, Agent, or Firm—William C. Babcock

[57] **ABSTRACT**

A wingless aircraft that has a generally truncated cone fuselage that has a cockpit in the upper thereof in which the pilot sits, and a transparent rigid dome mounted on the upper portion of the fuselage that extends over the pilot. A number of equally spaced, elongate, jet engine assemblies are pivotally and adjustably supported within the fuselage, with each engine in communication with an air inlet defined in the fuselage. Each jet engine assembly includes a combustion chamber that has an elongate tubular nozzle extending downwardly therefrom, in which exhaust openings are defined through which the hot gaseous products of combustion discharge. The exhaust openings are elongate and substantially angularly disposed relative to the vertical, and as a result the exhaust gases not only rotate the nozzle but exert a reactive force sufficient to lift the fuselage to an airborne position. Rotation of the nozzles results in concurrent rotation of fans that compress air entering the intakes prior to it being discharged to the combustion chambers to mix with atomized fuel and burned to produce the gases of combustion. Guidance of the aircraft is achieved by angular movement of the rotating nozzles relative to the fuselage.

5 Claims, 10 Drawing Figures

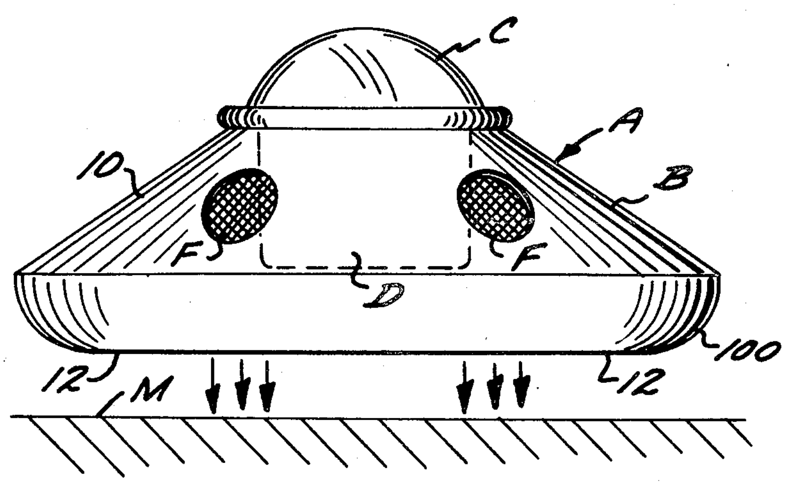


FIG. 1

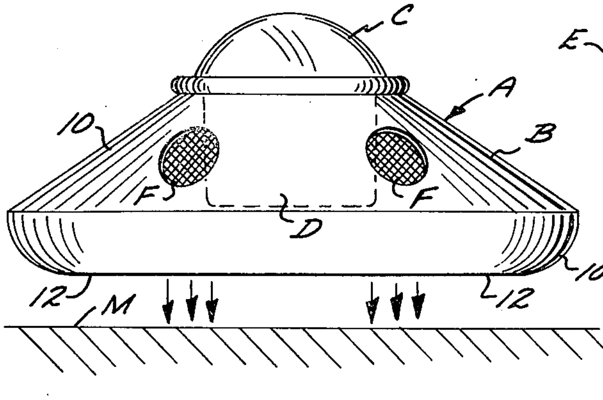


FIG. 2

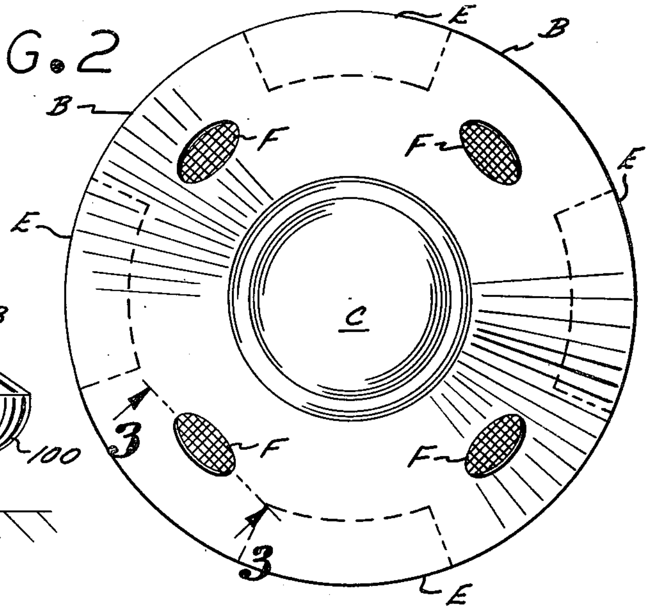


FIG. 3

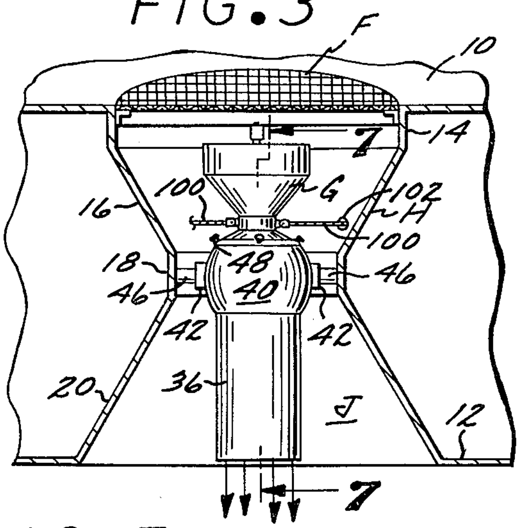


FIG. 4

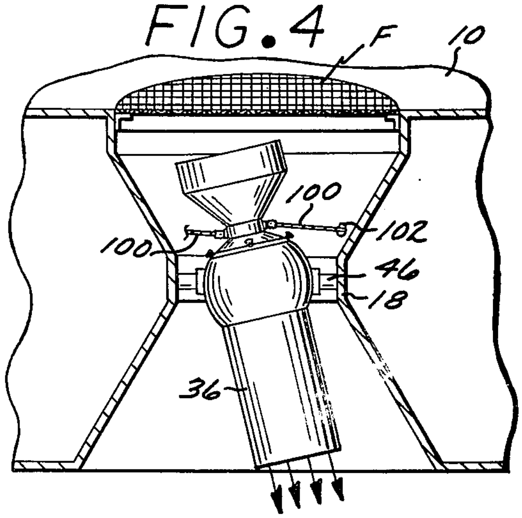


FIG. 5

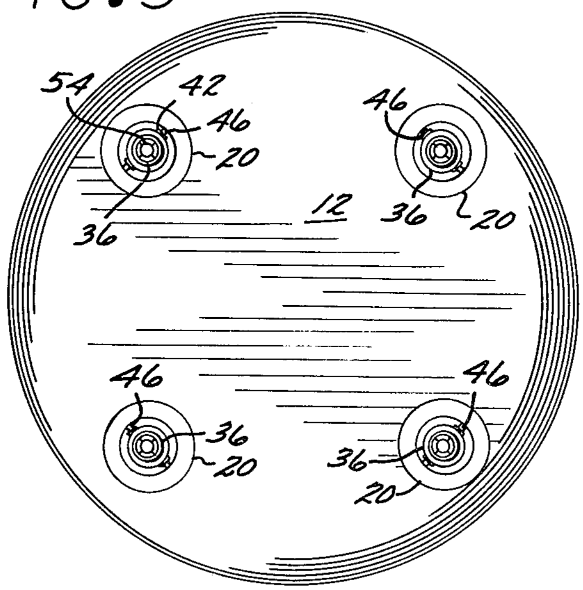


FIG. 6

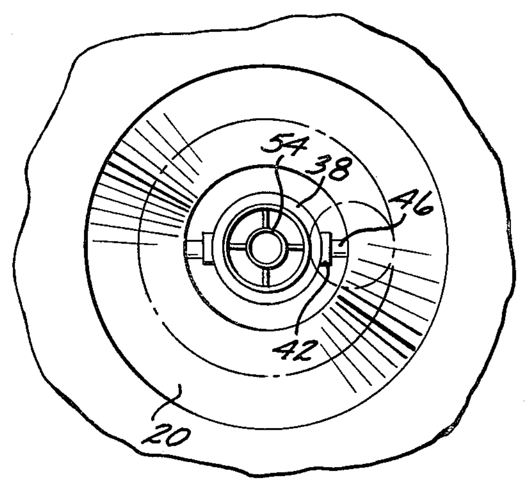


FIG. 7

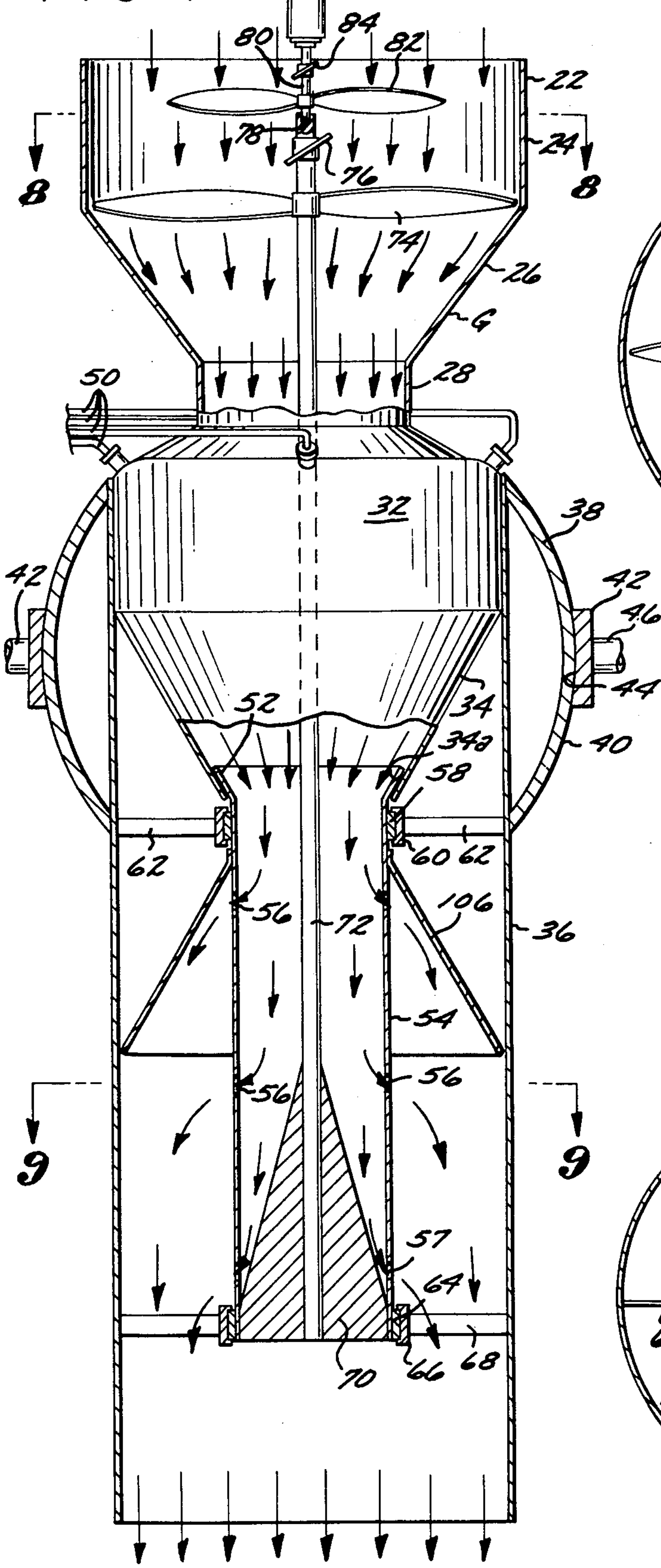


FIG. 8

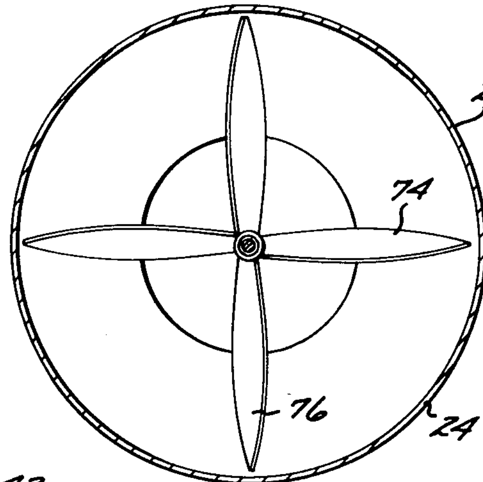


FIG. 10

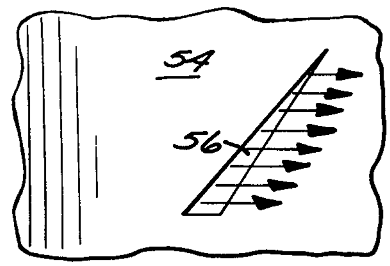
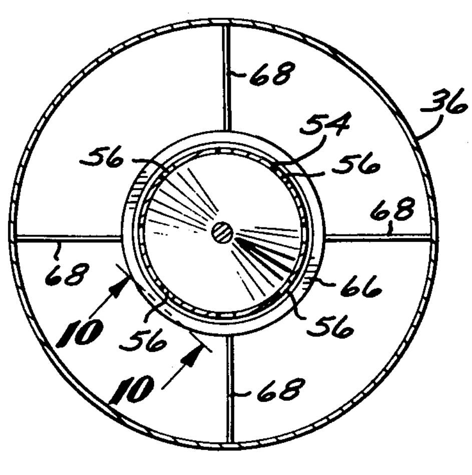


FIG. 9



WINGLESS AIRCRAFT

DESCRIPTION OF THE PRIOR ART

In the past, numerous attempts have been made to devise a wingless aircraft, but such attempts have met with but limited success.

A major object of the present invention is to provide a wingless aircraft that has a cone shaped overall appearance, is powered by a number of internally positioned, pivotally and adjustably supported elongate jet engines that each has a rotatable downwardly extending nozzle, with exhaust from combustion of fuel not only causing rotation of the nozzles to drive fans to compress air prior to it entering the combustion chamber, but developing a thrust to maintain the aircraft airborne, and guidance of the aircraft being achieved by varying the angle of the nozzles relative the fuselage.

Another object of the invention is to overcome operational disadvantages of prior art wingless aircraft by providing one that is simple and easy to fly, has a simple mechanical structure, requires a minimum of maintenance attention, and when not in use may be stored in a relatively small confined space.

These and other objects of the invention will become apparent from the following description of a preferred form thereof.

SUMMARY OF THE INVENTION

The wingless, jet engine, propelled aircraft of the present invention has a generally conical shaped fuselage, which in the upper portion is defined by a upwardly convex transparent rigid shield that protects the pilot who is disposed directly there below, when in the aircraft. The fuselage at substantially mid point of the fuselage has a number of screened air intake openings defined therein, with each of the openings being in communication with a jet engine assembly that is pivotally supported within the fuselage, and the nozzle of each jet engine being disposed downwardly for gases of combustion that discharge from the nozzle to be directed downwardly to impart an upward force to the aircraft. Each of the jet engines includes first and second propellers disposed within a shroud that extends inwardly from one of the air intakes to communicate with a combustion chamber that has a number of fuel atomizing nozzles that are connected by conduits to one of a number of fuel tanks situated within the fuselage. The fuel-air mixture in the combustion chamber is initially ignited by spark plug of the like, with the mixture after initial ignition continuing to burn. Products of combustion resulting in the burning of the fuel are directed downwardly through a converging section to a tubular nozzle that is rotatably supported therefrom.

The combustion chamber and nozzle that is rotatably supported therefrom in a downwardly depending position are situated within the confines of a tubular housing, which housing on the upper end has a ring shaped member extending outwardly therefrom that has a circular transverse cross section. The circular member is pivotally supported by engagement by a rigid ring that has a transverse interior surface of circular transverse cross section and of substantially the same radius of curvature as the exterior surface of the convex ring secured to the tubular housing. The circular ring is supported by a spider that extends to a depth that is in communication with one of the air intakes, and extends downwardly to an opening formed in the bottom of the fuselage.

As the fuel-air mixture is burned within the combustion chamber, hot gases of combustion are generated therein and discharged downwardly through the nozzle to be emitted through a number of elongate discharge openings that are angularly disposed at a substantial angle relative to the bottom of the vehicle. The lower end of each nozzle is sealed by an upwardly extending member that has a shaft continuing upwardly therefrom to terminate in at least one set of propellers situated adjacent the air intake. As fuel is burned in the combustion chamber hot gases of combustion discharge downwardly through the openings in the nozzle to rotate the same, as well as the shaft and propeller and also to continue flowing downwardly through the tubular shell as a stream of gases at substantial velocity which imparts an upward thrust to the engine and the fuselage secured thereto. Rotation of the shaft and propeller previously described results in air flowing into the air intake being compressed to a substantial degree prior to entering the combustion chamber and burning in combination with the fuel that is discharged there into.

The invention includes a number of jet engine assemblies as above described, each of which is equally spaced from the other within the fuselage, and each of the jet engine assemblies being pivotally movable to direct the downward flow of gases of combustion therefrom, in guidance of the aircraft being achieved by varying the angulation of the jet engine containing shells relative to one another. As the angulation of the downwardly extending nozzles are varied, the direction of gases of combustion are flowing therefrom is changed, and as a result the direction of movement of the aircraft through the air may be controlled by the pilot varying the angulation of the jet engines in the tubular shells that enclose the rotating nozzles. Initiation of the operation of each of the jet engines above described is by an electric motor or other prime mover driving a propeller situated in one of the air intakes, to direct a downward flow of air through the combustion chamber and cooperate with fuel discharged thereinto to provide a stream of gases of combustion that flow downwardly through the rotating nozzle and shell. After the nozzle of each engine is rotating, the shaft associated with that nozzle is driving a first set of propellers, and the motor set of propellers is disconnected. Driving the first set of propellers results in an air stream being directed downwardly through the combustion chamber to mix with atomized fuel ejected thereinto, and the air-fuel mixture burning to provide the downwardly flowing stream of gases of combustion that result in rotation of the nozzle associated with that particular engine, and also due to the stream of gases discharging through one of the tubular shells effecting an upward lift on the fuselage to cause it to rise. After the fuselage is airborne, guidance of the fuselage is achieved by varying the angulation of the nozzles relative to the fuselage and to one another.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of the wingless jet propelled aircraft;

FIG. 2 is a top plan view of the aircraft shown in FIG. 1;

FIG. 3 is a fragmentary vertical transverse cross sectional view taken on the line 3—3 of FIG. 2;

FIG. 4 is the same view as shown in FIG. 3 but with the jet engine assembly having been tilted to an angular position relative to the vehicle for guiding purposes;

FIG. 5 is a bottom plan view of the aircraft;

FIG. 6 is a bottom plan view of one of the jet engine assemblies and illustrating in phantom line the position to which the lower end of the nozzle may be manipulated by the pilot of the invention;

FIG. 7 is a vertical, enlarged, cross sectional view of one of the jet engine assemblies and movable support therefor taken on the line 7—7 of FIG. 5;

FIG. 8 is a transverse cross sectional view of the invention taken on the line 8—8, and illustrating two sets of propellers that are utilized in compressing air prior to the same being discharged into the combustion chamber of one of the engines;

FIG. 9 is a transverse cross sectional view of one of the engine assemblies, taken on the line 9—9 of FIG. 7;

FIG. 10 is a fragmentary enlarged side elevational view of one of the elongate upwardly and angularly disposed gaseous products of combustion openings formed in one of the nozzles and taken on the line 10—10 of FIG. 9.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The wingless jet engine propelled aircraft A as may best be seen in FIG. 1 includes a generally frustoconical shaped fuselage B, that on the upper ends supports a transparent protective rigid dome C, and with a cockpit D situated therebelow in which the pilot (not shown) is seated. The aircraft A is illustrated as including four fuel tanks E as may be seen in FIG. 2 that are situated within the confines of the fuselage and equally spaced from one another. The fuselage B has four intakes F formed therein, with four jet engine assemblies G of elongate shape being disposed within the fuselage B and in communication with the air intakes F. Each of the jet engine assemblies G which is of elongate shape as may be seen in FIG. 3 is situated in a downwardly extending shroud H that has the upper end secured to the sheet material 10 defining the fuselage B. The shell 10 develops on the lower end into a convex portion 10*a* that merges into a flat bottom 12, as shown in FIG. 1. Each shroud as may best be seen in FIG. 3 includes a cylindrical member 14 secured to the shell 10, and extending downwardly therefrom, which cylindrical member develops into a converging section 16 of circular transverse cross section.

Each of the converging sections 16 on the lower end develops into a ring 18, which ring on the lower end develops into a diverging section 20 of circular transverse cross section that merges into the bottom 12.

Each shroud H defines an interior confines space J that is open at the bottom as shown in FIG. 3. In FIG. 3 it will be seen that each shroud H includes a cylindrical member 14 secured to the shell 10, with the cylindrical member 14 on the lower end merging into a converging section 16. Each section 16 on the lower end develops into a ring 18, from which a diverging section 20 extend downwardly to merge into the bottom 12.

Each of the jet engines G as may best be seen in FIG. 7 includes an air intake portion 22 that is partially defined by a first cylindrical shell 24, that on the lower end thereof develops into a converging section 26. The section 26 on the lower end merges into the upper end of a second cylindrical shell 28. The shell 28 on the lower end develops into a downwardly and outwardly converging section 30 that has the outer end thereof in communication and secured to the upper outer portion of a cylindrical combustion chamber 32. The combustion chamber 32 on the lower end develops to an inwardly converging section 34 that has a lower tapered opening 34*a* defines therein.

A tubular shell 36 is provided for each of the jet engines G as may be seen in FIG. 7, with the shell being secured by conventional means to the exterior surface of the combustion chamber 32.

A first ring shaped member 38 is secured to the upper exterior portion of the shell 36, with the ring 38 having an exterior surface of 40 of circular cross section. A second ring 42 of substantially less width than that of the first ring 38 is provided, which second ring has an interior convex surface 44 that is of circular shape and slidably engages the surface 40 to permit the first ring 38 to pivot relative to the second ring 42. The second ring 42 is supported by a spider 46 from the ring 18 as may be seen in FIG. 3.

In FIG. 7 it will be seen that a number of fuel injecting nozzles 48 are provided that discharge fuel into the interior of the combustion chamber 32, which fuel is delivered to the nozzles from conduits 50 that extend to one of the tanks E in which the fuel is pressurized. The opening 34*a* rotatably engages the flared upper end 52 of a cylindrical nozzle 54 that extends downwardly in the tubular shell 36 and is concentrically disposed therein. The cylindrical nozzle 54 has a number of longitudinally and circumferentially spaced discharge openings 56 formed therein as may be seen in FIG. 10, each of the openings being of triangular configuration and extending upwardly relative to the bottom 12 at a substantial angle. A collar 58 is secured to the exterior surface of the tubular nozzle 54 adjacent the upper outwardly flared end 52 thereof. The collar 58 is rotatably supported in a ring shaped recessed bearing 60, which bearing is supported in a fixed position relative to the tubular shell 56 by a first spider 62. Each cylindrical nozzle 54 on the lower end thereof has a second collar 64 secured thereto that is rotatably supported in a second bearing 66. The bearing 66 is maintained at a fixed position relative to the tubular shell 36 by a second spider 68.

Each tubular nozzle 54 is illustrated as in FIG. 7 as including an elongate plug 70 of generally triangular vertical transverse cross section, which plug has a shaft 72 extending upwardly therefrom into the air intake portion 22. The shaft 72 on the upper end thereof supports a first and second propeller 74 and 76 that are preferably vertically spaced from one another. The upper end of the shaft 72 has a recess 78 formed therein that is rotatably engaged by a second shaft 80. The recess 78 is engaged by a shaft 80 that supports third and fourth propellers 82 and 84. The shaft 80 and the propellers 82 and 84 may initially be driven by an electric motor 86 or like prime mover to initiate operation of the jet engine assembly G with which it is associated. The combustion chamber 32 has a fuel-air mixture igniting device 86 mounted thereon, which is used only in the starting of the jet engine assembly.

In operation, each of the jet engines G is initially actuated by causing the electric motor 86 to rotate the third and fourth propellers 82 and 84 to direct a current of air downwardly through the combustion chamber 32. Concurrently, fuel is delivered through the conduits 50 to the atomizing nozzles 48, where a fuel-air mixture is formed in the combustion chamber 32. The fuel igniting device **86** which may be a spark plug or the like causes the fuel-air mixture to ignite, with hot gases of combustion being directed downwardly through the nozzle **54** to discharge tangentially through the openings **56**, and in so doing causing rotation of the nozzle **54** together with the shaft **72**. Rotation of the shaft **72** results in rotation of the first and second propellers **74** and **76** to draw air into the intake **22** and compress the same as the air is directed downwardly into the combustion chamber **32**. The air flowing downwardly is mixed with the fuel to form a combustable mixture, which burns and with the hot gases of combustion flowing downwardly through the nozzle **54** to cause the same to rotate as it discharges through the openings **56**. The hot gases of combustion after discharging through the openings **56** flow downwardly through the shell **36** in the direction of the arrows shown in FIG. **7** in the lower portion thereof, and these discharging gases imparting an upward force to the aircraft A to cause the same to lift from the ground surface M. After each engine is in operation as above described, the motor **86** is no longer supplied with current through the conductors **87**, and accordingly no longer drives the third and fourth propellers **82** and **84**.

Each of the jet engine assemblies G may be pivotally moved by pairs of cables **100** that are secured thereto above combustion chamber **32**, with the cables extending through openings **102** in the shroud H associated with that engine to the cockpit where they are secured to manually movable members or other conventional control devices (not shown) that may be manipulated by the pilot. Each jet engine has a cone shaped deflector **106** secured to the nozzle **54** thereof as shown in FIG. **7** to direct the jet of hot gases of combustion downwardly in the tubular shell **36** associated therewith.

The construction and operation of the wingless aircraft A has been described previously in detail and need not be repeated.

What is claimed is:

1. A wingless aircraft that includes:

a. a truncated cone shaped fuselage assembly that includes a bottom that has a plurality of circumferentially spaced openings therein, a side wall that tapers upwardly and inwardly from said bottom; a convex transparent dome removably secured to the upper portion of said side wall; a cockpit for a pilot situated in said fuselage below said dome; a plurality of circumferentially spaced fuel tanks disposed within said fuselage, a plurality of air intake openings in said side wall, and a plurality of tubular shrouds disposed within said fuselage each of said shrouds communicating with one of said air intake openings and one of said openings in said bottom, each of said shrouds defining a compartment isolated from the balance thereof;

b. a plurality of elongate jet engine assemblies, each of said jet engine assemblies including an air intake, a combustion chamber and a nozzle for hot gases of combustion that extend from said combustion chamber in a direction opposite from that of said air intake, each of said nozzles being an elongate tubular member having a lower end, and a plurality of elongate upwardly extending openings in each of said nozzles through which pressurized gases of combustion from the burning of said air and fuel discharge tangentially;

c. first means for pivotally supporting each of said jet engine assemblies in one of said compartments, with said nozzle and said jet engine extending downwardly;

d. second means for supplying atomized fuel from said fuel tanks to said combustion chambers;

e. third means for compressing air from said air intake openings prior to it discharging into said air intakes of said jet engines;

f. fourth means for initiating burning of said atomized fuel and compressed air in said combustion chambers to develop a plurality of thrusts through said nozzles that will lift said aircraft from the ground;

g. fifth means for rotatably supporting said nozzles from said combustion chambers;

h. a plurality of cylindrical shells disposed within said shrouds that extend around said nozzles and are secured to said engine assemblies;

i. a plurality of deflectors disposed in said cylindrical shells above said openings, said deflectors serving to direct hot gases of combustion discharging from said openings in said nozzles downwardly to exert an upward thrust on said aircraft to dispose the latter in an airborne position, said gases of combustion as they discharge tangentially through said openings in said nozzles causing the latter to rotate;

j. a plurality of plugs that close the lower ends of said nozzles and are rigidly secured thereto;

k. a plurality of shafts that extend upwardly from said plugs through said combustion chambers to positions adjacent said air intakes;

l. sixth means rotated by said shafts for compressing air entering said air intakes from said air intake openings prior to said air entering said combustion chambers; and

m. seventh means manually actuatable from said cockpit for pivoting said jet engine assemblies after said aircraft is airborne to so dispose the direction of thrust of said gases of combustion from said nozzles as to guide said aircraft when the latter is airborne.

2. An aircraft as defined in claim **1**, in which said sixth means are propellers mounted in said air intakes of said jet engine assemblies and driven by said rotation of said plugs and nozzles.

3. An aircraft as defined in claim **2**, which in addition includes:

eighth means for discharging current of air downwardly through said combustion chambers to initially start combustion of fuel and air therein.

4. An aircraft as defined in claim **3**, in which said eighth means includes:

a plurality of prime movers mounted in intermediate positions between said air intake openings and said air intakes; and

a plurality of second propellers situated above said first propellers that are initially driven by said prime movers.

5. An aircraft as defined in claim **4**, in which said prime movers are electric motors.

* * * * *

United States Patent [19]

Willis

[11] **Patent Number: 4,519,562**

[45] **Date of Patent: May 28, 1985**

[54] **AIRCRAFT**

[76] Inventor: **William M. Willis**, 19440 Citronia St., Northridge, Calif. 91324

[21] Appl. No.: **446,279**

[22] Filed: **Dec. 2, 1982**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 287,229, Jul. 27, 1981, abandoned.

[51] **Int. Cl.**[3] **B64C 21/04**

[52] **U.S. Cl.** .... **244/207**; 244/12.2; 244/23 C; 244/75 R

[58] **Field of Search** .... 244/73 B, 73 R, 73 C, 244/76 J, 200, 204, 207, 208, 209, 226, 12.1, 12.2, 12.5, 23 R, 23 A, 23 C, 23 D, 52, 78, 34 R, 12.3

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Primary Examiner—Trygve M. Blix
Assistant Examiner—Rodney Corl
Attorney, Agent, or Firm—Poms, Smith, Lande & Rose

[57] **ABSTRACT**

A vertical take-off and landing (VTOL) aircraft is disclosed. In one embodiment designed for manned flight, the aircraft employs an aerodynamically-shaped body carrying a pair of lifting elements disposed longitudinally along the body on opposite sides thereof. The lifting elements extend outwardly and curve smoothly downward from a horizontal to a vertical orientation at the outboard edge. Lifting air is flowed over them transverse to the direction of flight. In a second embodiment designed for unmanned use such as cropdusting, military surveillance, or the like, the body is a single circular lifting element of parabolic cross-section. In both embodiments, a turbine is carried within the body to provide forward thrust and, primarily, a supply of pressurized air which is flowed through a nozzle slit opening outwardly over the tops of the lifting element(s) in confined segments. A porous aspirating member provides a divergent outer boundary to the airflow adjacent the tops of the lifting surfaces in a manner which induces augmenting air into the primary airstream in sufficient quantity to maintain the resultant combined airflow in a laminar flow to maximize lift.

38 Claims, 16 Drawing Figures

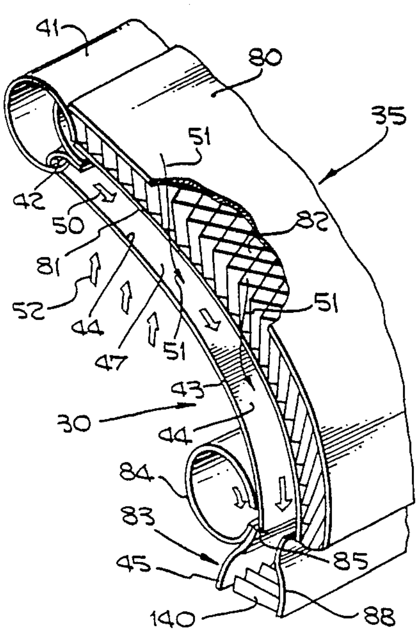
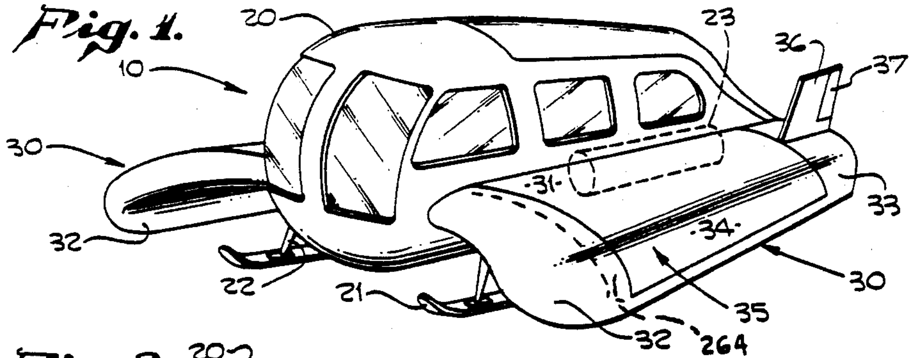


Fig. 1.



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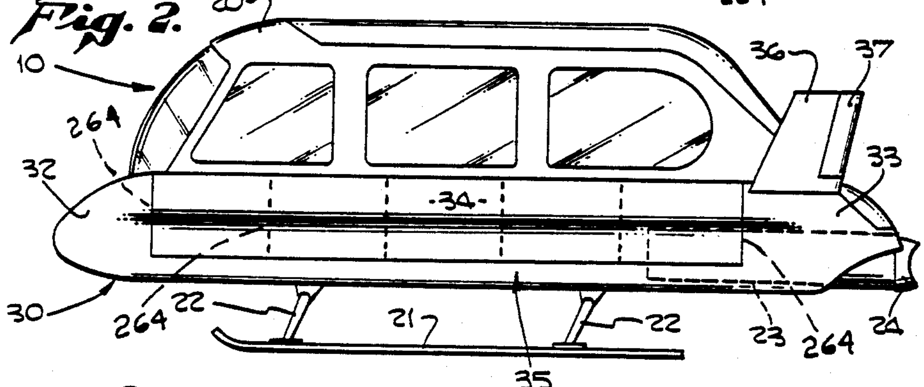

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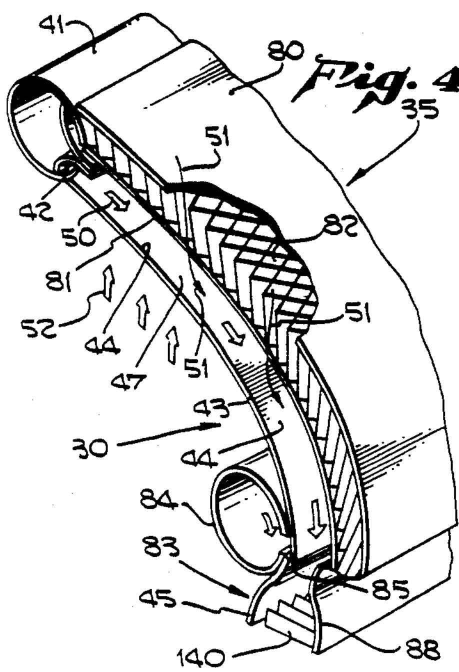
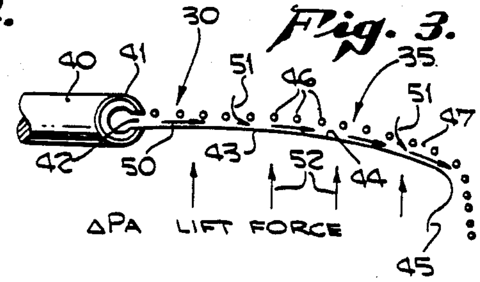


Fig. 3.



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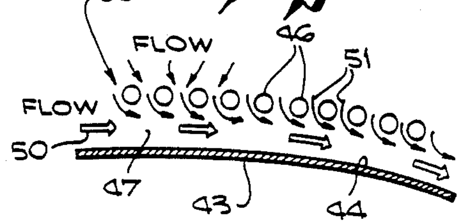


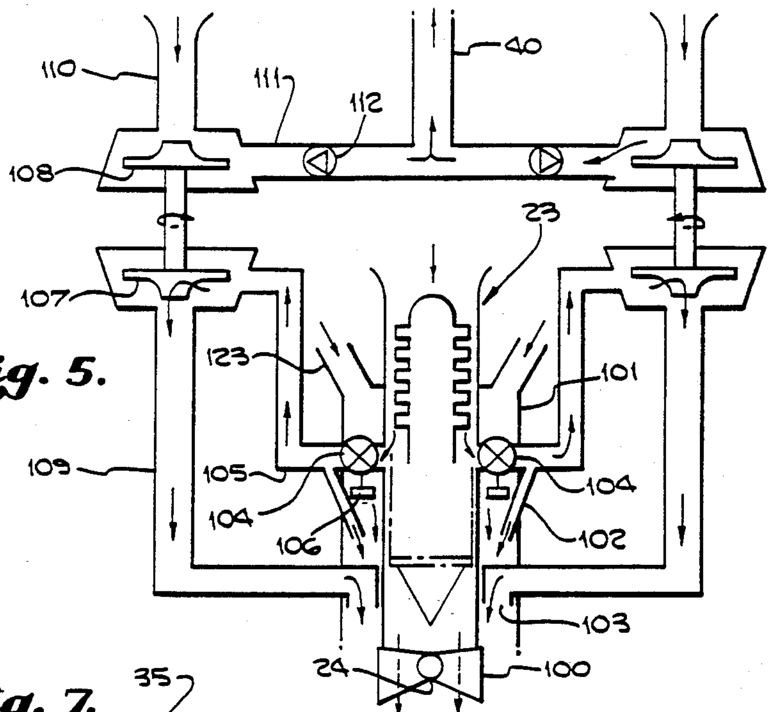


Fig. 5.

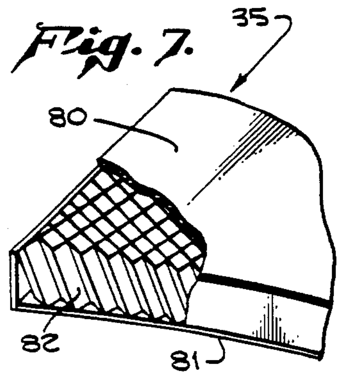


Fig. 7.

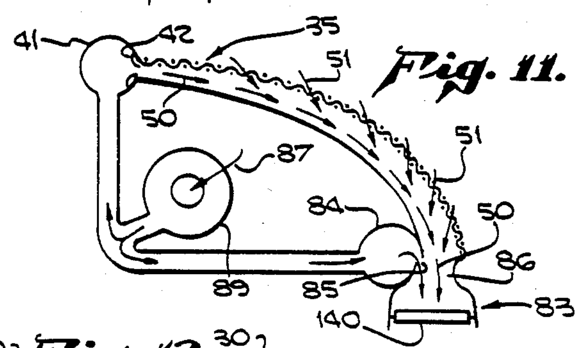


Fig. 11.

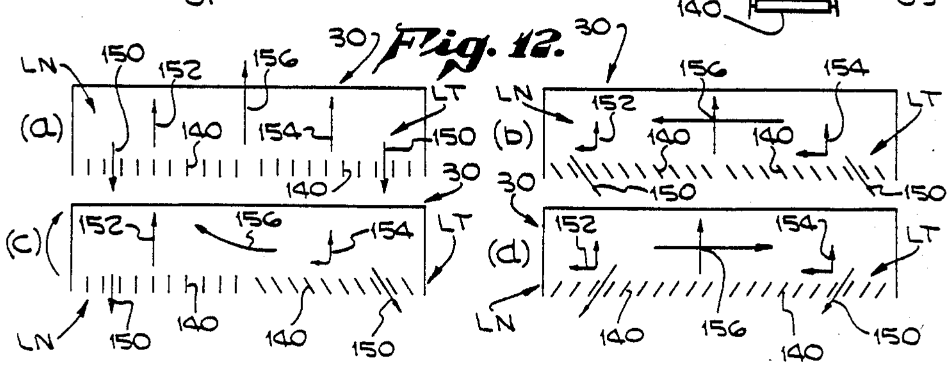


Fig. 12.

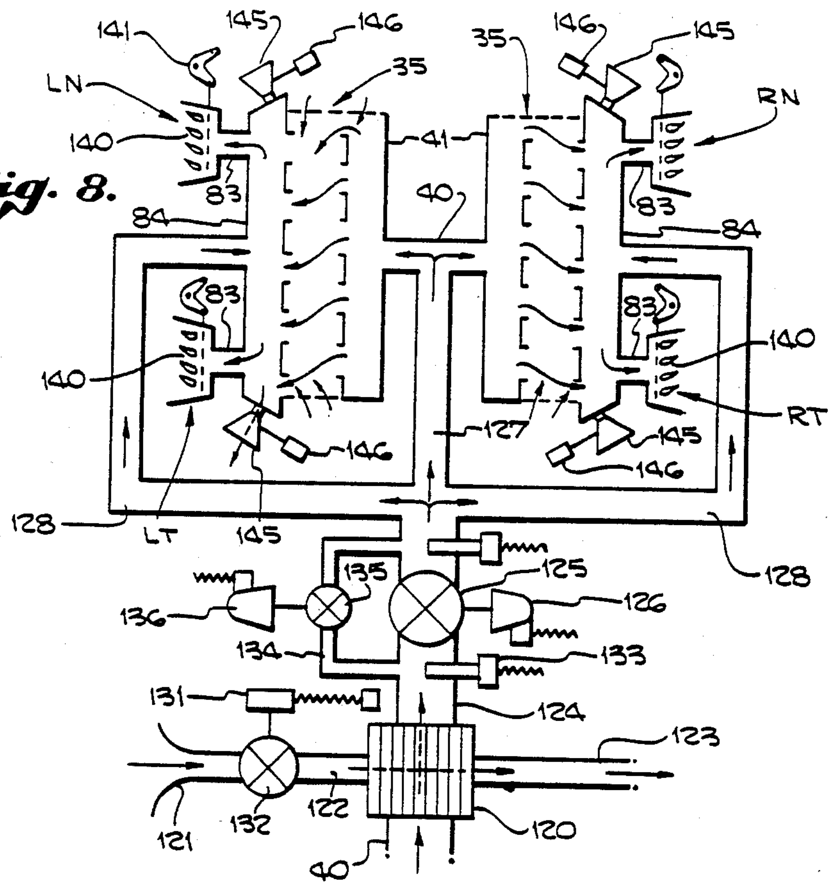


Fig. 8.

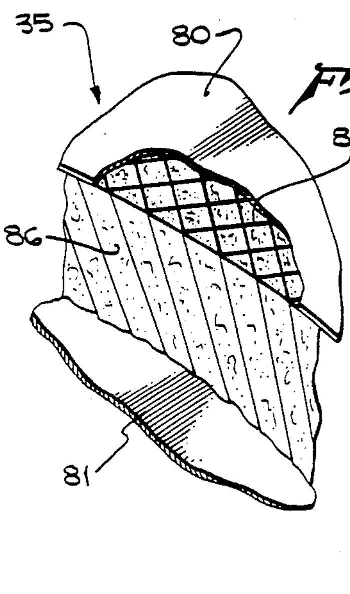


Fig. 9.

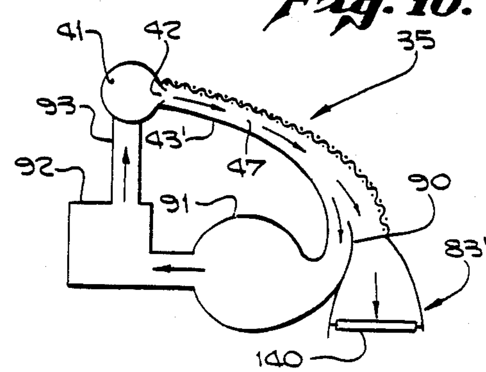


Fig. 10.

Fig. 13.

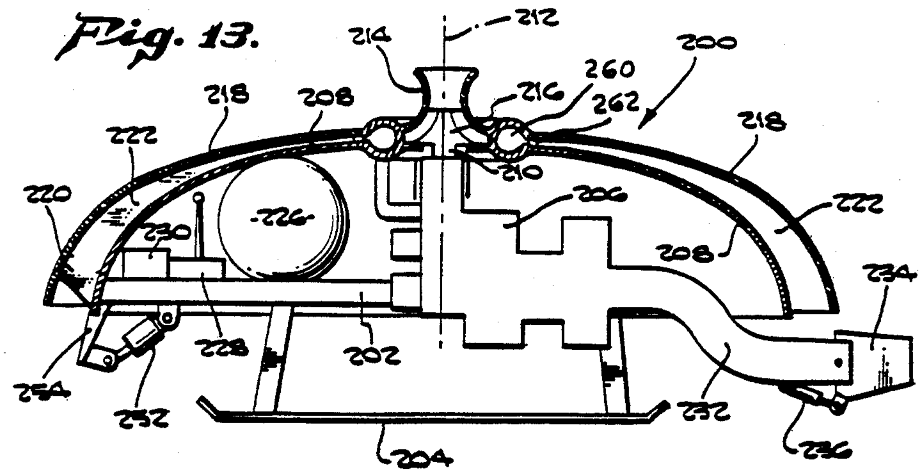
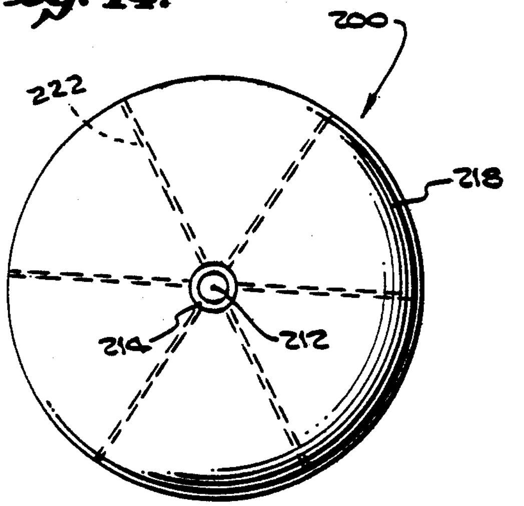


Fig. 14.



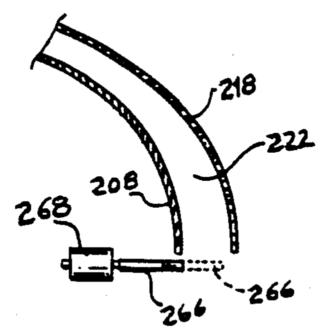


Fig. 16.

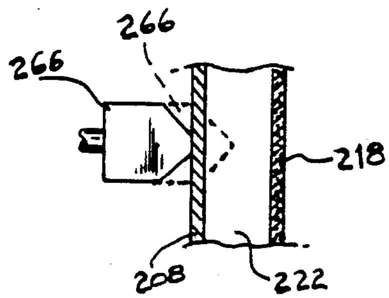


Fig. 15.

AIRCRAFT

BACKGROUND OF THE INVENTION

This application is a continuation-in-part of application Ser. No. 287,229, filed July 27, 1981, now abandoned.

The present invention relates to aircraft and, more particularly, to aircraft of the type being capable of vertical take-off and landing, hovering, and movement in horizontal or lateral flight modes.

Early examples of aircraft employing lift principles similar to those of the aircraft of the present invention are disclosed in my earlier U.S. Pat. Nos. 2,990,137; 3,237,888; and 3,365,149. Each of the aforementioned aircraft employed a lifting force derived from a fluidic principle of force amplification referred to as the "Coanda effect". The Coanda effect is a phenomenon of jet stream deflection and augmentation which, in general, provides that upon fluid flow along a surface, the fluid, such as air, has a tendency to cling or to remain parallel to the surface rather than to follow a more normal straight line flow trajectory. This effect has been known for many years and various experimenters have employed it to some extent. Recently, the Coanda effect has been employed in the design of a prototype short take-off and landing (STOL) aircraft under development for the armed services by a major aircraft manufacturer.

The problem of employing the Coanda effect to advantage has always been the providing of some means to confine fluid flow adjacent to the aerodynamic upper surface in a manner which will enable a laminar flow of air without cancelling the ΔP forces by an opposing confining means. That is, the underlying lift effect produced on an aerodynamically-shaped lifting element such as an airplane wing remains Bernoulli's principle. The airflow over the lifting element (i.e., wing) is made to travel a longer distance than the airflow beneath the wing. The longer distance is accompanied by an increase in air speed over the wing which, according to Bernoulli's principle, causes an accompanying reduction in pressure on the top surface. This ΔP causes a resultant "lift" on the wing. If a confining member is placed adjacent the upper surface, the ΔP can be destroyed and result in a complete loss of lift.

In my earlier aircraft as described in the foregoing patents, I had discovered that it was possible to shield the upper airfoil surface with a porous member whereby the airflow following the upper surface of the lifting element under the Coanda effect is protected from disruptive forces of outside air currents while allowing the maintenance of the necessary ΔP for lift.

While the aircraft of the aforementioned patents were workable for their intended purpose, there were certain shortcomings attendant thereto as regards large scale commercial applicability as to the principles disclosed therein. The apparatus was not designed for multiple passenger occupancy, provided little, if any, sound isolation, and disclosed only a basic control system. Moreover, subsequent investigations have shown that in such a confined passageway as created by the principles of the foregoing patents, a turbulence can easily be created wherein an expulsion of the primary air outward thorough the porous surface is effected with an attendant disruption in the desired laminar flow, which was the

primary impetous for the construciton of a confined passageway in the first place.

Wherefore, it is one objective of the present invention to provide a commercially adaptable aircraft of the foreging type having provision for carrying a number of occupants in quiet and comfort wherein an improved lifting and control mode of operation is provided for maximum effectiveness and ease of operability.

Additionally, there is an urgent need for a lifting platform to be used in such uses as cropdusting, military surveillance, and the like. For example, in conventional cropdusting, the lifting platform remains primarily bi-planes of, basically, World War I design. Helicopters are of limited use as cropdusters as their excessive downwash blows everything from the crop including the blooms, the bees and the material being sprayed. As a result, the cropdusters continue to use the bi-planes with attendant low efficiency, low convenience, and not infrequently, accidents.

Wherefore, it is also an objective of the present invention to provide a lifting platform of a different type and operating principle particularly adapted to the needs of such applications as cropdusting and military surveillance.

SUMMARY OF THE INVENTION

The improved lifting phenomenon employed in the present invention in its various embodiments has been accomplished by the method of creating a vertical lifting force on a lifting element curving outwardly from horizontal to vertical comprising the steps of flowing primary fluid through a nozzle slit opening across the top of the element from one side to the side opposite thereof; divergently bounding the flowing primary fluid adjacent the entire length of the top of the element with a surface of at least 40% porosity; and, continuously adding sufficient augmenting fluid to the flowing primary fluid through the porous surface to maintain the combined flowing fluid stream in laminar flow adjacent the top of the element whereby a differential pressure is created on the element tending to lift it vertically.

The disclosed preferred embodiment for a passenger-carrying aircraft employs this methodology or "Willis effect" in an aircraft comprising an aerodynamically-shaped body for housing one or more passengers; a pair of lifting elements carried by the body disposed longitudinally along the body on opposite sides thereof and extending outwardly from the body, the lifting elements curving smoothly downward from being substantially horizontal adjacent the body to substantially vertical at the outboard edge thereof; power means for producing a supply of pressurized air at an output thereof; means connected to the output of the power means for directing a flow of air through a slit opening outwardly across the upper surface of the pair of lifting elements traversing the direction of flight; and, means carried by the lifting elements for divergently bounding the airflow adjacent the upper surfaces of the lifting elements, the bounding means being of sufficient porosity in relation to the airflow that sufficient augmenting air will be aspirated through the bounding means and added to the airflow to maintain the resultant combined airflow in laminar flow adjacent the upper surfaces of the lifting elements. The preferred cross-section shape for the lifting element and porous bounding means is a half-parabola which has been found to produce an aspriated to primary air volume ratio of as much as 6:1 with attendant high "lift" production.

The preferred embodiment for use in cropdusting and the like is a radio-controlled, unmanned aircraft being of circular shape and with the same preferred parabolic cross-section.

The preferred attitude control system comprises a plurality of tapered vanes spaced radially about the periphery of the aircraft and adapted to be selectively interposed in the airstream as a "spoiler" to vary the airflow and, thereby, the lift forces on respective segments of the lifting surface.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is an orthogonal drawing of an aircraft according to the preferred embodiment of the present invention for carrying passengers.

FIG. **2** is a side elevation of the aircraft of FIG. **1**.

FIG. **3** is a simplified drawing of a cutaway end elevation of the lifting element employed in the present invention showing the method of producing lift force thereon.

FIG. **4** is a partially cutaway orthogonal drawing of a portion of a lifting element of the aircraft of FIG. **1** and FIG. **2** showing the preferred construction thereof.

FIG. **5** is a simplified drawing of the power means and pressurized air source employed in the present invention in its embodiment of FIGS. **1** and **2**.

FIG. **6** is an expanded view of the simplified drawing of FIG. **3** showing the aspiration of augmenting air employed in the present invention to maintain the laminar flow of air adjacent the lifting element.

FIG. **7** is a partially cutaway segment of one embodiment of the porous member employed in the lifting element of the present invention.

FIG. **8** is a simplified drawing of the pressurized air control and manifolding system employed in the lift and control assemblies of the present invention in one embodiment.

FIG. **9** is a partially cutaway segment through the porous member employed in the present invention according to an alternate embodiment thereof.

FIG. **10** is a simplified drawing of the airflow in an alternate embodiment of the present invention.

FIG. **11** is a simplified drawing of the airflow employed in the preferred embodiment of the present invention.

FIGS. **12**(*a*)–**12**(*d*) is a simplified drawing of one manner of attitude control for pitch, roll, and altitude employed in the present invention.

FIG. **13** is a cutaway side elevation through the unmanned, radio-controlled embodiment of the present invention employed as a lifting platform for cropdusting, military surveillance, and the like.

FIG. **14** is a plan view of the embodiment of FIG. **13** showing thereon the position of the sidewalls used to segment and confine the airflow.

FIG. **15** is a cutaway elevation cross-section of the embodiment of FIG. **13** adjacent the inlet air outlet showing the preferred method of control.

FIG. **16** is a plan view of the tapered vane used in the apparatus of FIG. **15**.

DESCRIPTION OF THE TWO PREFERRED EMBODIMENTS

Referring first to FIGS. **1** and **2**, an aircraft, generally indicated as **10**, according to the preferred embodiment for carrying passengers, is shown as comprising a fuselage **20** having a pair of lift and control assemblies, generally indicated as **30**, longitudinally extending generally outward from each side. To enable an at-rest ground position and for landing and take-off, suitable landing gear in the form of skids **21** are provided, being mounted to the fuselage **20** by suitable linkages **22**. The base area of the fuselage **20** is adapted to support a suitable engine structure which may be in the form of a gas turbine **23** having an exhaust outlet **24**. The engine and its relationship to the remainder of the present invention will be discussed hereinafter in detail.

Both the fuselage **20** and the lift and control assemblies **30** are aerodynamically-shaped. The lift and control assemblies are generally outwardly extending structures attached to the fuselage **20** as at **31** utilizing known aircraft construction techniques which form no part of the present invention. The lift and and control assemblies **30** are rigid bodies, extending outwardly in an aerodynamically outwardly and downwardly curved configuration (i.e., curving outwardly from horizontal to vertical). Each has a forward direction enclosed portion **32** and a like rearward extending portion **33**. The central area of each assembly **30** intermediate the portions **32** and **33** is provided with a lifting area according to the present invention generally defined by the outer surface **34** of a non-pressure supporting boundary member indicated generally as **35**. The area defined by the surface **34** comprises substantially the entire upper surface of the assemblies **30**. To assist in lateral control when the aircraft **10** is travelling in a forward direction, the assemblies **30** may each also be provided with a vertical stabilizer **36** fitted with an appropriate rudder **37**. These latter elements, however, are for minor control purposes only and form no particular part of the present invention.

Referring now to FIG. **3**, the principle of operation of the present invention (i.e., the "Willis effect") may be more fully understood. In FIG. **3**, one of the lift and control assemblies **30** is illustrated and diagrammatically includes a duct **40** for delivering air under pressure from a source (to be described in detail hereinafter) to a manifold **41** having an outlet nozzle **42** longitudinally disposed therein. The nozzle **42** is an elongated slit opening of 0.050 inches maximum height. An aerodynamically configured lifting element **43** is provided which has an upper surface **44** that is contiguous with the lower portion of the nozzle **42**. The lifting element **43**, which may be in the form of a sheet metal plate or member, extends outwardly from the manifold **41** and is curved downwardly terminating in a nozzle portion as at **45**. It is preferred that the lifting element **43** be parabolic or eliptical in cross-section as will be discussed in greater detail hereinafter. It is to be noted that the nozzle **42** can take the form of a plurality of close adjacent nozzle openings of similar dimensions. What is desired is a source of a thin sheet of uniformly pressurized air flowing outwardly from adjacent the fuselage **20** over the upper surface **44** of the lifting element **43**.

The non-pressure supporting boundary member **35** is illustrated as comprising a plurality of spaced rods, bars, webs, or screen elements **46**, thus to porously define the outer boundary of a generally divergent passageway **47** intermediate the inner surface of the elements **46** and the upper surface **44** of the lifting element **43**. It is preferred that the porosity of surface **35** be at least 40%. It is also preferred that the boundary member **35** be parabolic or eliptical in cross-section. An enlarged view of the structure of a portion of FIG. **3** is shown in FIG. **6**. As indicated with reference to FIGS. **3** and **6**, it is desired that the sheet of compressed air from the manifold **41** flow over the upper surface 44 of each lifting element 43 in uniform laminar flow throughout the longitudinal extend thereof as indicated by the arrows 50 within the passageway 47. To prevent the aforementioned disruptive turbulence within the passageways 47, the passageway 47 should be slightly divergent and the spacing between the elements 46 (i.e., the porosity of the non-pressure supporting member 35) such that sufficient augmenting air, as indicated by the arrows 51, is induced to be aspirated along the confined passage-way 47, as necessary, to maintain the laminar flow symbolized by the arrows 50. The divergence and porosity will, of course, be a function of both the fluid dynamics and the curve of the lifting element 43. These relationships can be easily determined employing apparatus and techniques well known to those in the aerodynamic art which apparatus and techniques per se form no part of the present invention. It has been found that the preferred parabolic shape results in an aspirated to primary air ratio of as much as 6:1, with attendant high lifting forces produced.

It has been found that superior results are obtained (and such construction is therefore preferred) if sidewalls 264 as shown dotted in FIGS. 1 and 2 are positioned on the ends and intermediate of the upper surface 44 and the boundary member 35 to contain and seal the air flow in channels.

The primary lifting force is, thus, derived by flowing a high velocity thin sheet stream of air over the upper surface 44 whereby a negative pressure below that of atmosphere is created according to Bernoulli's principle, as indicated by the arrows 52 in FIG. 3. The resultant upward force from the lower solid surface of the lifting element 43 is the primary lifting force for vehicle take-off, landing, and hovering modes. The flow augmentation provided by the induced aspiration through the non-pressure supporting boundary member 35 serves to insure maintenance of the laminar flow indicated by the arrows 50, thereby maximizing the resultant lifting force. The required flow of air through the porous member 35 can be induced by its being constructed in the manner of FIG. 9 wherein the metallic honeycomb 82 has a sound-abating/air passing material such as fiberglass, steel wool, or a sintered material disposed therein to assist in noise abatement. As indicated by laboratory tests to date, the metallic mesh material 80, 81 is preferably of a stainless steel screen or mesh with approximately 50% open areas. The material may also be a perforated sheet of metallic material having a plurality of openings therein for approximately the same percentage. As thus constructed with the honeycomb material 82 therebetween, the boundary member 35 is provided with a combination of structural rigidity and high porosity. To assure aspiration through the honeycomb material 82 and aid in sound abatement, the sidewalls forming the honeycomb material 82 should be angled between 15° and 45° from normal in the direction of fluid flow as shown in FIGS. 4 and 7. If the top of one honeycomb sidewall overlaps the bottom of the next adjacent sidewall, the sound abatement will be maximized.

As shown in FIG. 4, air is delivered, in the manner described hereinbefore, through the manifold 41 and through the slit nozzle 42 to the passageway 47 in the direction of arrows 50. This air is induced to follow the surface 44 by the existence of the boundary member 35. Air is aspirated, as indicated by the arrows 51, through the openings provided in the angled honeycomb 82 of the member 35. The divergent passageway 47 can be terminated in an outwardly expanding longitudinal nozzle generally indicated as 83 existing between nozzle portion 45 of lifting element 43 and outer nozzle portion 88 disposed longitudinally on the opposite side of passageway 47 from nozzle portion 45.

Flow through the passageway 47 can be increased by airflow from a lower manifold 84 having a tangential outlet 85 that communicates with the throat 86 (i.e. venturi) of the nozzle 83 at the end of the sheet 43. The lower manifold 84 is provided with air under pressure from the same source as the manifold 41 and serves to aid in inducing air aspiration into the passageway 47 and to thus maintain the desired laminar flow over all areas of the surface 44 of the lifting element 43. Consequently, the desired maximized lifting force is created on the lifting elements 43 as indicated by the arrows 52.

This mode of operation is shown in simplified form in FIG. 11. As can be seen, outside air 87 is drawn into the pressurized air supply means 89 from whence it is forced under pressure into manifold 41 and lower manifold 84. The air within manifold 41 passes therefrom through slit nozzle 42 to form the laminar sheet airflow symbolized by the arrows 50 through the addition of the induced aspirated air indicated by the arrows 51. That air entering lower manifold 84 is directed through the tangential outlet 85 into the throat 86 of nozzle 83 to increase the airflow through the venturi created by throat 86 of nozzle 83 to, thereby, create a low pressure area tending to draw the laminar flow air 50 into the nozzle 83 and out thereof to be utilized in a manner to be more fully described hereinafter.

With brief reference to FIG. 10, an alternate nozzle arrangement is shown. In this instance, manifold 41 delivers air through nozzle 42 to the passageway 47 in the same manner as previously described with reference to the embodiment of FIG. 11. A nozzle 83' is provided at the end of the passageway 47 for the purpose of providing a reactive lift force and controls in the manner to be hereinafter described with reference to the preferred embodiment for passenger carrying. A portion of the air emerging from the passageway 47, however, is reintroduced to the system and recirculated by means of an inlet member 90 to a return manifold 91 which permits recirculation to the fan or compressor 92 which provides air to manifold 41 through the conduit 93. This partial recirculating arrangement provides ram pressure to the compressor inlet to reduce power requirements.

The engine or power supply and associated air compression and delivery system of the embodiment described above are shown in FIGS. 5 and 8. With reference first to the power supply and thrust arrangement of FIG. 5, a gas turbine engine is shown generally at 23 and consists of a compressor, combustion system, turbine, and required accessories. Hot gas from the engine is exhausted through the jet nozzle 24 which is fitted with a relatively conventional thrust deflector and spoiler 100. The central core machinery of the engine 23 is enclosed by an outer cool-gas plenum 101 which receives air which may be heated by passage through a suitable heat exchanger to be described hereinafter and wherein energy is added to the ambient incoming air. The air entering plenum 101 is accelerated through the plenum by primary jet pumps 102 and secondary jet pumps 103. Valves 104 are provided in conduits 105 from which the jet pumps 102 depend, the valves having a suitable operating mechanism 106. The valves permit bleed air from the compressor of the engine **23** to flow through the conduits **105** to air turbine motors **107** which drive compressor elements **108**. The exhaust from the air turbine motors **107** is coupled through conduits **109** to the secondary jet pumps **103**. Air to the compressor **108** is introduced at inlet **110** and exhausted through the conduit **111** past check valves **112** to a supply conduit **40**. As previously illustrated in FIG. **3**, the supply conduit **40** is connected to the manifold **41**.

It should be noted that the exhausted air from the plenum **101**, with heat energy added, forms an outer thrust annulus effectively utilizing energy available and acting as an efficient sound abatement mechanism for the hot gas shearing at the nozzle **24**. The clam shell spoilers **100** may be suitably deployed as thrust reversers as used with many conventional jet reaction engines on normal aircraft. These serve to back-pressure the compressor of the engine **23**, delivering hot bleed gases to the air turbine motors **107** and to the primary jet pump **102**. Such action of the spoilers or clam shells **100** also serves to aspirate and retain the outer annulus airflow for added pumping thrust spoiling. The valves **104** serve to conserve bleed air and the control **106** therefore, may be modulated from a suitable pressure transducer which may be located upstream of the primary valve **104**. This arrangement allows total energy recovery and energy conservation as it is a demand system regulated by requirements of the compressors **108** that are also compatible with all flight modes. The scoop inlets **110** for the compressors **108** receive the ambient air to create a compression ratio in the order of 2.2:1 and the check valves **112** prevent loss of pressure in the event one compressor becomes inoperative.

Turning now with reference primarily to FIG. **8** taken in conjunction with FIG. **5**, one manner of delivery, use, and control of the air flowing through the system is shown. Air under high pressure from the compressors **108**, as previously described, is delivered through the conduits **111** and join in an outlet conduit **40**. As shown in FIG. **8**, the air in conduit **40** passes in heat exchange relationship to ambient air by use of heat exchanger **120**. Ambient air is delivered through a scoop **121** to a conduit **122** through the heat exchanger **120** and thereafter through a conduit **123** that may be connected to the annulus **101** surrounding the propulsion tubine **23**. This connection is shown in FIG. **5**. From the heat exchanger **120** the air is conducted through a conduit **124** under control of a primary valve **125** positioned in the conduit **124**. The valve **125** is operated by a suitable controller **126** that is coupled to a pilot control system for presetting to enable the pilot to preselect his altitude flight corridor by mechanically setting the valve **125** to deliver a predetermined flow of air at a particular terminal pressure to the manifolds **41** and the plenums **84**. The connection in the manifolds **41** is made by way of a conduit **127** and to the plenums **84** by way of conduits **128**. The air in the conduit **124** downstream from the heat exchanger **120** has its temperature in the order of 300° F. by means of a temperature transducer **130** that is operatively connected to an operating mechanism **131** of a flow control valve **132** positioned in the conduit **122** which conducts ambient air through the heat exchanger **120**. In order that the efficient use of the bleed air from the compressor of the engine **23** may be accomplished, a pressure transducer **133** is positioned in the conduit **124** upstream from the valve **125**. The transducer **123** is operatively connected to the controllers **106** of the valves **104**, thus to regulate bleed air from the engine compressor in the manner described in connection with FIG. **5**. A bypass conduit **134** is also provided about the primary valve **125**. An altitude compensating vernier valve **135** operable by a controller **136** is positioned in the bypass conduit **134**. The controller **136** is coupled to the pilot's control and may also be mercury vapor contolled whereby to maintain desired altitude of the aircraft.

As previously described, the air delivered to the manifold **41** flows through the passageway **47** of the lift and control assemblies **30**. The air is also delivered to the lower manifold **84** and from the lower manifold **84** through the nozzle **83**. As shown diagrammatically in FIG. **8** and in cross-section in FIG. **11**, a plurality of vanes **140** are disposed longitudinally traverse nozzle **83**. The vanes **140** are controlled through an appropriate linkage **141** connected in the usual manner to the pilot's control and are able to control the pitch and roll of the aircraft by selectively deflecting the air emerging from the nozzles **83** away from the vertical direction. This action can best be understood with simultaneous reference to FIGS. **8** and **12**. FIG. **12** diagrammatically shows the effect of the movable vanes **140** in different attitudes. FIG. **12** symbolically shows the lift and control assemblies **30** in the same position as the aircraft **10** of FIG. **2**. That is, it can be visualized in viewing FIG. **12** that the front or nose of the aircraft **10** is to the viewers left and that the tail or aft end is to the viewer's right. As will be noted, the movable vanes **140** are grouped into a left-hand (or nose) portion and a right-hand (or tail) portion. These correspond to the groups labeled LN and LT (standing for "left nose" and "left tail") respectively. The right-hand side of the aircraft has a corresponding pair of controlled nozzle openings for the right nose and right tail labeled, appropriately, RN and RT, respectively. Referring first specifically to the (a) portion of FIG. **12**, the vanes **140** of both the LN and LT portions are in a neutral or non-deflecting position allowing the merging air symbolized by the arrows **150** to pass vertically downward so that the reactant force vector at the left nose indicated by the arrow **150** is only upward and the reactant force vector at the left tail symbolized by the arrow **100** and **154** is also totally upward such that the resultant lift force on the left lift and control assembly **30** is vertical as symbolized by the arrow **156**.

Referring now to the (b) portion of FIG. **12**, both the LN and LT vanes **140** have been moved to deflect the merging air **150** in a slightly rearward direction. Both the resulting force vectors **152** and **154** are a combination of lifting and forward directing forces. Correspondingly, the resultant effect on the left lift and control assembly **30** is symbolized by the crossed arrows **156** as being a horizontally disposed vertical and forward movement. As can be seen by reference to the (d) portion of FIG. **12**, a correspondingly horizontal, vertical and rearward motion can be effected by moving the LN and LT vanes **140** to effect equal deflection of the air **150** in a forward direction.

Referring now the the (c) portion of FIG. **12**, it can be seen how combined movement of the LN and LT vanes **140** to different attitudes can effect an attitude change in the aircraft. In this example, the LN vanes **140** are disposed vertically to allow the air **150** to produce a reactant force **152** in only the vertical direction. At the same time, however, the LT vanes **140** are disposed to deflect the air **150** rearward, thus imparting combined vectors **154** in both the vertical and forward direction. The resultant effect as symbolized by the curved arrow **156** is a combined forward and nose-up reaction on the left lift and control assembly **30**.

With reference to the various deflection possibilities shown in the views of FIG. **12** and those that can be envisioned following inspection of FIG. **12**, it can be easily envisioned how the positioning of the vanes **140** of both the left and right lift control assemblies **30** in the manner of the (c) portion of FIG. **12**, would cause the aircraft **10** to remain in a stable horizontal roll position while pitching vertically upward.

If the LN vanes **140** are moved to deflect the air **150** in one direction and the LT vanes **140** are moved to deflect the air **150** in the opposite direction, it should be apparent that a reduction in reactive lift force will be effected without any resultant forward or rearward reactive force (i.e., they are self-cancelling). If, therefore, the vanes **140** on the left lift and control assembly **30** are placed in such configuration and, simultaneously, the vanes **140** comprising the RN and RT groupings of the right lift and control assembly **30** are placed in the configuration of the (a) portion of FIG. **12**, the aircraft will be placed in a left roll condition.

Thus, it can be seen that by selectively deflecting the emerging air from the passageways **47** flowing through the the nozzles **83**, control of the aircraft can be effected. It should also be appreciated at this point, that the additional air forced through the nozzle **83** by the embodiment of FIG. **11** provides for an increased reactive airflow whereby control of the aircraft by the foregoing manner is enhanced. It should also be appreciated that a total lift on the aircraft can be effected by simultaneously moving all the deflecting vanes **140** in the same amount. Thus, by controlling the movement of the vanes in such a manner simultaneously as a function of the altitude sensing apparatus previously discussed, the aircraft can be made to maintain a given preselected altitude as a function of both the controlled airflow through the passageways **47** and the deflection of the airflow (and resultant reactive force) emerging from the nozzles **83**.

Referring now once again primarily to FIG. **8**, it will be seen that the lower manifolds **84** are also provided with four opposing vectoring crossed nozzles **145** that are used primarily only when the aircraft is in a hovering, vertical take-off, or landing mode for steering and maneuvering control; i.e., rotational and yaw control. The nozzles **145** are each provided with actuators **146** that are suitably connected to the pilot's control station. These controllers may be operated by a normal thumb-control arrangement on the control wheel to permit desired maneuvering of the aircraft by the application of horizontal directed rotational forces on the aircraft.

Turning now to FIGS. **13** and **14**, the present invention in a second embodiment as incorporated into a pilotless, radio-controlled, lifting platform is shown, generally indicated as **200**. The lifting platform **200** comprises a frame **202** mounted on a landing skid **204**. A power plant **206** is mounted to the frame **202**. A parabolic disc lifting element **208** is mounted to the frame **202** and the power plant **206**. The output shaft **210** of the power plant **206** is disposed along the centerline **212** of the lifting element **208**. Above the center of the parabolic disc lifting element **208** is disposed an inlet nozzle **214** and an annular manifold **260** disposed to be concentric with the centerline **212**. A centrifugal compressor impeller **216** is disposed within inlet nozzle **214** on the output shaft **210**. A parabolic disc porous boundary element **218** is connected concentrically about the inlet nozzle **214** and manifold **260** at the upper end and to the frame **202** and lifting element **208** by means of radially spaced sidewalls **220** so as to create a plurality of divergent wedge-shaped passageways **222** between the lifting element **208** and the boundary element **218**. The spacing of the sidewalls **220** is shown in FIG. **14**. Equal spacing of 45° to 60° is preferred.

Air is drawn into the inlet nozzle **214** by the centrifugal compressor impeller **216** and expelled radially outward equally about the circumference thereof across the lifting element **208** through the manifold **260** and the slit nozzle opening **262** which is also 0.050 inches in height or less. Thereafter, the operation of the lifting element **208** in combination with the boundary element **218** in inducing the aspiration of augmenting air through the porous boundary of element **218** into the divergent passageway **222** is substantially identical to the embodiment for passenger carrying as described in detail above.

The principle difference between the lifting platform **200** and the pilot driven aircraft of the previously described embodiment is in more simplified controls and the radio-controlled operation thereof. The space **224** between the inside of the lifting element **208** and the frame **202** can be used for a payload to be lifted by the platform **200**. For example, a tank **226** can be placed therein for the containing of chemical spray for cropdusting. Whereas the conventional bi-plane as presently used for cropsdusting may have a useful payload of 100 pounds or less, it is calculated that the platform **200** of the present invention can be made with a diameter of 10 feet so as to be able to be moved to a field to be or a conventional flatbed truck dusted and yet have a payload of 500 pounds or more.

As can be seen in FIG. **13**, space **224** also provides a convenient place to hide the radio receiver **228** to which the actuating controller **230** for the control surfaces is operably connected.

Several possible methods for effecting control of the lifting platform **200** are possible. Forward propulsion can be accomplished by positioning the engine exhaust pipe **232** from the power plant **206** to face horizontally and radially outward. The exhaust from the exhaust pipe **232** would, therefore, provide a reactive force in one direction which could be controlled by a gimbled nozzle **234** placed over the outlet of the exhaust pipe **232** and controlled by one or more actuators **236**. That would, of course, make one point on the disc-shaped lifting platform **200** be the "front" and the point of the gimbled nozzle **234** be the "rear".

In the particular applications for which the lifting platform **200** is particularly adapted (i.e., cropdusting), high-speed forward mobility is not particularly necessary of even desirable. Rather, it is more desirable to be able to take off and land vertically and to move forward, backward, and sideward at a low speed rate with little or no downwash. For example, in cropdusting, the ideal situation would be to run a "pattern" wherein the lifting platform **200** started at one corner of the field, moved along one edge, stopped at the far end, shifted sideways one spray width, and went back down the field in the opposite direction to the far end, moved sideward one spray width again, and repeated the same procedure over and over until the field was sprayed completely. As can be seen, this type of manuever does not require a "front" or "back". Accordingly, a control system which is easily operable by radio control and which is simple to construct and maintain is the most highly desirable.

Referring briefly to FIG. **14**, assume that the top view of the lifting platform **200** is designated at four points as north ("N"), east ("E"), south ("S"), and west ("W") being the top, right, bottom, and left sides as the figure is viewed, respectively. For simplified control particularly adaptable for radio control operation, the lifting platform **200** can be simply and conveniently controlled with some means for attitude control located at the four 90° separated locations (i.e., N, E, S, and W). If the vertical lift can be tilted from the vertical an angle θ, a vertical component in combination with a horizontal component will be produced. Thus, if either additional lift can be created at the "south" point and/or reduced lift produced at the "north" point, a horizontal force vector will be produced in the northerly direction and the lifting platform **200** will move in the northerly direction. Likewise, if the "west" edge of lifting platform **200** is raised and/or the "east" edge is lowered, the lifting platform will move in an easterly direction.

Increasing the lift over a radial portion of the lifting element **208** is difficult. By contrast, reducing the lift over a radial portion of the lifting element **208** is easily accomplished and, therefore, provides a unique and simple form of attitude control for the lifting platform **200**.

Turning now to FIGS. **15** and **16**, the preferred method of control for the lifting platform **200** is shown. A tapered vane **266** is placed at each desired control point about the periphery. The vane **266** is adapted to be moved into the air stream as a "spoiler" by the solenoid **268**, thus reducing the lift at that point as a function of the amount disposed in the air stream.

While not preferred, an alternate control method of fairly simplified form is shown on the left side of FIG. **13** as the Figure is viewed. Therein, a plurality of control flaps **254** are positioned about the periphery of the bottom of the lifting element **208** and higned thereto. Each control flap **254** is operably connected to the frame **202** by an actuator **252**. With the control flaps **254** all withdrawn from contact with the emerging airstream about the periphery of the lifting platform **200**, only equalized lift is produced and no horizontal force vector is present. By causing the actuator **252** to push a control flap **254** into the emerging airstream, the emerging airstream will impinge aganst the control flap producing a horizntal force vector component.

It should also be noted that any of the techniques for airflow augmentation and control described in detail with respect to the first embodiment could be employed with this latter embodiment but are not repeated once again. They are to be considered within the scope of either embodiment. This will be particularly realized when it is recognized that while the first embodiment described two opposed lifting elements, this latter, circular embodiment can be considered as having two opposed semi-circular lifting elements.

While the example shown and described above employs control elements at four 90° spaced points about the periphery of the lifting platform, it should be understood that such placement affords one of the simplest methods of control, but that either type of control element as hereinbefore described could be placed at three 120° spaced locations or six 60° spaced points about the periphery of lifting platform **200** with success.

Thus it can be seen that the aircraft hereinbefore described has met its stated objective by increasing lift through employment of the "Willis effect" and by the novel control method employed therein.

Having thus described my invention, I claim:

1. The method of creating a vertical lifting force on a lifting element which smoothly curves outwardly from horizontal to vertical comprising the steps of:

(a) flowing primary fluid in a thin sheet from a pneumatic plenum via a rectangular nozzle extending substantially the full length of the lifting element to cause said sheet to flow across the upper surface of the element from the horizontal side to the vertical side opposite thereof;

(b) divergently bounding said flowing primary fluid adjacent the entire length of the upper surface of the element from the horizontal to vertical by a porous surface which smoothly curves in generally like manner but slightly divergently; and

(c) continuously adding sufficient augmenting fluid to said flowing primary fluid through the porous surface to maintain the combined flowing fluid stream in laminar flow adjacent the upper surface of the element whereby a differential pressure is created across the element tending to lift it vertically.

2. The method of claim **1** and additionally comprising the step of:

creating a low pressure area adjacent said vertical opposite side of the element to increase the speed of the flowing fluid.

3. The method of claim **1** wherein said step of divergently bounding said flowing primary fluid additionally includes the step of:

segmenting and confining said flowing primary fluid in channels.

4. In an aircraft having an aerodynamically shaped body for housing one or more passengers, a pair of lifting elements which curve outward from the body smoothly from horizontal to vertical disposed longitudinally along the body on opposite sides thereof, and power means for supplying a source of air under pressure, the method of providing lift and control for the aircraft comprising the steps of:

(a) simultaneously directing primary air from the power means horizontally outward across the upper surfaces of the pair of lifting elements in a thin sheet from pneumatic plenums via rectangular nozzles extending substantially the full length of the lifting elements;

(b) divergently bounding the airflow adjacent the entire length of the upper surfaces of the lifting elements from horizontal to vertical by porous surfaces which smoothly curve in generally like manner but slightly divergently relative said upper surfaces of the lifting elements;

(c) continuously including the aspiration of sufficient augmenting air through said porous surface into said divergently bounded airflow to maintain the combined airflow in laminar flow adjacent the upper surfaces of the lifting elements; and,

(d) creating an imbalance in the overall lift on the aircraft which produces a resultant force vector on the aircraft having both a lift component and a horizontal force component in the desired direction of horizontal travel.

5. The method of claim **4** wherein said step of creating an imbalance comprises:

reducing the flow of primary air from the power means adjacent the peripheral portion of the lifting elements in the direction of desired travel with a spoiler whereby the lift is reduced and the aircraft is tipped downward in that direction.

6. The method of of claim 4 wherein said step of creating an imbalance comprises:

selectively deflecting portions of the vertical combined airflow away from the vertical direction to create imbalances in the vertical lift created on the aircraft whereby control is effected by deflecting on one lifting surface more than the other to create a roll force on the aircraft and by simultaneously deflecting on both lifting surfaces adjacent one end of the aircraft more than on the opposite end to create a pitch force on the aircraft.

7. An aircraft comprising:

(a) an aerodynamically shaped body for housing one or more passengers;

(b) a pair of lifting elements carried by said body disposed longitudinally along said body on opposite sides thereof and extending outwardly from said body, said lifting elements curving smoothly downward from being substantially horizontal adjacent said body to substantially vertical at the outboard edge thereof;

(c) power means carried by said body for producing a supply of pressurized air at an output thereof;

(d) means connected to said output of said power means for directing a flow of air in a thin sheet from a pneumatic plenum via a rectangular nozzle extending substantially the full length of the lifting elements to cause said sheet to flow across the upper surfaces of said pair of lifting elements; and,

(e) means carried by said lifting element for divergently bounding said airflow by a porous surface which smoothly curves in generally like manner but slightly divergently adjacent the entire length of said upper surfaces of said lifting elements, said bounding means being of sufficient porosity in relation to said airflow that sufficient augmenting air is induced to be aspirated through said porous bounding means and added to said airflow to maintain the resultant combined airflow in laminar flow adjacent said upper surfaces of said lifting elements.

8. The aircraft of claim 7 and additionally:

means for segmenting and confining the flow of air in channels.

9. The aircraft of claim 7 and additionally comprising:

means disposed between said upper surfaces of said lifting elements and said porous bounding means adjacent the outboard ends thereof for selectively deflecting portions of the vertical combined airflow emerging therefrom away from the vertical direction to create imbalances in the vertical lift created on the aircraft whereby control is effected by deflecting on one of said lifting elements more than on the other to create a roll force on the aircraft and by simultaneously deflecting on both said lifting elements adjacent one end of the aircraft more than on the opposite end thereof to create a pitch force on the aircraft.

10. The aircraft of claim 9 wherein:

said deflecting means comprises a plurality of controlled movable spoilers adapted to be adjustably disposed transverse the space between said upper surfaces of said lifting elements and said bounding means.

11. The aircraft of claim 9 wherein said deflecting means comprises:

(a) a pair of longitudinal nozzle assemblies connected to receive said airflow as it emerges from between respective ones of said lifting elements and said bounding means, each of said assemblies having a longitudinal nozzle opening facing in a substantially vertically downward direction; and,

(b) a plurality of controlled movable vanes disposed transverse each of said nozzle openings.

12. The aircraft of claim 11 wherein:

(a) each of said nozzle assembies includes a venturi constriction disposed longitudinally therein between the point of receiving said emerging airflow and said movable vanes; and additionally including,

(b) means connected to said output of said power means for directing an additional airflow through said venturi constrictions in combination with said emerging airflow whereby an increased volume of air is available passing through said vanes for effecting control of the aircraft and a low pressure area is created outboard of said lifting elements to induce increased airflow over said lifting elements to thereby increase the lifting forces on said lifting elements.

13. The aircraft of claim 9 wherein:

said bounding means comprises a porous material having a sound abating material disposed within the pores thereof.

14. The aircraft of claim 13 wherein:

the effective porosity of said material including said sound abating material is about 50%.

15. The aircraft of claim 9 wherein:

said bounding means comprises a pair of porous outer sheet members carried by a honeycomb material disposed therebetween.

16. The aircraft of claim 15 wherein:

said honeycomb material has an airflow passing sound abating material disposed in the voids thereof.

17. The aircraft of claim 15 wherein:

said honeycomb's core structure is angled away from normal in the direction of fluid flow from 15° to 45°.

18. The aircraft of claim 17 wherein:

said honeycomb's core structure is angled and sized such that the top of one honeycomb core sidewall overlaps the bottom of the next adjacent core sidewall whereby sound abatement is maximized.

19. An aircraft comprising:

(a) a frame having means for supporting said frame extending downward therefrom;

(b) circular lifting element carried by said frame and disposed above said frame to create a space between said lifting element and said frame, said lifting element curving smoothly downward from being substantially horizontal adjacent the center thereof to being substantially vertical at the outboard edge thereof;

(c) power means carried by said frame within said space for producing a supply of pressurized air at an output thereof;

(d) means connected to said output of said power means for directing a flow of air in a thin sheet from a pneumatic plenum via a rectangular nozzle extending substantially the full length of the lifting element to cause said sheet to flow outwardly across the upper surface of said lifting element; and,

(e) means carried by said lifting element for divergently bounding said airflow by a porous surface which smoothly curves in generally like manner but slightly divergently adjacent the entire length of said upper surface of said lifting element, said bounding means being of sufficient porosity in relation to said airflow that sufficient augmenting air is induced to be aspirated through said porous bounding means and added to said airflow to maintain the resultant combined airflow in laminar flow adjacent said upper surface of said lifting elements.

20. The aircraft of claim **19** and additionally:

means for segmenting and confining the flow of air into wedge-shaped channels of between 45° and 60°.

21. The aircraft of claim **19** and additionally comprising:

a plurality of spoiler means adapted to be adjustably disposed between said upper surface of said lifting element and said porous bounding means adjacent the outboard ends about the periphery at spaced points thereof for selectively deflecting portions of the vertical combined airflow emerging therefrom away from the vertical direction to create imbalances in the vertical lift created on the aircraft whereby control is effected.

22. The aircraft of claim **19** wherein:

said bounding means comprises a porous material having a sound abating material disposed within the pores thereof.

23. The aircraft of claim **22** wherein:

the effective porosity of said material including said sound abating material is about 50%.

24. The aircraft of claim **19** wherein:

said bounding means comprises a pair of porous outer sheet members carried by a honeycomb material disposed therebetween.

25. The aircraft of claim **24** wherein:

said honeycomb material has an airflow passing sound abating material disposed in the voids thereof.

26. The aircraft of claim **24** wherein:

said honeycomb's core structure is angled away from normal in the direction of fluid flow from 15° to 45°.

27. The aircraft of claim **26** wherein:

said honeycomb is angled and sized such that the top of one honeycomb core sidewall overlaps the bottom of the next core adjacent sidewall whereby sound abatement is maximized.

28. The method of creating a vertical lifting force on a disc-shaped lifting element comprising the steps of:

(a) flowing primary fluid in a thin sheet from a pneumatic plenum via a rectangular nozzle extending substantially the full length of the lifting element to cause said sheet to flow across the upper surface of the element from the center to the outer periphery thereof;

(b) divergently bounding said flowing primary fluid by a porous surface which smoothly curves in generally like manner but slightly divergently adjacent the entire length from the center to the periphery of the upper surface of the element with a porous surface of at least 40% porosity; and,

(c) continuously adding sufficient augmenting fluid to said flowing primary fluid through the porous surface to maintain the combined flowing fluid stream in laminar flow adjacent the upper surface of the element whereby a differential pressure is created across the element tending to lift it vertically.

29. The method of claim **28** and additionally comprising the step of:

creating a low pressure area adjacent the outer periphery of the element to increase the speed of the flowing fluid.

30. The method of claim **28** wherein said step of divergently bounding said flowing primary fluid additionally includes the step of:

segmenting and confining said flowing primary fluid in wedge-shaped channels.

31. The method of claim **30** wherein:

said channels are between 45° and 60° each.

32. In an aircraft having an aerodynamically shaped circular lifting element and power means for supplying a source of air under pressure, the method of providing lift and control for the aircraft comprising the steps of:

(a) directing primary air from the power means from the center horizontally outward across the upper surfaces of the lifting element in a thin sheet from a pneumatic via a rectangular nozzle extending substantially the full length of the lifting element to cause said sheet to flow across the upper surface of said lifting element;

(b) divergently bounding the airflow by a porous surface which smoothly curves in generally like manner but slightly divergently adjacent the entire length from the center to the periphery of the upper surface of the lifting element;

(c) continuously inducing the aspiration of sufficient augmenting air through said porous surface into said divergently bounded airflow to maintain the combined airflow in laminar flow adjacent the upper surface of the lifting element; and,

(d) creating an imbalance in the overall lift on the aircraft which produces a resultant force vector on the aircraft having both a lift component and a horizontal force component in the desired direction of horizontal travel.

33. The method of claim **32** wherein said step of creating an imbalance comprises:

introducing a spoiler in the air flow at a point on the periphery opposite the direction of desired travel whereby the lift is reduced and the aircraft is tipped downward in said direction.

34. In an aircraft having an aerodynamically shaped body for housing one or more passengers, a pair of lifting elements which curve outward from the body smoothly from horizontal to vertical disposed longitudinally along the body on opposite sides thereof, and power means for supplying a source of air under pressure, the method of providing lift and control for the aircraft comprising the steps of:

(a) simultaneously directing primary air from the power means horizontally outward across the upper surfaces of the pair of lifting elements in a thin sheet starting at 0.050 inch thickness or less;

(b) divergently bounding the airflow adjacent the entire length of the upper surfaces of the lifting elements from horizontal to vertical with a porous surface of at least 40% porosity;

(c) continuously inducing the aspiration of sufficient augmenting air through said porous surface into said divergently bounded airflow to maintain the combined airflow in laminar flow adjacent the upper surfaces of the lifting elements; and,

(d) creating an imbalance in the overall lift on the aircraft which produces a resultant force vector on the aircraft having both a lift component and a horizontal force component in the desired direction of horizontal travel by selectively deflecting portions of the vertical combined airflow away from the vertical direction to create imbalances in the vertical lift created on the aircraft whereby control is affected by deflecting on one lifting surface more than the other to create a roll force on the aircraft and by simultaneously deflecting on both lifting surfaces adjacent one end of the aircraft more than on the opposite end to create a pitch force on the aircraft, said selectively deflecting comprises the steps of:

(d1) passing the emerging airflow from the upper surfaces of the lifting elements through a pair of longitudinal venturis disposed outboard of the respective lifting elements into respective longitudinal vertically downward facing nozzles having controlled movable vanes transverse thereof at least adjacent a portion of the front and rear of each of said nozzles;

(d2) injecting an additional quantity of pressurized air from the power means through the venturis into the respective nozzles to create an additional volume of pressurized air emerging from said nozzles and create a low pressure area adjacent the outboard end of the confined airflow paths to stimulate increased airflow therethrough with attendant increase in lift on the lifting surfaces thereby; and,

(d3) moving said transverse vanes selectively in groups between positions parallel to the flow of the emerging air from said nozzles and at least partially transverse said emerging air whereby said air is selectively deflected.

35. The method of claims **1**, **4**, **28** or **32** wherein said step of flowing primary fluid in a thin sheet includes the substep of starting said thin sheet at 0.050 inches thickness or less.

36. The method of claims **1**, **4**, **28** or **32** wherein said step of divergently bounding includes the substep of bounding said primary fluid with a porous surface of at least 40% porosity.

37. The aircraft of claim **7** or **19** wherein said thin sheet has a starting thickness of 0.050 inches or less.

38. The aircraft of claim **7** or **19** wherein the porosity of said bounding means is at least 40%.

* * * * *

United States Patent [19]

Kim

[11] **Patent Number: 4,651,953**

[45] **Date of Patent: Mar. 24, 1987**

[54] **INDUCTION LIFT AIRCRAFT**

[76] Inventor: **Kyusik Kim,** 5026 Rhoads Ave., Santa Barbara, Calif. 93111

[21] Appl. No.: **849,116**

[22] Filed: **Apr. 7, 1986**

Related U.S. Application Data

[63] Continuation of Ser. No. 701,856, Feb. 14, 1985, which is a continuation of Ser. No. 240,619, Mar. 5, 1981, Pat. No. 4,500,052.

[51] **Int. Cl.**[4] **B64C 21/00**

[52] **U.S. Cl.** **244/12.1;** 244/15; 244/36

[58] **Field of Search** .... 244/12.1, 15, 12.5, 244/12.6, 36, 207, 62, 53 R, 73 R, 74

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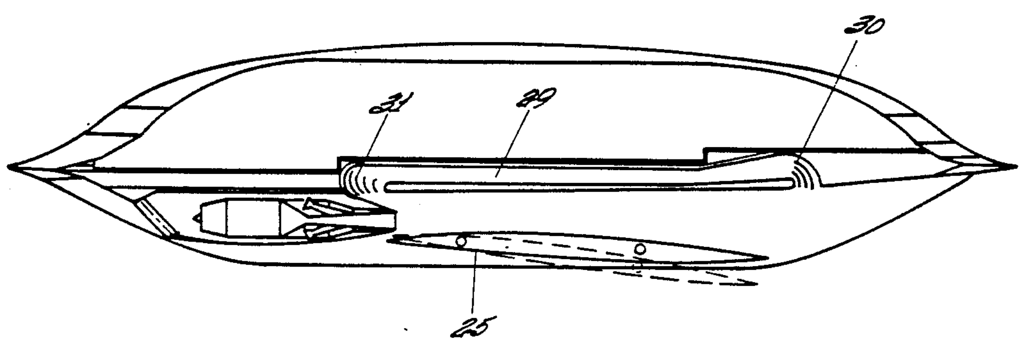
Primary Examiner—Galen Barefoot
Attorney, Agent, or Firm—Daniel J. Meaney, Jr.

[57] **ABSTRACT**

A vacuum cell induction lift wing adapted to be used in an aerodynamic generating channel wherein the lift wing includes an airfoil having a leading edge and a trailing edge and a top panel and an acoustically treated hollow interior, and wherein the airfoil includes airtight partitions forming individual cells within the hollow interior and the airfoil has inclined slots extending from the top panel into each of the individual cells wherein the inclined slots extend at an angle from each of the individual cells toward the trailing edge of the airfoil and wherein the airfoil is adapted to be positioned within an aerodynamic generating with the top panel of the airfoil being adapted to form a lower boundary of the aerodynamic generating channel and to define a slip thereacross from an airstream support operatively coupled to the airfoil adjacent the trailing edge to enable the airfoil to be rotated therearound to change the angle of incidence of the top panel to an airstream passing thereacross and a pivot support operatively couples to the airfoil adjacent the leading edge for moving the airfoil leading edge relative to an airstream by rotating the airfoil around the support member to change the angle on incidence of a top panel relative to an airstream enabling the airflow thereof to generate a vacuum within the individual cells is shown.

A jet thrust peripheral flow recycling system and induction lift aerodynamic generating channel using the vacuum cell induction lift wing is also shown.

3 Claims, 22 Drawing Figures



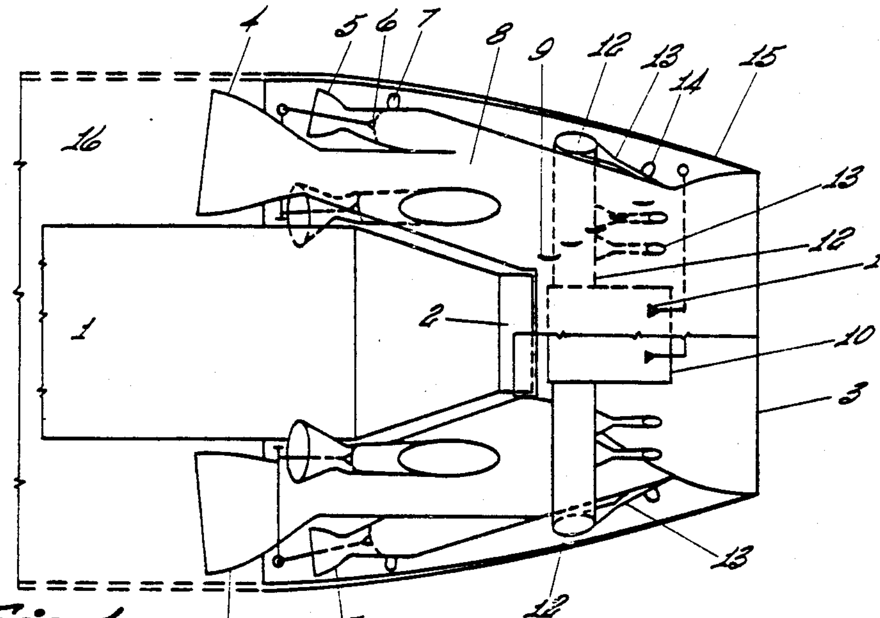


Fig 1

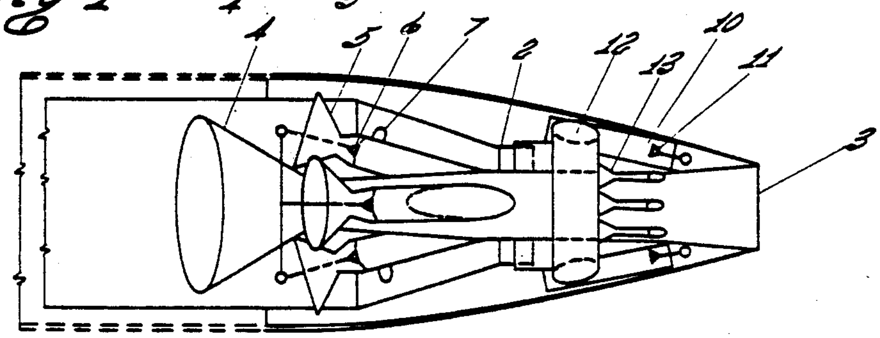
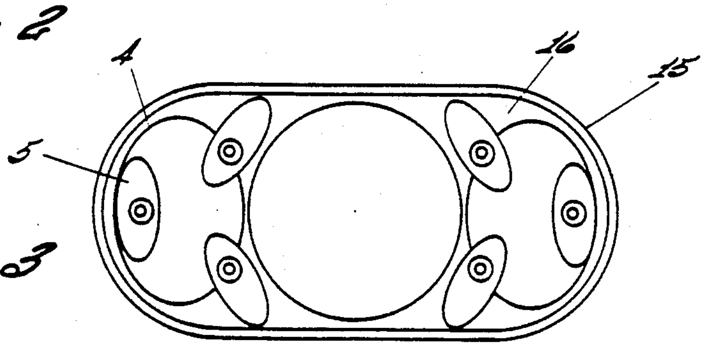


Fig 2



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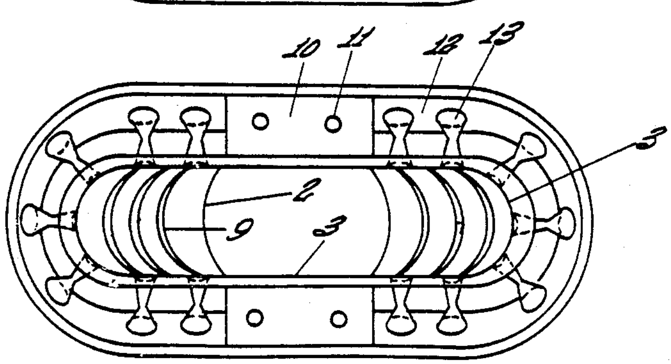

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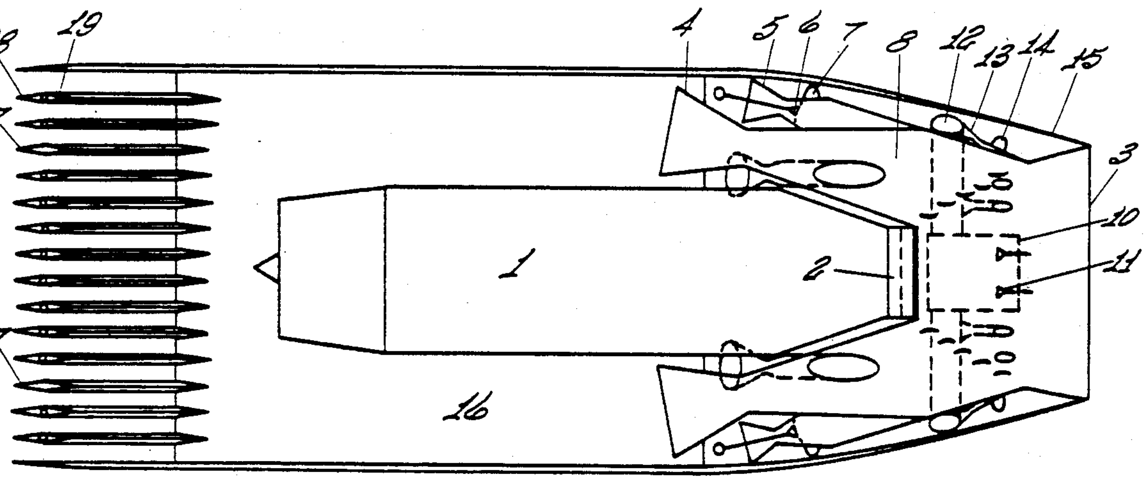

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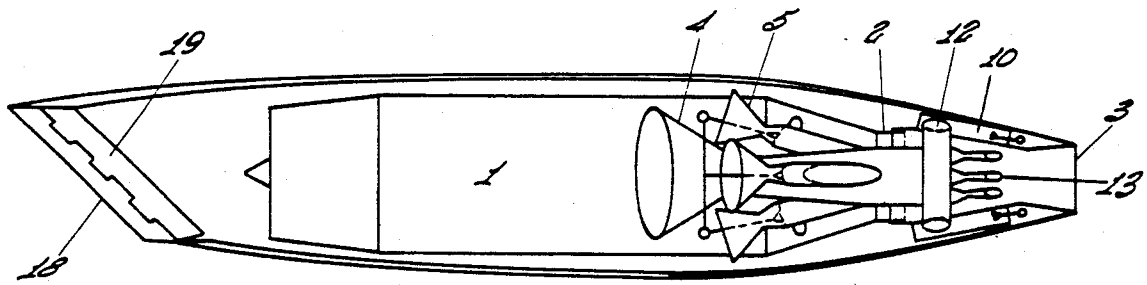

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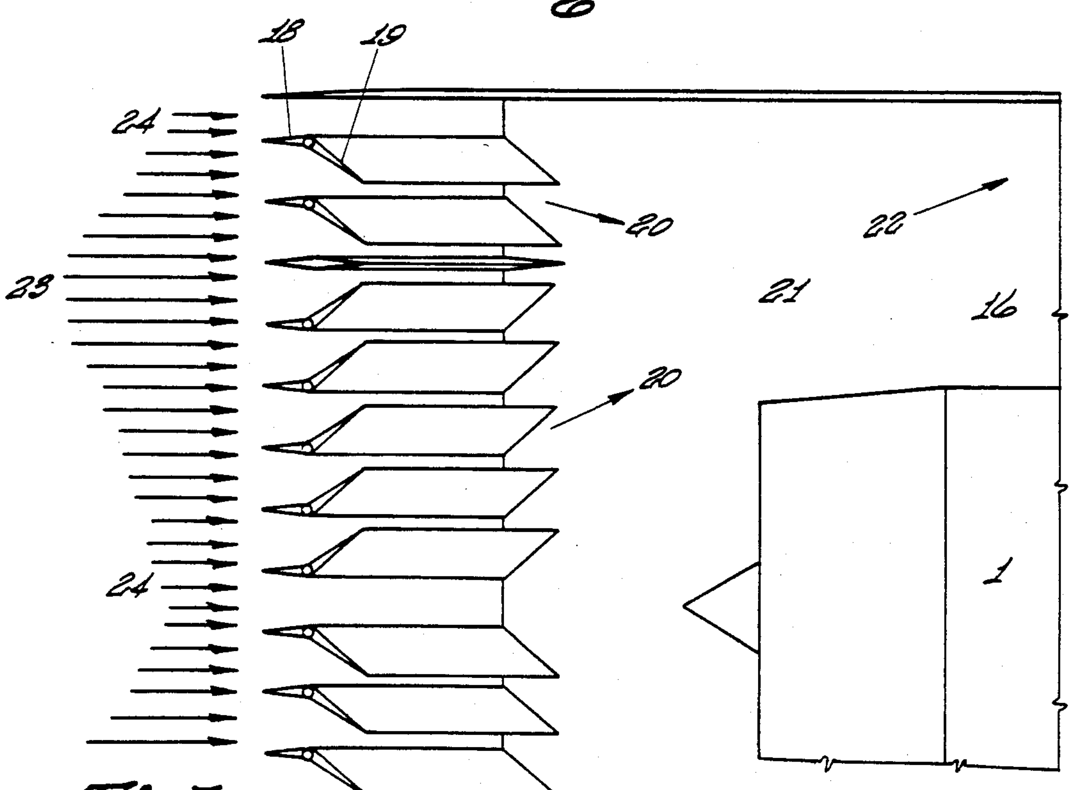

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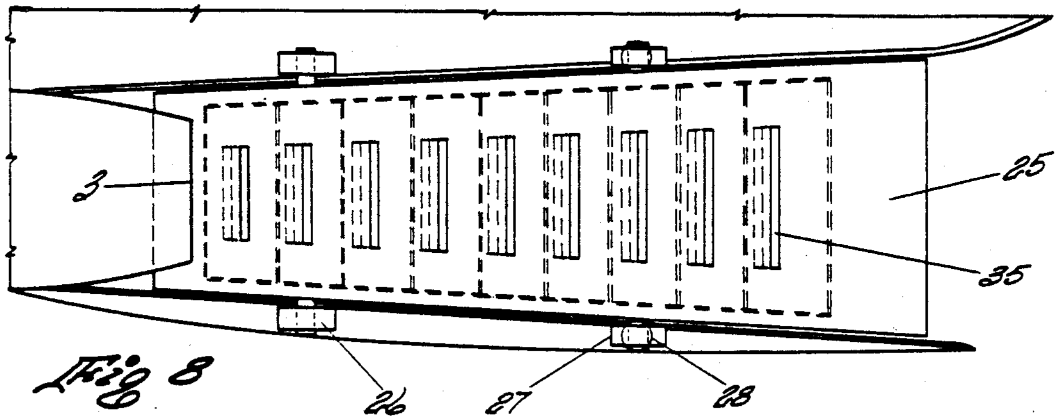

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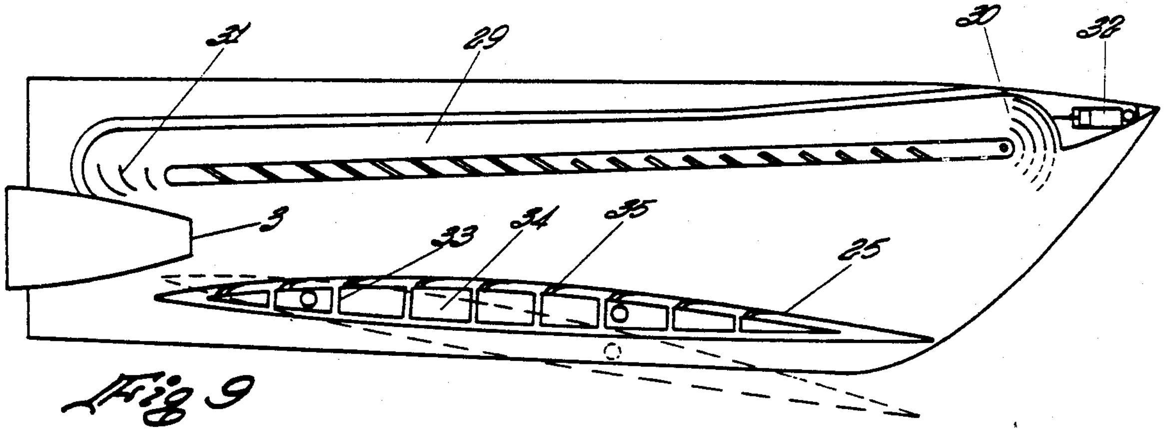

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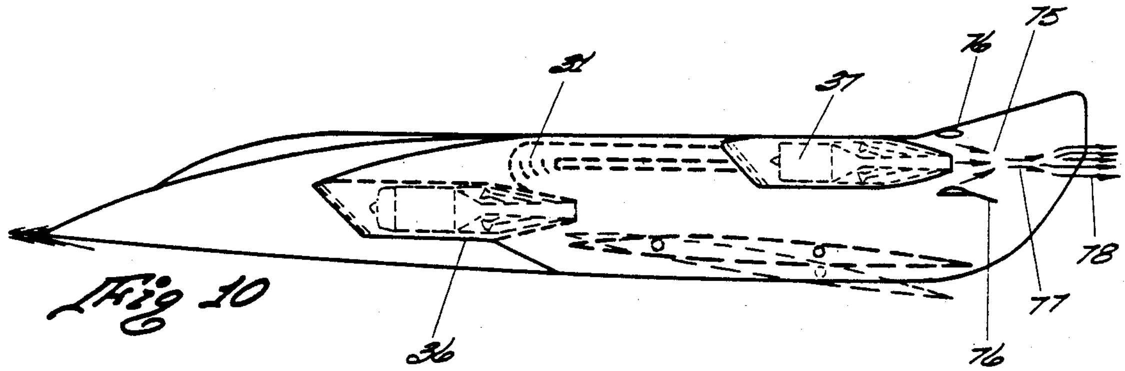
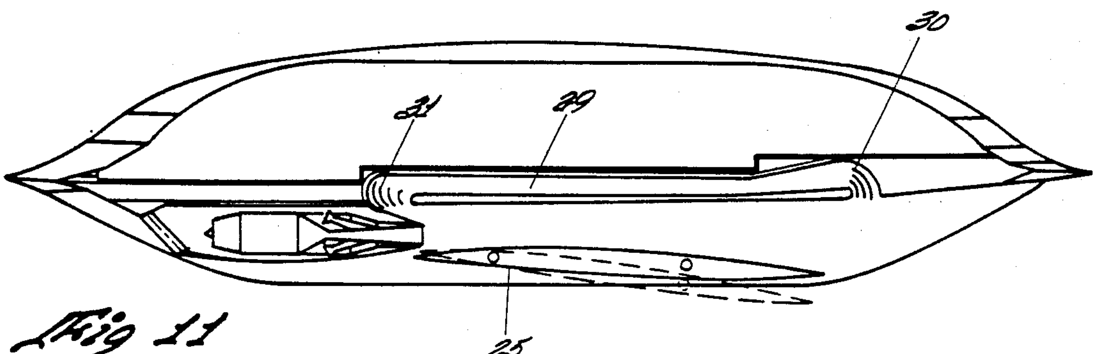


Fig 10



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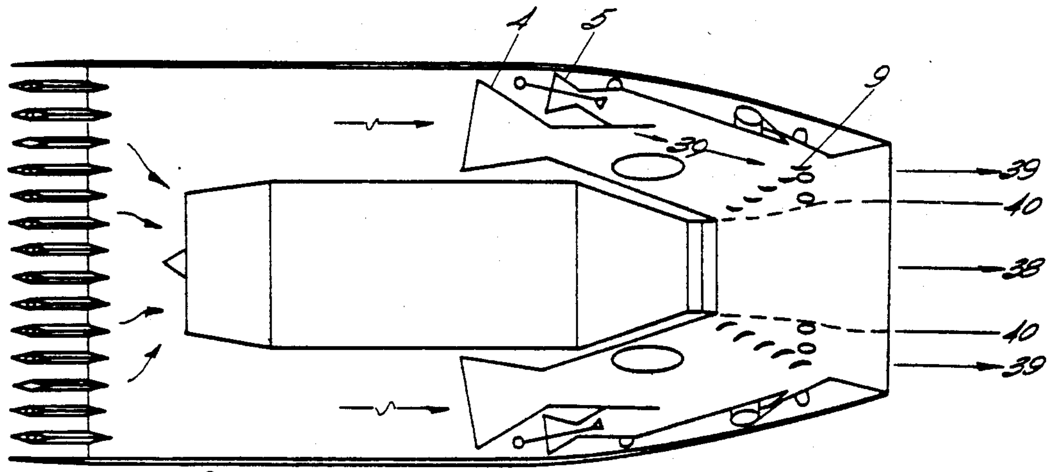

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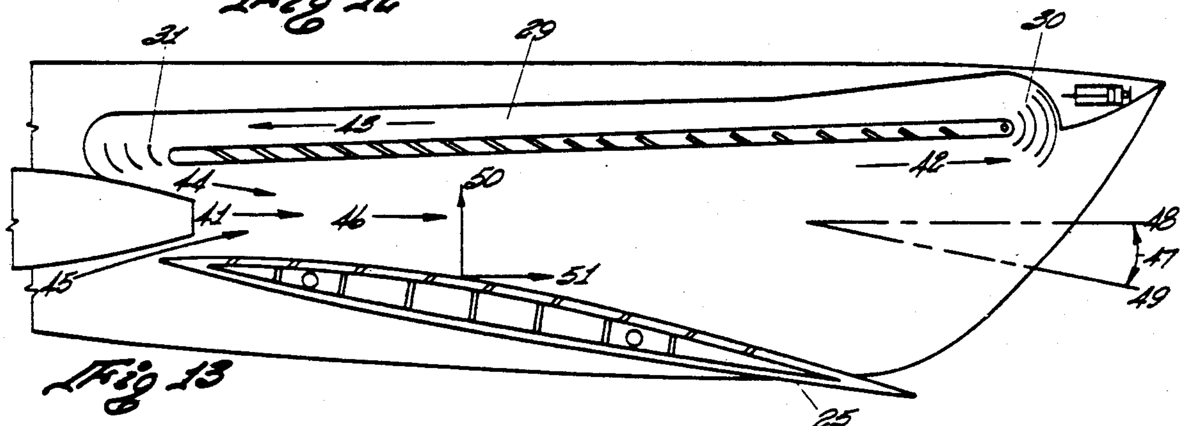

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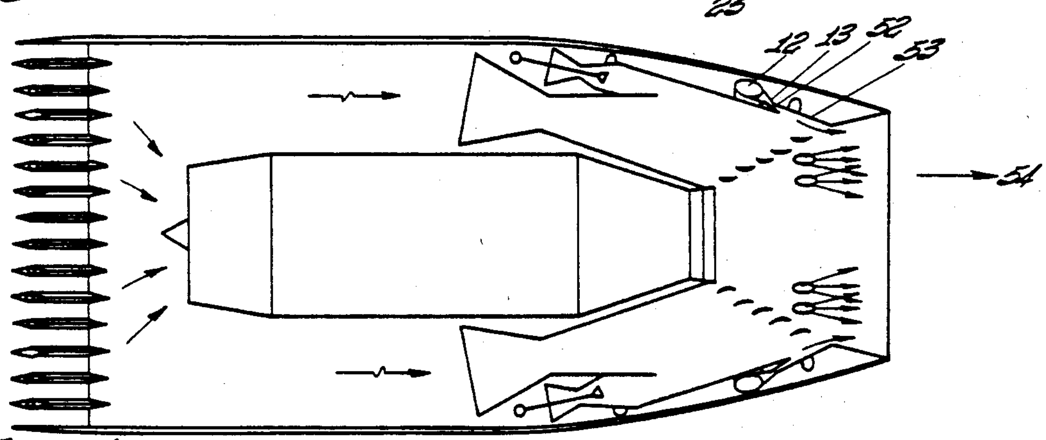
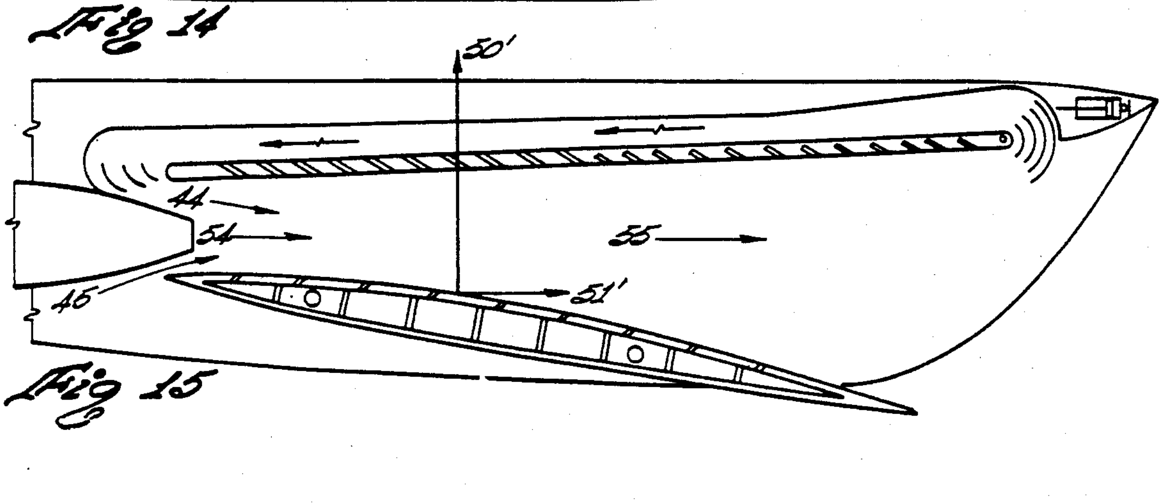


Fig 14



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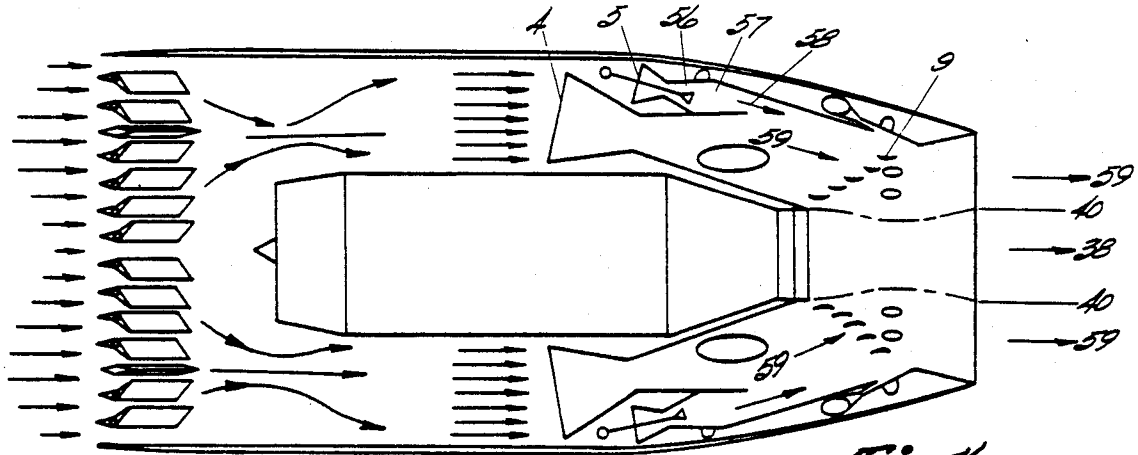

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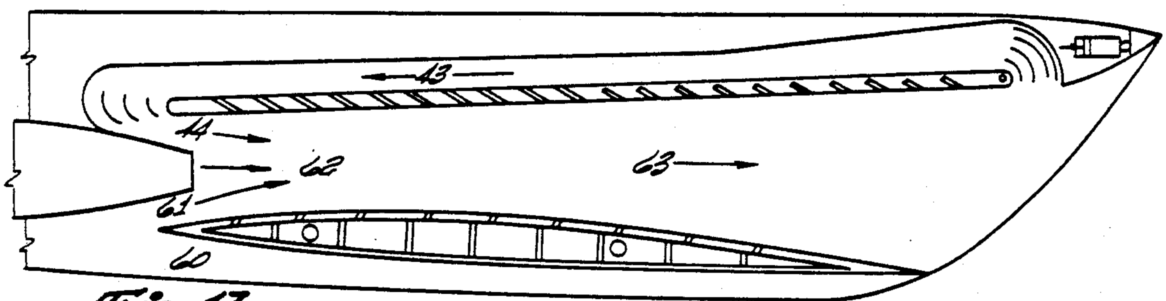

Fig 17

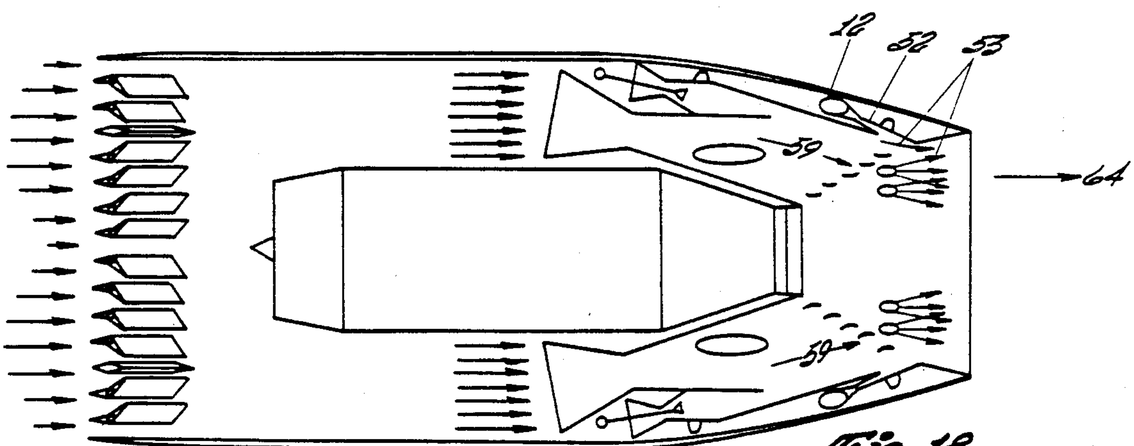

Fig 18

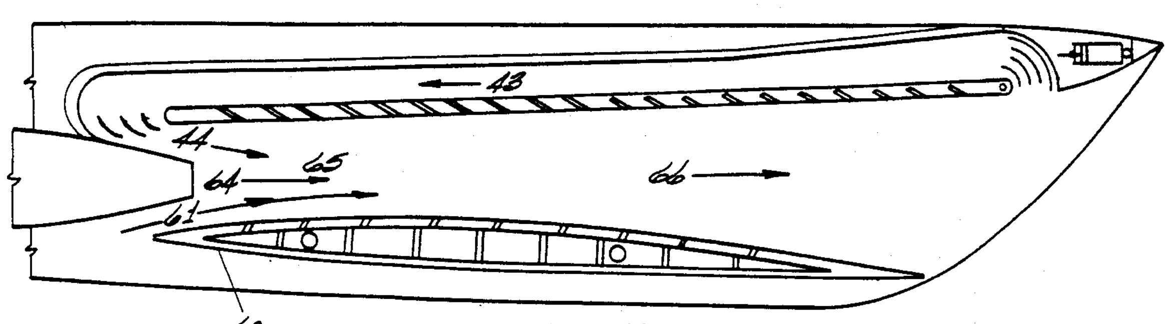

Fig 19

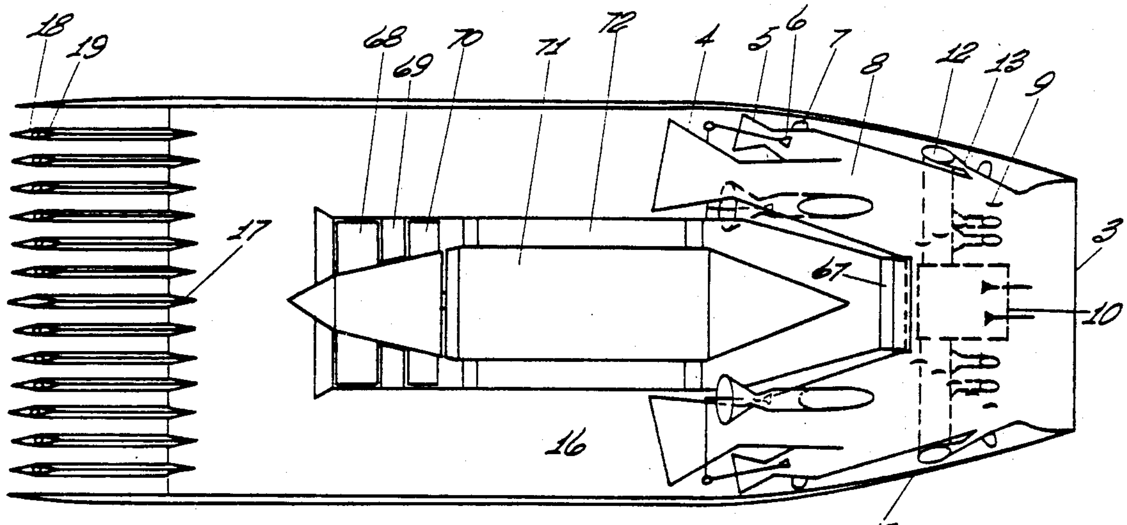

Fig 20

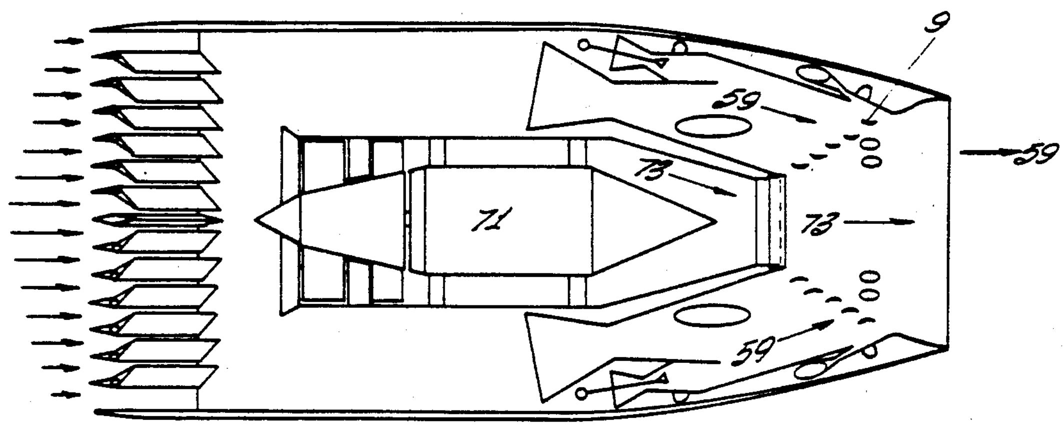

Fig 21

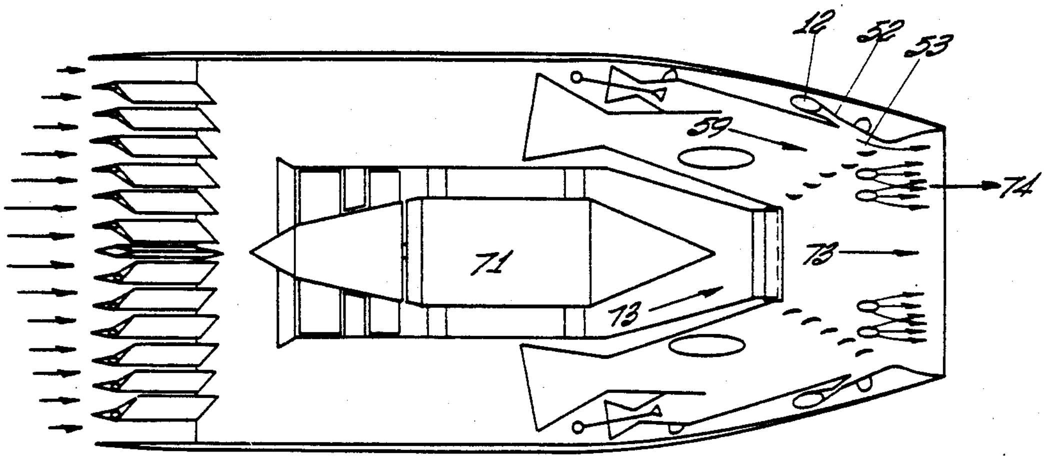

Fig 22

INDUCTION LIFT AIRCRAFT

This is a continuation of application Ser. No. 06/701,856 filed Feb. 14, 1985, which was a continuation of application Ser. No. 06/240,619 filed Mar. 5, 1981 now U.S. Pat. No. 4,500,052.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the propulsion system of an aircraft. It utilizes a liquid fuel prevaporization and back burning induction jet oval thrust nozzle which is fitted onto the exit nozzle of a conventional turbojet engine having a ram constriction air inlet plenum-engine pod located forward of the aerodynamic generating channel. The aerodynamic generating channel is located forward and above a vacuum cell induction lift wing and below recycling air inductor vanes.

2. Description of the Prior Art

Tail pipes having round exit nozzles adapted to be affixed the exit nozzle of conventional turbojet engines are known in the art.

SUMMARY OF THE PRESENT INVENTION

This invention relates to a round engine exit nozzle transition to a vertically converging and horizontally diverging oval thrust nozzle wherein the thrust nozzle has main airflow inducing nozzles, fuel injecting airflow inducing nozzles, combustion chambers, inductor vanes, liquid fuel prevaporization chambers, vaporized gas distributing manifolds with discharge nozzles, fuel injectors, ignitors and empty spaces adjacent the engine pod which forms a plenum. Air intake bellmouths of airflow inducing nozzles are installed inside the ram constriction air inlet plenums which are empty spaces in the engine pod on both sides of engine throat downstream of airflow inducing nozzles. The outlet of the airflow inducing nozzles are diverging and enter into the combustion chambers. The downstream ends of the combustion chambers are parallel vertical equally spaced and downstreamwardly curved inductor vanes. Hollow spaces between the plenum wall and the flat span of transition walls comprise vaporization chambers fitted with fuel injecting sprays and vaporized gas distributing manifolds with discharge nozzles. The discharge nozzles are downstreamwardly inclined and connected on the minor axes span areas of the oval thrust nozzle. The openings of the inclined discharge nozzles are adequate for the slipflow of the thrust stream and the discharge nozzles are positioned slightly upstream from throat of the oval thrust nozzle for accommodation of ignition time span and to process the temperature reactants of back firing combustion downstream of the oval thrust nozzle. The dynamic pressure of the turbojet engine exhaust stream slipflows over the inductor vanes and induces induction air flow from the plenums through the airflow inducing nozzles. This results in increased airstream volume at the oval thrust nozzle. The turbo-induction jet air breathing is operative when the aircraft is on the ground with engine idling, during low speed operation of the aircraft or deceleration of the aircraft during flight.

When the the induction jet air breathing stream is injected with prevaporized liquid fuel to produce a combustable mixture which when ignited produces a flame thrist stream downstream of the oval thrust nozzle. The expansion of the flame stream through the diverging contour of aerodynamic generating channel causes the flame thrust stream dynamic pressure to induce streams of air from surrounding air through the slot gap between the flat span of oval thrust nozzle and the leading edge of wing. This results in a recycled airstream at the forward upper portion of the aerodynamic generating channel which passes-through the reverse flow duct which is caused by the peripheral flow of rarefied thrust. These airstreams are merged with flame thrust which then produce the expanding combustion thrust stream in the diverging contour of the aerodynamic generating channel over the vacuum cell induction lift wing. The dynamic pressure of the expanding combustion thrust stream slipflows over the downstreamwardly inclined slot openings of vacuum cell wing. This stream action on the wing induces vacuum in internal cells of the wing which creates aerodynamic lift and drag forces on the wing. These forces correspond with the incidence angle of the wing which is the angle between the center-line of thrust stream and the wing chord line. The forces generated on the wing results in the drag force which counteracts the forward thrust of engine and stabilizies the horizontal moment of the airframe. The lift forces balance the weight of the aircraft during hovering of the aircraft. Hovering capacity for the aircraft is accomplished by the turbo-inducting jet air breathing rocket thrust aerodynamic generating channel.

Forward speed of the aircraft generates additional lift forces on the airfoil shaped airframe. These additional lift forces correspond to the reduction of the incident angle of the wing which reducts the drag forces on the vacuum cell wing. Forward acceleration is accomplished by the aircraft, from the aircraft hovering to the aircraft operating at hypersonic flight, by use of the liquid fuel prevaporization and backburning induction jet oval thrust nozzle.

The ram constriction air inlet plenums produce ram-static pressures when the aircraft is in high speed flight.

The ram airstream from the plenum pass through the airflow inducing nozzles and flow into the oval thrust nozzle. When fuel injectors are turned on downstream of the throat of the fuel injecting airflow inducing nozzles, a combustable mixture is produced. The combustion mixture is ignited and produces a flame stream which flows downstream of the main airflow inducing nozzles and enter the combustion chamber. The expanded combustion streams product ramjets through the diverging contours of the combustion chambers. The expanding ramjet airstream are combined with the turbojet stream at oval thrust nozzle. The oval thrust nozzle handles the turbojet stream and the ramjet streams creating a turbo-ram induction jet air breathing engine. The turbo-ram induction jet air breathing engine operates on the principle of free stream air intake, which are tangential oblique stream flows, interacting with a throat constriction to achieve a critical pressure. The free stream throat, located inside the low velocity air plenums, results in first a constraining of the ram airflow and then the expanding of the ram-airstream which controls the ram pressure on air intake bellmouths of the ram-airflow inducing nozzles which are ramjet components of the induction jet oval thrust nozzle. The turbo-ram induction jet air breathing oval thrust stream is operated when the aircraft is in supersonic flight.

When the turbo-ram induction jet air breathing oval thrust stream receives an injection of prevaporized liquid fuel prevaporization a combustable mixture is produced. The combustable mixture is ignited and produces a flame thrust stream downstream of the oval thrust nozzle in the forward section of aerodynamic generating channel. The dynamic pressure of back burning oval thrust stream induces a recycled peripheral thrust airstream which diverts the stream into the forward and upper portion of channel through the reverse flow duct and recycling inductor vanes. The leading edge of wing on an aircraft operating at high speed induces an oblique shock airstream which interacts with the flame stream of a turbo-ram induction jet air breathing rocket thrust. The streams are tangentially constricted to develop a critical pressure and form a high velocity free stream throat in the forward section of channel. These streams are merged with the expanding ignited combustion mixture downstream of the free stream throat and the expansion of thrust stream in the diverging contours of channel results in a hypersonic velocity which is accomplished by the turbo-ram induction jet air breathing rocket thrust aerodynamic generating channel.

The liquid fuel prevaporization and back burning induction jet oval thrust nozzle which is fitted on the round exit pipe of conventional ram-axialflow turbine having a ram constriction air inlet plenum which is installed in the ram-stream zone of airframe. The ram-axialflow turbine is operated during high speed flight and the fuel injectors in the ram-airflow inducing nozzles are activated to ignite the combustible mixture to produce, downstream of the airflow inducing nozzles, the ramjet streams in the combustion chambers. The expanding ramjet streams slipflow over the exit pipe of axialflow turbine and induce a negative pressure region downstream of the turbine which, result in an increased pressure differential on the turbine inlet and outlet. This enchances the power of the ram-axialflow turbine and operates an electric generator. The ramjet-induction axialflow turbine operation is obtsined by the liquid fuel prevaporization and back burning induction jet oval thrust nozzle fitted onto the conventional axialflow turbine. When the ramjet induction axialflow turbine thrust stream is mixed with the prevaporized liquid fuel at the throat of ramjet induction oval thrust nozzle and the combustible mixture is ignited, hypersonic flame thrust is produced which provides the capacity of hypersonic flight and the ability to generate a high capacity electrical power source for future developments.

The liquid fuel prevaporization and back burning induction jet oval thrust nozzle is technically feasibile for use with conventional air breathing engine to convert the same to a multi-stage power plant using an induction jet air breathing engine. The multi-stage power plant can be used in an induction lift aircraft. The multi-stage power plant using the air breathing jet engine is based on the principal of management of fuel injection, as described above, and on the principals of induction and free stream constriction where the induction is based on the freedom balancing beyond-dynamic pressure of thermal thrust stream interacting on the diverging contours of the transition tail pipe and aerodynamic generating channel. A free stream formed of tangentially flowing oblique stream intersects with and is shaped by a throat constriction to develop a critical pressure in a constricted free stream flow and the constricted free air stream flow is then expanded on the air intake zone of the low velocity air plenums and in the aerodynamic generating channel. The power plant stages are summarized below:

Stage 1: Turbo-induction jet air breathing engine;

Stage 2: Turbo-induction jet air breathing rocket engine;

Stage 3: Turbo-ram induction jet air breathing engine; and

Stage 4; Turbo-ram induction jet air breathing rocket engine.

DESCRIPTION OF THE DRAWINGS

This invention is described in accompanying drawings which are:

FIG. **1** is a plan view of a liquid fuel prevaporization induction jet oval thrust nozzle which is adapted to be attached to a conventional turbojet engine;

FIG. **2** is a side view of FIG. **1** showing the riund engine exit nozzle;

FIG. **3** is a cross section of FIGS. **1** and **2** showing the throat of the airflow inducing nozzles;

FIG. **4** is a cross section at the throat of the oval thrust nozzle;

FIG. **5** is a plan view of the induction jet air breathing power plant having a conventional turbojet engine and the liquid fuel prevaporization and back burning induction jet oval thrust nozzle which includes a plenum containing an inclined air intake opening fitted with rigidly fixed straight vanes and deflectable tailing sectin of vanes;

FIG. **6** is a side view of FIG. **5** showing inclined air intake of the plenum showing the fixed and deflectable vanes;

FIG. **7** is a partial paln view of the ram constriction air inlet plenum;

FIG. **8** is a plan view of the aerodynamic generating channel;

FIG. **9** is a longitudinal section of the aerodynamic generating channel having an a vacuum cell induction lift wing with an acoustically treated hollow interior wherein the airfoil has airtight partitions containing downstream inclined slot openings;

FIG. **10** is a side elevation of the induction lift aircraft;

FIG. **11** is a longitudinal sectional view of an induction lift flying saucer;

FIG. **12** is a schematic view of a turbo induction jet aircraft when the aircraft is operated in a neutral position, low speed flight or deceleration of flight;

FIG. **13** is a schematic showing the air distribution of turbo-induction jet air breathing thrust stream in the aerodynamic generating channel when the aircraft is operated in a neutral position, low speed flight or deceleration of flight;

FIG. **14** is a schematic diagram of a turbo induction jet air breathing engine when the aircraft is operated in VTOL;

FIG. **15** is a schematic diagram showing the distribution of turbo-induction jet rocket air breathing thrust stream in the aerodynamic generating channel when the aircraft is operated in maximum hovering capacity with extreme incidence of angle of wing;

FIG. **16** is a schematic diagram of of turbo-induction jet air breathing thrust stream when the aircraft is operated in supersonic flight;

FIG. **17** is a schematic diagram showing the distribution of turbo-ram induction jet air breathing thrust stream in the aerodynamic generating channel when the aircraft is operated in supersonic flight;

FIG. 18 is a schematic diagram of of turbo-ram induction jet rocket air breathing thrust stream when the aircraft is operated in hypersonic flight;

FIG. 19 is a schematic diagram showing the distribution of turbo-ram induction jet air breathing rocket thrust stream in the aerodynamic generating channel when the aircraft is operated in hypersonic flight;

FIG. 20 is a plan view of the liquid fuel prevaporization and back burning induction jet oval thrust nozzle attached to the round exit pipe of an air breathing jet engine;

FIG. 21 is a schematic diagram showing the air distribution of the ramjet induction axialflow turbine when the aircraft is is supersonic flight;

FIG. 22 is a schematic diagram showing the air breathing of the ramjet induction axialflow turbine ehaust stream which receives the prevaporized liquid fuel to produce the flame thrust stream during hypersonic flight.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As illustrated in FIGS. **1** through **4**, the outside of the power plant has a shape which defines a low velocity air plenum-engine pod. Multiple vanes are fitted on the inclined air intake opening at the forward section of the plenum. The induction jet oval thrust transition tail pipe is fitted on the rear end of the plenum. The conventional turbojet engine is installed inside of and on the center-line of the plenum.

The air inlet of the ram constriction system is illustrated in FIGS. **5**, **6** and **7**. Multiple inflective vertical vanes assemblies are fitted on the inclined opening at the forward portion of the low-velocity air plenum-engine pod. The vanes are fabricated with rigidly fixed straight vanes **17** and are positioned in the center-zones of the low velocity air plenums **16** located in the empty spaces on both sides of engine **1**.

Deflectable trailing section of vanes **19** are hinged with rigidly fixed forward section of vanes **18** and are equally spaced from the rigidly fixed straight vanes **17**. The deflectable trailing section of vanes **19** are linked with conventional hydraulic actuators for adjusting the position of vanes such as in the closed or open position. Deflectable vanes **19** are positioned straightly and parallel with the rigidly fixed straight vanes **17** when the air intake is wide open as illustrated in FIGS. **12** and **14**. The postion of the vanes illustrated in FIGS. **12** and **14** applies when the aircraft is in stationary or low speed and deceleration of flight.

FIGS. **16** and **18** illustrate the positon of the vanes when actuated by the hydrauic actuators to deflect the trailing sections thereof toward the straight vanes **17**. This position applies when the aircraft is in high speed flight. The sahping action of the ram-stream inside the low velocity air plenums are illustrated in FIG. **7**. This occurs when the deflected trailing sections of vanes **19** are bent toward the rigidly fixed straight vanes **17** positioned on the center-line of the low velocity air plenums, which occurs during supersonic flight.

The ram-stream impacts on the rigidly fixed forward section of the vanes **18**. The ram-stream is restricted and deflected by the trailing section of vanes **19**. The stream flow directions are inflected by the vanes **19** to produce the oblique streams **20**. These streams are tangentally constrained towards the center-line zone of the low velocity air plenums **16**. The shaping action of the ram-constriction causes the ram-stream to reach the critical pressure to form the free stream throat **21** and controls the stream pressure which is achieved by the ram-stream and controls the ram-air volume and ram-pressure inside the low velocity plenums **16**. This results in a reduction of the dynamic drag force on the engine suction diffuser during high speed flight. The ram drag is reduced on the front of the air intake opening. This is caused by the variable ram back pressure gradient downstream of the vanes where the center zones of ram constriction portion has more pressure drag force **23** on the front of the vanes and less pressure drag force **24** on the front of the engine suction and on both sides the air separation zones downstream of the vanes. The ram drag force on the front of the vanes, which is ram pressure, exceeds the critical pressure downstream of the vanes. This results in the pressure drag dynamic slip-down on the inclined face of the air intake which is a reduction of the ram drag force on the front of the air intake opening. Ram stream constrictions enhance the ram static pressure inside the low velocity air plenums which enhance the efficiency of ramjets on the ram-axialflow inducing nozzles **4** and **5** of turbo-induction jet air breathing engine.

The ram-stream constriction air intake system for ramjets induction axialflow is illustrated in FIGS. **20**, **21** and **22**. Rigidly fixed straignt vane **17** is positioned on the center-line of the axial flow turbine. Deflectable trailing section of vanes **18** and **19** are equally spaced and located on both sides of the rigidly fixed straight vans and deflect the trailing section of vanes **19** which are bent towards the rigidly fixed straignt vane **17**. A stream shaping action occurs downstream of the vanes at the front of the axialflow turbine during supersonic flight. The streams are constrained and control the stream properties and the conversation of ram dynamic pressure to static pressure at the stream critical pressure on the front of the axialflow turbine to enhance the power of the axialflow turbine.

The power plant of an aircraft utilizing the liquid fuel prevaporization induction jet oval thrust nozzle is illustrated in FIGS. **1**, **2**, **3** and **4**. The engine has a round engine exit nozzle **2** and the fuel prevaporization induction jet oval thrust nozzle has an oval thrust nozzle **3** and the interior of the thrust nozzle provides the transition from the round exit nozzle **2** to the oval thrust nozzle **3**. The thrust nozzle is fabricated with main airflow inducing nozzles **4**, fuel injecting airflow inducing nozzles **5** fitted with conventional fuel injectors **6** and ignitors **7**, combustion chambers **8**, inductors vanes **9**, liquid fuel prevaporization chambers **10** fitted with fuel injecting sprays **11** and pressurized vapor gas distributing manifolds **12** having discharge nozzles **13** fitted with ignitors **14**. Airflow inducing nozzles **4** and **5** having bellmouths, which enable the air to enter the nozzles, are installed inside of the ram-constriction air inlet plenums **16** which are empty spaces in the engine pod on both sides of the engine.

The downstream throat of the airflow inducing nozzle are diverging throats and direct the airflow into the combustion chamber **8**. The combustion chamber **8** has major axes span which extend from the round exit nozzle to the oval transition tail pipe and encloses the parallel, verically, equally spaced curved inductor blades which curve in the direction of the downstream flow. The hollow spaces between the envelope of the plenum **15** and flat span of the major axes transition wall comprise the open pressure vessel for vaporization boiling chambers **10** fitted with liquid fuel injecting sparays **11**.

The chambers are connected with prevaporization and pressurized gas distributing manifolds **12** with discharge nozzles **13**. The discharge nozzles **13** are inclined in a downstream direction and are connected to the minor axes areas of the oval thrust nozzle. The discharge nozzles **13** are fitted with ignitors **14** which are located at the vaporized gas air mixing point. The openings of the discharge nozzles **13** are adequate for slip flows of thrust stream and are positioned slightly upstream from the throat of the oval thrust nozzle for accommodation of ignition time span and to process the temperature reactants of the after/back burning combustions at downstream throat of the oval thrust nozzles. The vaporization boiling chambers are installed in the center portion of the diverging major axes exhaust stream zones of the oval thrust nozzles. This results in the boiling chambers **10** inner walls increasing in temperature due to heat transmitted from the engine exhaust stream.

The pressure inside the vaporization boiling chambers fluctuates in response to the injecting rates of the liquid fuel sprays. When the fuel injection is turned off, the boiling chambers are maintained at a high temperature and a negative pressure. Cavitation is caused by the dynamic pressure of the oval thrust stream as it slipflows over the downstreamwardly inclined openings and induces the negative pressure inside the hollow chamber through the throats of the inclined suck nozzles **13** and the distributing manifolds **12**. When this occurs, the boiling chambers are maintained at a high temperature and negative pressure. The means that the air mass inside the boiling chambers is maintained at a minimum for preventing explosion when the fuel injection is started and continuous combustion cannot occur in inside the vaporization boiling chambers.

In order to turn-on the liquid fuel prevaporization and back burning, liquid fuel spray is injected into the high temperature-negative pressure of the boiling chambers. The liquid fuel is vaporized which expands its volume and builds up the local pressure inside the boiling chambers. The thermal energy of the engine exhaust is converted into dynamic pressure inside the boiling chambers. The temperature of the engine jet stream after the engine exit nozzle and before the throat of the oval thrust nozzle is reduced which increases the nozle efficiency and enhances the random velocity of the thrust stream downstream of the oval thrust nozzle. The vaporized and pressurized gases expand and are discharges through the convergent-divergent inclined nozzles **13**.

The liquid fuel prevaporization and pressurization afterburners result prevaporization and pressurization of liquid fuel before mixing of the same in the airstream and to reduce the time required for vaporization and expansion of the gas in the airstream. The expansion/-combustion of in the short span of the airstream and the explosion in the downstream throat of the oval thrust nozzle increases the thermal head/dynamic pressure of the oval thrust rarifies stream. Any excess of the flamable vaporized gas flow resulting from the fuel injection flows into the throat of the oval thrust nozzle. As a result, continuous combustion will occur downstream of the nozzle exit and preceeding the back-fire on the surrounding airstream interaction which is an oblique shock stream induced from the forward speeding edge of the wing. The actuation of the oval thrust nozzle produces a real high temperature thrust stream from the rocket nozzle. As a result, a liquid fuel prevaporization and backburning induction jet oval thrust nozzle is achieved. This is power source operates on the induction principal and is the aerodynamic system of the aircraft.

The induction jet power plant os illustrated in FIGS. **5** and **6** is a prefabricated liquid fuel prevaporization and back burning induction jet oval thrust nozzle and slip fits on the round exit nozzle **2** of the conventional air breathing engine **1** which is enveloped with ram constriction air inlets plenums **15**, **16** **17**, **18** and **19**.

Installation of the power plant is illustrated in FIGS. **8**, **9**, **10** and **11** and the power plant is installed forward of the aerodynamic generating channel located forward of and above the vacuum cell induction lift wing **25** and below the recycling air inductor vanes **31**. The transition tail pipe of the oval thrust nozzle is designed such that their major axes are horizontal and their minor axes are vertical. The engine jet stream passes through the engine exit nozzle **2**, then through the transition tail pipe where the stream is constrained vertically. The converging jet stream is converted into an adverse pressure in the direction of flow and this adverse pressure reconverts into a velocity head in the direction of flowing in the diverging region of the oval thrust transition tail pipe.

The converging of the stream with the diverging transition tail pipe functions to shape the stream and to reduce turbulence in the round vorticity engine exhaust stream. The stream is constrained in the converging zones. The stream geometric contours are subject to stream separation at the horizontal divergent region. Thus, the stream underexpands in the direction of flow and the conversion into a velocity in the diverging zones is achieved through adverse pressure from the converging portion of the tail pipe. Conversion into a velocity is achieved by the thermal head effect occuring on the diverging contours of the transition tail pipe. The conversion velocity effect is proportional to the contours of nozzle and to the thermal head.

The stream shaping action inside the transition tail pipe develops the momentum equilibrium-freedom balancing of the stream dynamic pressure developed by the induction airflow inducing nozzles and inductor vanes.

The stream shaping action results in a vertically constrained, laminated stream which gains adverse pressure in the direction of flow in the converging zones and which underexpands in the direction of flow on the diverging zones. This action stimulates random velocity flow in the diverging zones of the oval thrust transition tail pipe.

The random velocity of underexpanding airstream contours will slipflow over the downstreamwardly curved inductor blades **9** and generate a cavitation at the intermediate area of the inductor vanes. This cumulative cavitation is equal to the pulling force which occurs beyond the thermal stream dynamic pressure in the diverging stream contours. The pulling force of the stream dynamics induces the induction airflow from the low velocity air plenums through the airflow inducing nozzles. This results in the induction airflow balancing the pulling pressure of the thermal stream dynamics. The balancing occurs because of the freedom balancing of stream shaping action with the momentum equilibrium of the stream dynamic pressure of the induction jet oval thrust transition tail pipe.

The inductor vanes **9** are so positioned near the boundary layers which surround the underexpanded region of the engine exhaust stream inside the diverging area of the oval transition tail pipe. FIGS. **12** and **16** show the boundary layers **40** and **40'** which exists at the interface of the turbojet stream **38** and the induction airstream **39** or ram jets **59**.

The position of boundary layers will shift in response to changes in the speed of flight. FIG. **12** shows the boundary layers **40**, which are located near the inductor vanes **9**, when the aircraft is stationary or during low speed flight of the aircraft. FIG. **16** shows the boundary layers **40'**, which shift toward the center-line of the engine jetstream **38**, when the aircraft is in supersonic flight.

The processing of the thrust stream inside the induction jet oval thrust transition tail pipe's result in a cylindrical vortex engine jet stream passing first through the round section of the engine nozzle **2** and then through the transiton tail pipe. The strong random velocity of the engine exhaust stream will be constained by the adverse pressure gradient at the vertical convergence zone. The stream will be underexpanded in the direction of flow in the region of horizontal divergence. The diverging contours are subject to stream separation illustrated in FIG. **12**. The underexpanding engine jet stream **38** slipflows over the inductor vanes **9** and generates the induction airstreams **39** through the airflow inducing nozzles **4** and **5**. This results in an induction airflow having a reduction in separation of engine exhaust stream at the diverging contours of the tail pipe and an increase in the volume of the oval thrust stream. A drastic reduction of stream separation occurs at the horizontal divergent due to the vertical constriction of stream-strain action resulting in a vertical converging, airstream shaping action taking over which nearly dies-out the stream rotation vorticity distribution and fully develops the atream flow into a nearly uniform profile, which means a laminated high volume thrust stream is achieved in the oval thrust nozzle. The above can be achieved by an induction jet oval thrust nozzle being fitted onto a conventional air breathing engine.

The prime force behind the induction air flowing is that a turbojet stream is achieved by means of the turbo-induction jet air breathing engine wherein the thrust stream is processed by the principle of induction which is freedom balancing beyond the dynamic pressure of thermal thrust stream on the diverging contours of transition tail pipe. A laminary high volume rarefied flow results which is used for the produciton of aerodynamic forces.

These streams shaping actions are processed by the local component of the induction jet oval thrust tail pipe before the stream passes through the exit nozzle of the oval thrust nozzle. This results in reduced vorticity turbulences of engine exhaust stream and the lamination of the stream by the transition tail pipe's convergance combining with the diverging shaping action of the induction airflow. The induction jet oval thrust transition tail pipe induces a high volume air breathing effect while reducing turbulance in the rarefied jet thrust which flows through the aerodynamic generating channel over the vacuum cell induction lift wing. The vacuum cell induction lift wing has an acoustically treated hollow interior and the airfoil has airtight partitions which contain downstream inclined slot openings and the jet thrust stream flows over the slots.

The turbo-induction jet air breathing oval thrust stream in the aerodynamic generating channel is illustrated in FIG. **13**. The dynamic pressure of the oval thrust stream **41** is an induced airstream which recycles and surrounds the aerodynamic generating channel. The airstream **44** is recycled as the thrust peripheral flow diverts the stream flow into the forward upper portion of channel as a diverting flow **42** turning vanes **30** and as a reversed flow **43** through duct **29** and recycling air inductor vanes **31**. The surrounding airstream **45** is induced at the forward portion of the channel through the slot gap between the flat span of the oval thrust nozzle and leading edge of wing. These airstreams increase in volume at the forward section of the aerodynamic generating channel and are merged with the induction jet thrust stream. This increases the airstream **46** flowing through the aerodynamic generating channel over the vacuum cell induction lift wing and generates the aerodynamic lift **50** and drag **52** forces. The drag force on the wing counter balances the forward thrust of engine idling operation when the aircraft is stationary.

The operation of a turbo-jet air breathing rocket oval thrust stream is illustrated in FIG. **14**. During hovering operation or forward acceleration, which occurs with turned on fuel injecting sprays in the vaporization chambers, a prevaporized and pressurized gas stream **52** flows into the induction air stream zones **39** of the oval thrust nozzles **13**. As a result, the turbo-jet air breathing oval thrust stream receives the prevaporized liquid fuel. Ignition of the combustible air mixture **53** produces a flame thrust stream **54** downstream of the oval thrust nozzle. This results in a high thermal rocket thrust stream which creats a turbo-induction jet air breathing rocket thrust engine. This is accomplished by the liquid fuel prevaporization and back burning induction jet oval thrust nozzle which fits onto the convention air breathing engine.

The hovering capacity is generated by the turbo-induction air breathing engine rocket oval thrust channel as illustrated in FIG. **15**. In FIG. **15**, the dynamic pressure of the oval thrust flame stream induces recycling and surrounding air streams. The recycling airstream **44** is the thrust peripheral flow which is diverted into the forward and upper portions of the channel through the turning vanes **30**, through the reversed flow duct **29**, the lower portion of the channel, through the turning vanes **30** and reversed flow duct **29** and through the recycling air inductor vanes **31**. The surrounding airstream **45** is located at the forward and lower portion of channel, and passes through the slot gap between the flat span of the oval thrust nozzle and the leading edge of wing. These streams increase the volume of airstream in the channel and are merged with flame of the turbo-induction jet air breathing rocket thrust. The merging of these streams produces the expanding combustion thrust stream and flow through the diverging contours of the aerodynamic generating channel over the vacuum cell induction lift wing.

The dynamic pressure of the expanding combustion thrust stream **55** slipflows over the downstreamwardly inclined slot openings of vacuum cell wing. This stream action on the wing induces a vacuum in the internal cells of the wing which creates aerodynamic lift and drag forces on the wing. These forces correspond with the incidence angle **47** of the wing. The incidence angle **47** is the angle between the center-line of thrust stream and chord line wing. The forces generated on the wing result in the drag force counteracting the foreward thrust of engine and stabilizing the horizontal moment of the airframe. The lift force balances the weight of the aircraft. Hovering is produced by the turbo-induction jet air breathing rocket thrust aerodynamic generating channel. Aircraft VTOL hovering manoeuvers are achieved by the turbo-induction jet air breathing rocket thrust aerodynamic generating channel.

The operation of a turbo-ram induction jet air breathing oval thrust stream, during supersonic flight, is illustrated in FIG. **16**. FIG. **16** shows that the ram constriction air inlet plenums **16** gain in ram-static pressure and that the ramstream flows through the airflow inducing nozzles **4** and **5** past turned on fuel injectors **56** located downstream of the fuel injection airflow inducing nozzles **5**. The combustion mixture **57** is ignited and produces a flame stream **58** which flows into and combines, downstream of the main airflow inducing nozzle **4**, with the airstream as the flame stream enters the combustion chamber. The expanding combustion streams produce ramjet streams through the diverging contours of the combustion chamber and the expansion of the ramjets streams **59** which combine with turbojet stream **38** at oval thrust nozzle. The oval thrust nozzle handles the turbojet air stream and the ramjets streams to create a turbo-ram induction jet air breathing engine. The air intake free stream is a tangentially flowing, oblique-stream which interacts with the throat constriction inside the low velocity air plenums to producing critical pressures in the ram-airstream resulting first in the constraining and then the expansion of the ram-airstream which controls the ram pressure on air intake bell-mouths of airflow inducing nozzles which function as the ramjet components of the induction jet oval thrust nozzle.

The turbo-ram induction jet air breathing rocket oval thrust stream, during hypersonic flight, is illustrated in FIG. **18**. As illustrated in FIG. **18**, the fuel injecting sprays are turned on in the vaporization chambers to produce the prevaporized and pressurized gas stream **52** which is discharged into the ramjet stream zones located at the oval thrust nozzle. The prevaporized and pressurized gas stream **52** passes through the distributing manifolds and inclined discharge nozzles into the ramjet stream. The turbo-ram induction jet air breathing stream receives the prevaporized liquid fuel and when the mixture is ignited, the combustible mixture **53** produces flame thrust stream **64** downstream of the oval thrust nozzle. The ignited mixture products a high thermal stream, such as a rocket thrust stream, creating the turbo-ram induction air breathing rocket thrust engine.

As illustrated in FIG. **19**, hypersonic flight is generated with the turbo-ram induction jet air breathing rocket oval thrust stream flow through the diverging contours of aerodynamic generating channel. The dynamic pressure of the back burning oval thrust stream induces the recycled airstream **44** which is the thrust peripheral flow diverted into the forward and upper portion of the channel and through the reverse flow duct **43** and the recycling air inductor vanes **31**.

The forward leading edge **60** of wing at the airspeed of the aircraft induces the oblique shock airstream **61** to interact with the flame stream stream **64** of the turbo-ram induction jet air breathing rocket thrust. These streams are tangentially to develop the critical pressure and to form the high velocity free stream in throat **65** located in the forward section of the channel. These streams are merged which produces the expanding combustion downstream of the free stream throat and expanded to produce the hypersonic velocity of thrust stream **66** in the diverging contours of channel thus creating a turbo-ram induction jet air breathing rocket aerodynamic thrust channel.

The ramjet induction axialflow turbine is achieved by the liquid fuel prevaporization and back burning induction jet oval thrust nozzle, illustrated in FIGS. **20**, **21** and **22**, during high speed flight. The liquid fuel prevaporization and back burning induction jet oval thrust nozzle slip fits on the exit pipe **67** of a conventional axialflow turbine (rotators **68**, **70** and stators **69**). An electric generator is installed inside the exhaust pipe **72** of the axialflow turbine which has a ram constriction air inlet plenum.

Ram constriction assembly having multiple vanes **17**, **18** and **19** is fitted on the inclined ram-air intake opening foreward of the plenum pod located on the front of the axial flow turbine inlet diffuser. The forward speed of aircraft generates a ramstream which passes through the deflectable multiple vanes **18** and **19** of the air intake and then flows into the plenum pod. The trailing sections of multiple vanes **19** are deflected towards the rigidly fixed straight vane **17** at the center-line of the axialflow turbine. The ram-stream passing through the multiple vanes is inflected in the flow direction and is tangentially constrained to produce a critical pressure on front of the axialflow turbine inlet diffuser. The critical ram pressure flow impinges on the axialflow turbine blades **68** and **70** rotating the turbine wheels.

The expanding ramjet thrust streams **59** flow through the inductor vanes **9** and induce a negative pressure differential on the turbine inlet and outlet. This enhances the power of the ram-axialflow turbine and operates the electric generator. The ramjet-induction axialflow turbine operation is obtained by the liquid fuel prevaporization and back burning induction jet oval thrust nozzle fitted onto the conventional axialflow turbine having a ram constriction air inlet plenum located in ram stream zone of airframe.

The liquid fuel prevaporization and backburning induction jet oval thrust nozzle of this invention is used for an induction lift aircraft.

I claim:

1. A vacuum cell induction lift wing adapted for use in an aerodynamic generating channel having an elongated main generating channel defined by an inlet adjacent a jet engine which communicates with the main generating channel, an upper portion defining a reverse flow channel and wherein the lower portion and outlet of the main generating channel is opened and is part of said main generating channel comprising

an airfoil including a leading edge and a trailing edge and having a top panel and an acoustically treated hollow interior, said airfoil including airtight partitions forming individual cells within said hollow interior and having inclined slots which extend from the top panel of said airfoil into each of said individual cells, said inclined slots extending at an angle from each of said individual cells toward the trailing edge of said airfoil, said airfoil being adapted to be positioned within an aerodynamic generating channel in the lower portion thereof and spaced from the upper portion forming said elongated channel with the top panel of the airfoil being adapted to form a lower boundary of a said aerodynamic generating and forming an outlet for the main generating generating channel between the trailing edge of the airfoil and the rearward section of the upper portion forming the reverse flow channel and being adapted to define a slipflow thereacross from an airstream passing through a said aerodynamic generating channel;

support means operatively coupled to said airfoil adjacent the trailing edge for enabling said airfoil to be rotated therearound to change the angle of incidence of the top panel to a said airstream passing thereacross; and

pivoting means actuators operatively coupled to said airfoil adjacent the leading edge for moving said airfoil leading edge relative to a said airstream by rotating said airfoil around said support means to change the angle of incidence of said top panel relative a said airstream enabling a said airflow to generate a vacuum within said individual cells having a pressure which is determined by the angle of incidence of the top panel of the airfoil to the said airstream and by the shearing stress of a said airstream passing over said inclined slots in the top panel of said airfoil.

2. A jet thrust peripheral flow recycling system adapted to be located rearward of and adjacent to the thrust nozzle of a jet engine producing a jet thrust stream comprising

a housing defining an aerodynamic generating channel adapted to pass a jet thrust stream from a thrust nozzle of a jet engine therethrough, said housing including a main generating channel having an inlet and an outlet and a reverse flow channel located in the upper portion of the main generating channel channel and separated from the main generating channel by an acoustically treated panel having inclined orifices which are directed towards this outlet, said reverse flow channel having an inlet opening located at the outlet of the main generating channel and an outlet opening located adjacent the inlet of the main generating channel, said inclined orifices being operative to provide a slipflow for a said jet thrust stream passing through the main channel;

a vacuum induction lift wing comprising

an airfoil including a leading edge and a trailing edge and having a top panel and an acoustically treated hollow interior, said airfoil including airtight partitions forming individual cells within said hollow interior and having inclined slots which extend from the top panel of said airfoil into each of said individual cells, said inclined slots extending at an angle from each of said individual cells toward the trailing edge of said airfoil, said airfoil being positioned within an aerodynamic generating channel with the top panel of the airfoil being adapted to form a lower boundary of a said aerodynamic generating channel and being adapted to define a slipflow thereacross from an airstream passing through a said aerodynamic generating channel;

support means operatively coupled to said airfoil adjacent the trailing edge for enabling said airfoil to be rotated therearound to change the angle of incidence of the top panel to a said airstream passing thereacross; and

pivoting means actuators operatively coupled to said airfoil adjacent the leading edge for moving said airfoil leading edge relative to a said airstream by rotating said airfoil around said support means to change the angle of incidence of said top panel relative a said airstream enabling a said airflow to generate a vacuum within said

individual cells having a pressure which is determined by the angle of incidence of the top panel of the airfoil to the said airstream and by the shearing stress of a said airstream passing over said inclined slots in the top panel of said airfoil;

reverse flow turning vanes located in the inlet of the reverse flow channel and being adapted to divert a portion of a said jet thrust stream passing through said reverse flow channel back into the main generating channel; and

actuators operatively coupled to said reverse flow vanes for controlling the position of the reverse flow turning vanes relative to a said jet thrust stream passing through the main generating channel to regulate the volume of a said jet thrust stream being diverted into and pasing through said reverse flow channel.

3. An induction aerodynamic lift generating apparatus adapted to be located rearward of and adjacent to the thrust nozzle of a jet engine producing a jet thrust stream comprising

a housing defining an aerodynamic generating channel having an elongated main generating channel defined by an inlet adjacent a jet engine which communicates with the main generating channel, an upper portion defining a reverse flow channel and wherein the lower portion and outlet of the main generating channel is opened and is part of said main generating channel adapted to pass a jet thrust stream through including said main generating channel having said inlet and an outlet and said reverse flow channel located in the upper portion of the main generating channel channel and separated from the main generating channel by a panel, said reverse flow channel having an inlet opening located at the outlet of the main generating channel and an outlet opening located adjacent the inlet of the main generating channel;

an airfoil including a leading edge and a trailing edge and having a top panel and an acoustically treated hollow interior, said airfoil including airtight partitions forming individual cells within said hollow interior and having inclined slots which extend from the top panel of said airfoil into each of said individual cells, said inclined slots extending at an angle from each of said individual cells toward the trailing edge of said airfoil, said air foil being adapted to be positioned within said aerodynamic generating channel in the lower portion thereof and spaced from the upper portion forming said elongated channel with the top panel of the airfoil being adapted to form a lower boundary of a said aerodynamic generating and forming an outlet for the main generating generating channel between the trailing edge of the airfoil and the rearward section of the upper portion forming the reverse flow channel and being adapted to define a slipflow thereacross from a jet thrust stream passing through a said aerodynamic generating channel;

support means operatively coupled to said airfoil adjacent the trailing edge for enabling said airfoil to be rotated therearound to change the angle of incidence of the top panel to a said jet thrust stream passing thereacross; and

pivoting means actuators operatively coupled to said airfoil adjacent the leading edge for moving said airfoil leading edge relative to a said jet thrust stream by rotating said airfoil around said support means to change the angle of incidence of said top panel relative a said jet thrust stream causing a said airflow to generate a vacuum within said individual cells having a pressure which is determined by the angle of incidence of the top panel of the airfoil to the said jet thrust stream and by the shearing stress of a said jet thrust stream passing over said inclined slots in the top panel of said airfoil, said jet thrust stream being adapted to pass through the aerodynamic generating channel and over the top surface of the vacuum cell induction lift wing for producing thermal aerodynamic lift and drag forces which are determined by the angle of incidence of said vacuum cell induction lift wing and that portion of said jet thrust stream being diverted into and passing through said jet thrust stream being diverted into and passing through the reverse flow channel and back into the main generating channel.

* * * * *

United States Patent [19]
Warrington et al.
[11] Patent Number: 4,685,640
[45] Date of Patent: Aug. 11, 1987

[54] **AIR VEHICLE**

[75] Inventors: **John E. Warrington**, Toronto; **Dale C. Kramer**, Port Colborne, both of Canada

[73] Assignee: **Hystar Aerospace Development Corporation**, Vancouver, Canada

[21] Appl. No.: **770,490**

[22] Filed: **Aug. 29, 1985**

[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[4] **B64B 1/34**
[52] **U.S. Cl.** .... **244/29;** 244/23 C
[58] **Field of Search** .... 244/23 R, 23 A, 23 B, 244/23 C, 24, 26, 29, 30

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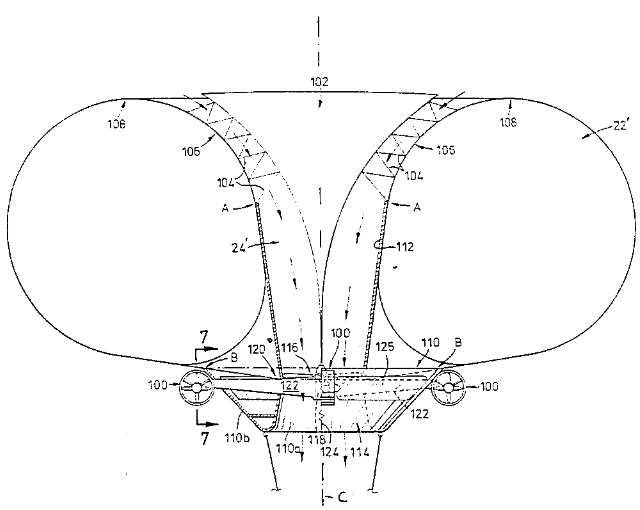
Assistant Examiner—Rodney Corl
Attorney, Agent, or Firm—Rogers, Bereskin & Parr

[57] **ABSTRACT**

An air vehicle for lifting loads generates lift forces from helium gas within a torus-shaped envelope having a central passageway, and from a fan arrangement designed to direct air downwardly through the passageway. Lateral propulsion units are provided on the envelope. In one embodiment, the fan arrangement comprises two fans carried by a saddle supported on the envelope, while in another embodiment a single fan is carried by a gondola suspended from the envelope.

11 Claims, 7 Drawing Figures



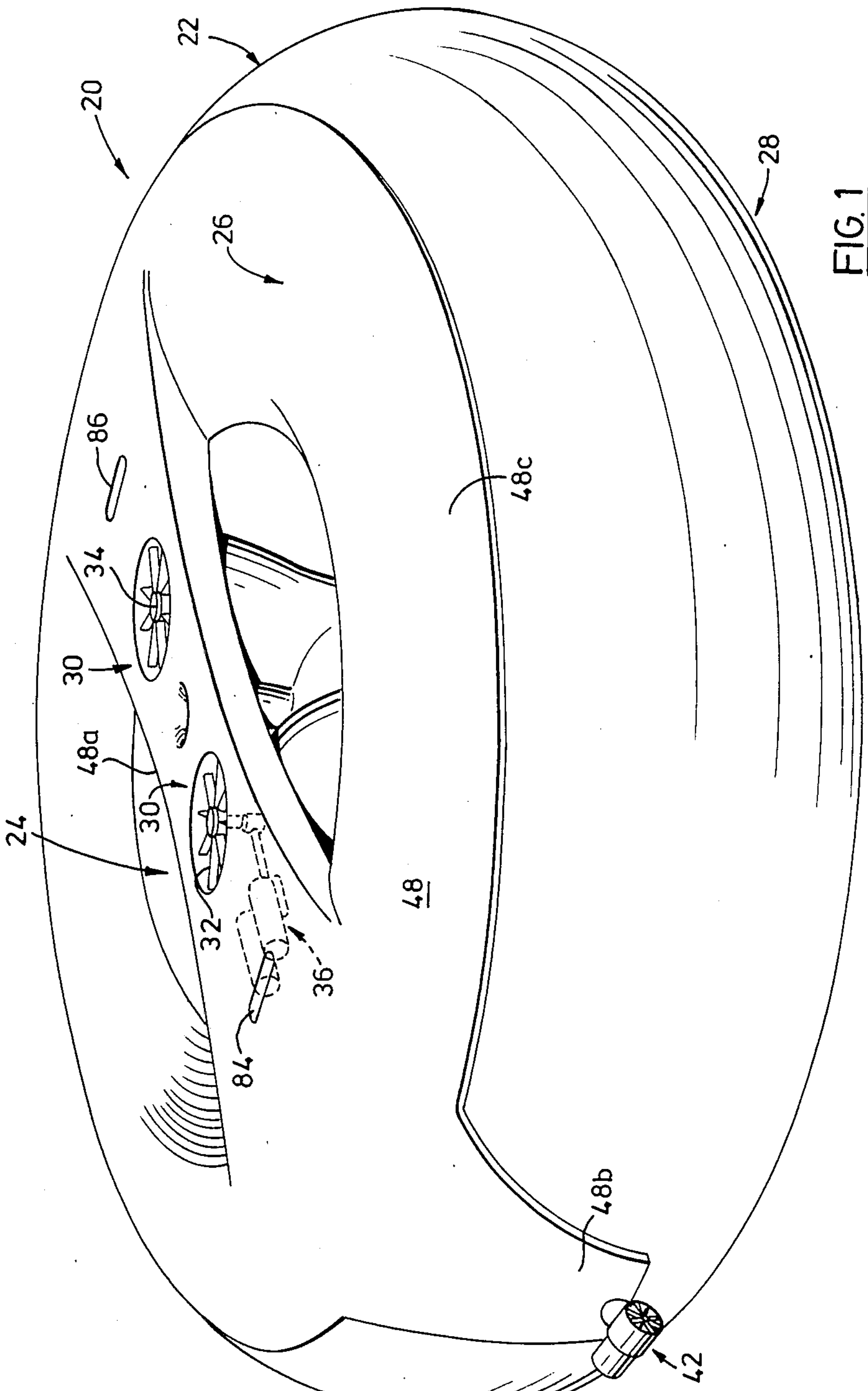


FIG.1

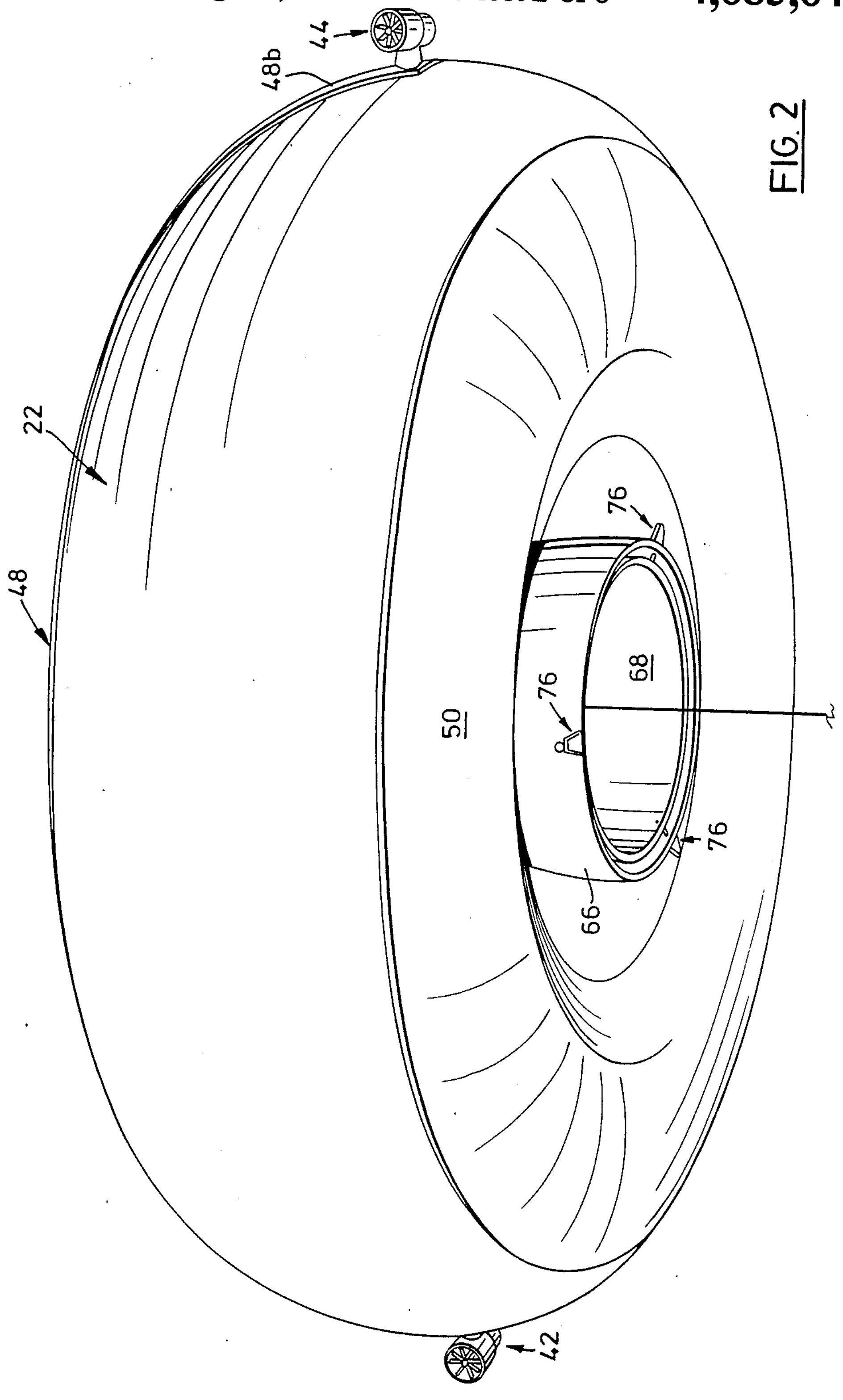
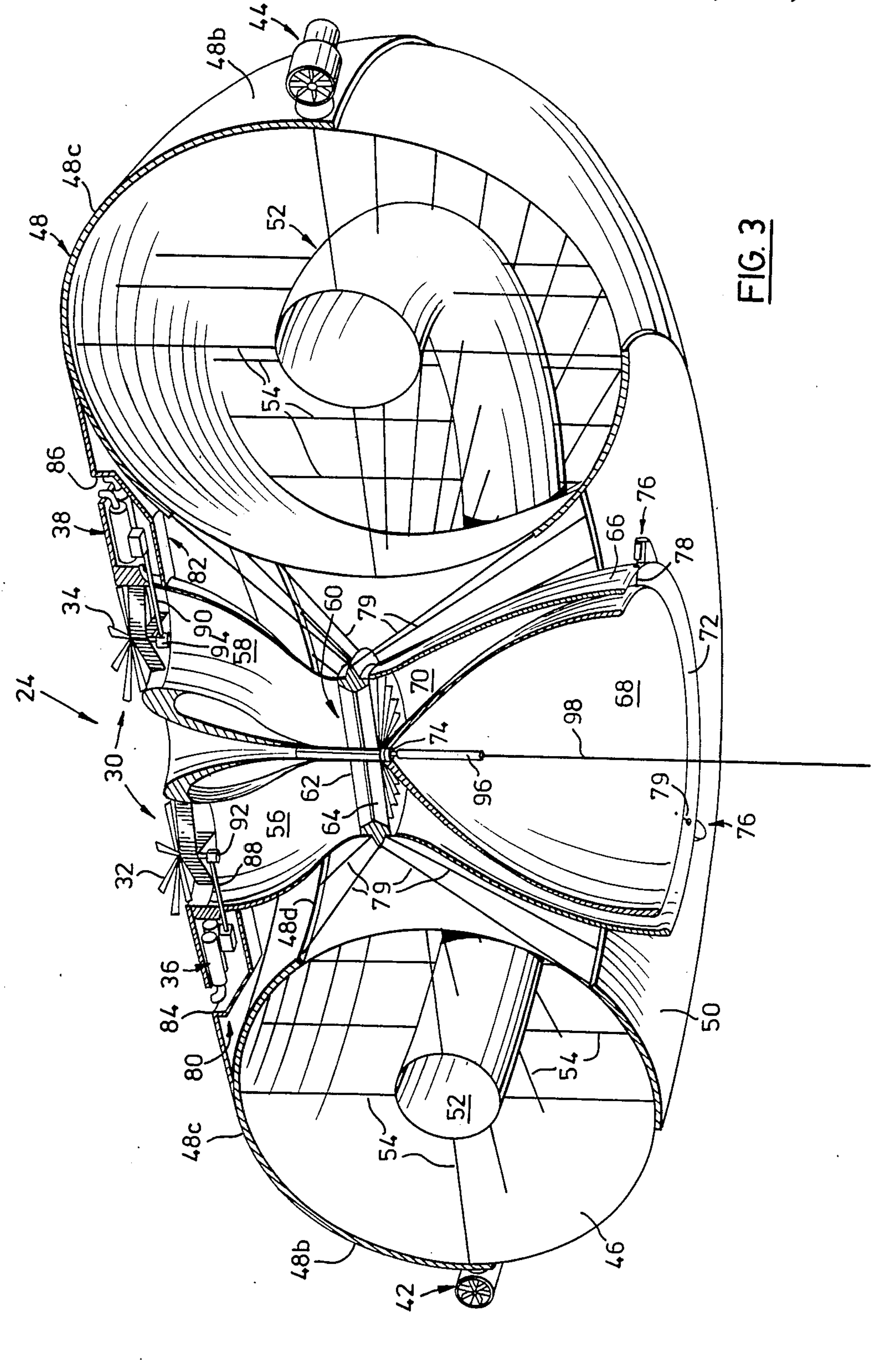


FIG. 2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50
46
42

FIG. 3

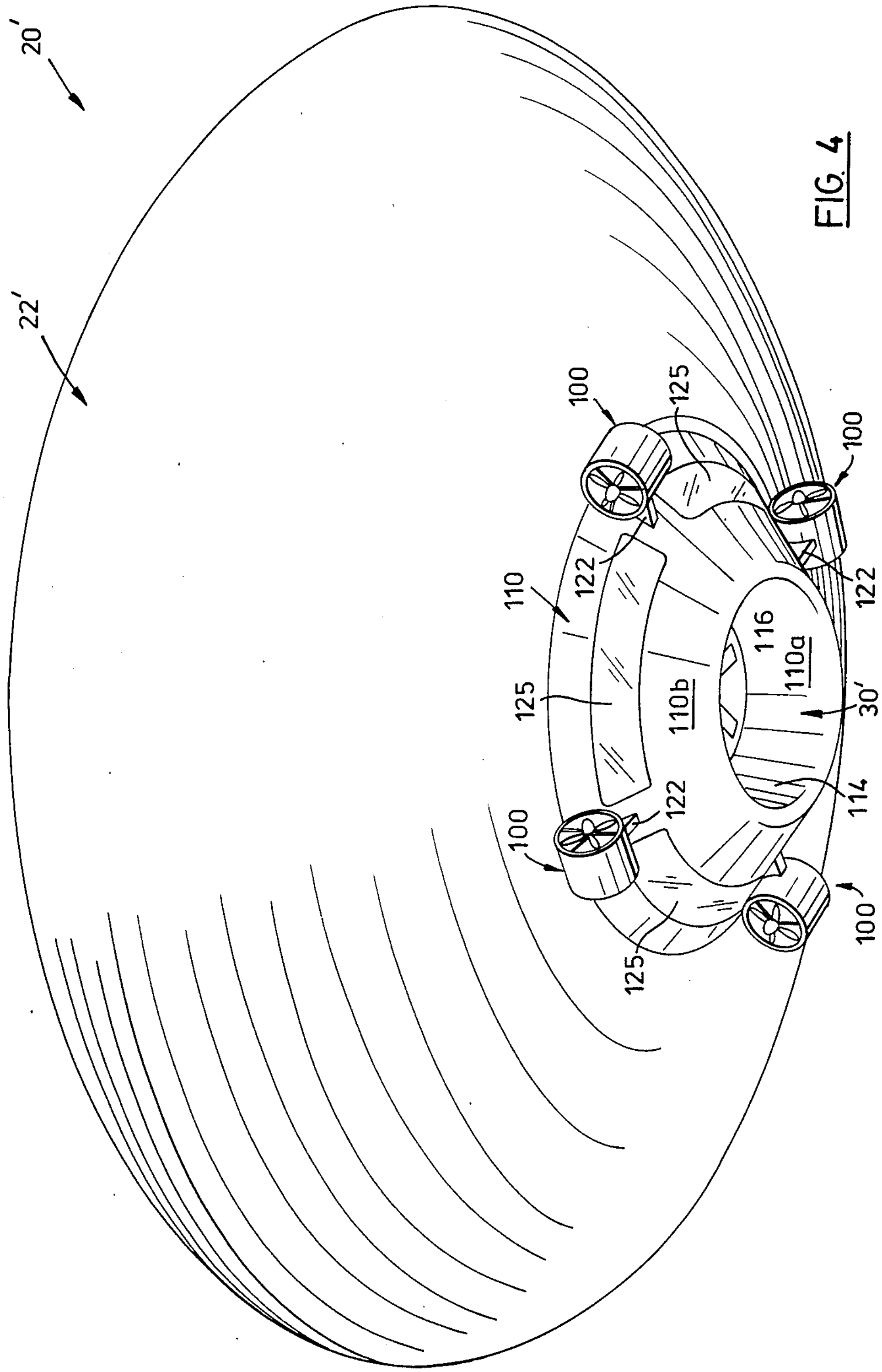
20'
22'
100
100
100
100
125
125
125
122
122
122
110
116
110a
110b
30'
114

FIG. 4

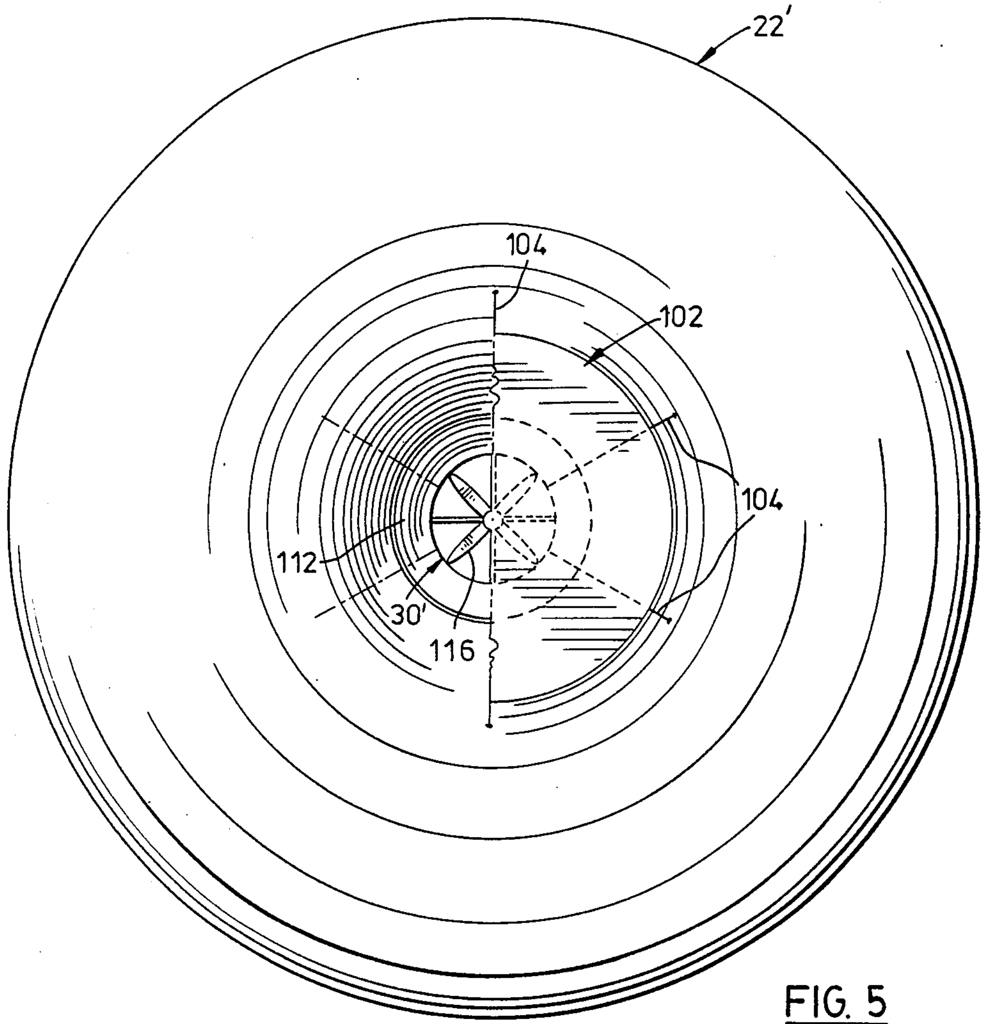

FIG. 5

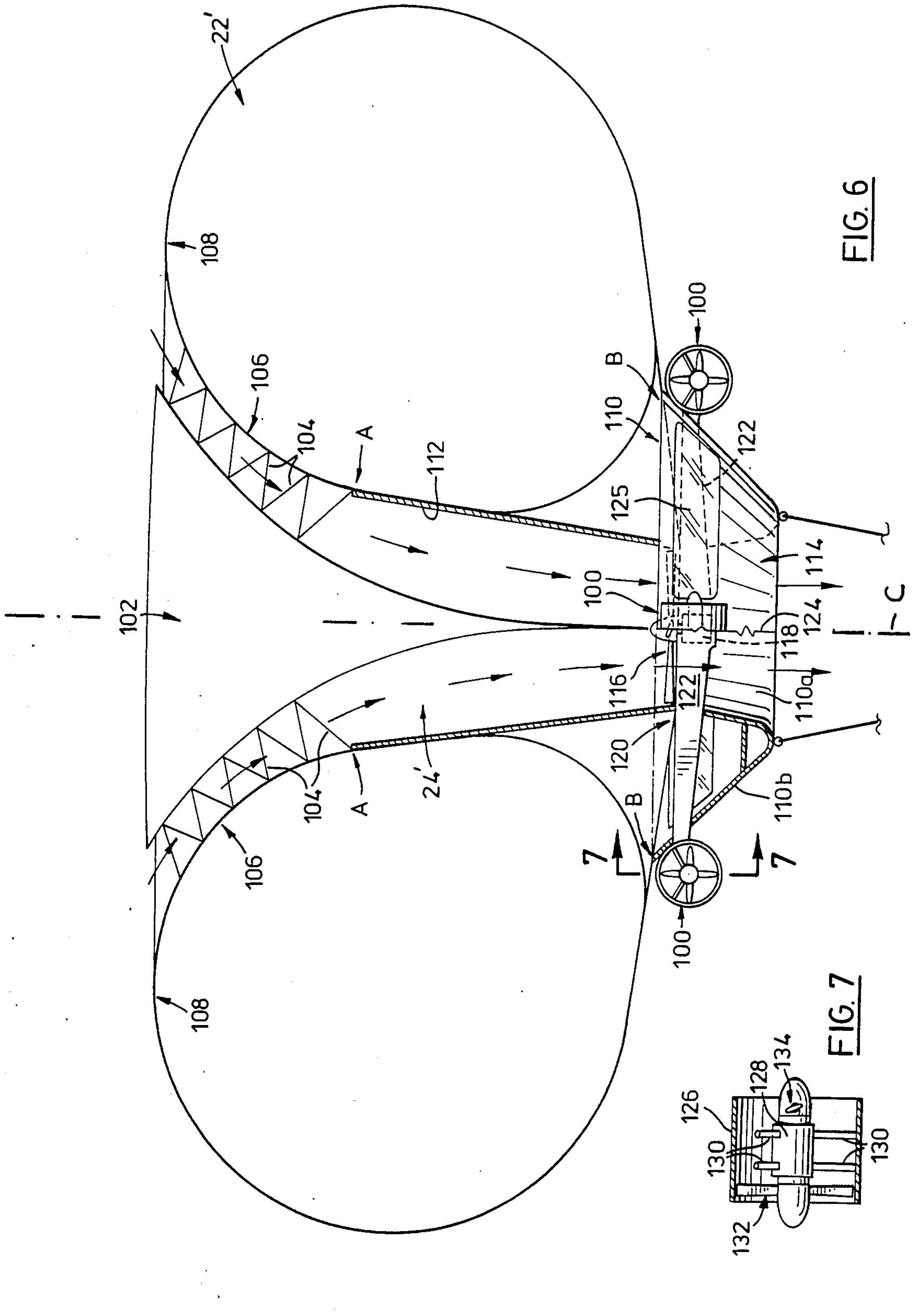
22'
108
106
104
A
112
102
100
B
110
122
125
114
124
118
C
116
110a
120
24'
110b
7
126
128
134
130
132

FIG. 6

FIG. 7

AIR VEHICLE

FIELD OF THE INVENTION

This invention relates generally to vehicles for lifting and transporting loads by air. For convenience, a vehicle of this type will hereinafter be referred to as an "air vehicle".

BACKGROUND OF THE INVENTION

So-called "lighter-than-air" air ships and balloons are well-known for load carrying purposes. An aircraft of this type relies on helium or some other gas which is lighter than air to create lift. Hot air balloons are also well-known and rely for buoyancy on the natural tendency of air to rise as its density decreases on heating. Generally, these known type of craft are difficult to control with precision and have not found wide application for commercial load lifting and transporting purposes.

DESCRIPTION OF THE PRIOR ART

United States Patent literature contains numerous examples of prior art proposals for transporting loads by air. For example, the following patents disclose proposals for using air ships and balloons in logging operations:

U.S. Pat. No. 3,221,897 (Matheson)
U.S. Pat. No. 3,249,237 (Stewart)
U.S. Pat. No. 3,270,895 (Stewart)
U.S. Pat. No. 3,369,673 (Mosher)

The following United States patents disclose prior art proposals for lighter-than-air balloons of generally annular form:

U.S. Pat. No. 3,941,384 (Wopschall)
U.S. Pat. No. 1,572,187 (Cooper)
U.S. Pat. No. 213,603 (Apraxine)
U.S. Pat. No. 3,558,083 (Conley et al.)

Proposals for jet propelled air vehicles are to be found in U.S. Pat. Nos. 3,053,483 (Stahmer) and 3,152,777 (McLean).

Eshoo (U.S. Pat. No. 4,326,681) discloses an example of a non-rigid air ship which relies for lift on both heated air and on a gas which is lighter than air.

Batchelor (U.S. Pat. No. 3,658,278) discloses a load transporting system in which a balloon supports a flexible electric line leading from a source of electricity to a load carrying device including a helium filled rotor and means for releasing gas to provide a load carrying force.

An object of the present invention is to provide an air vehicle suitable for use in commercial load carrying operations.

SUMMARY OF THE INVENTION

The vehicle provided by the invention includes an envelope having the general shape of a torus extending about a passageway between top and bottom surfaces of the envelope. The envelope contains a gas, preferably a lighter than air gas. Fan means is carried by the envelope and is arranged to direct air downwardly through the passageway to generate a downwardly vectored thrust for lifting the vehicle. The fan means is controllable to vary the magnitude of the thrust and hence the altitude of the vehicle in flight. The envelope also carries propulsion means for generally lateral propulsion of the vehicle.

In a preferred embodiment, the vehicle provided by the invention derives lift both from the lighter than air gas within the envelope and from the thrust provided by the fan means. It is believed that this provision for lift from two sources will permit the design of a vehicle which is not only capable of lifting relatively heavy loads but in which the altitude of the vehicle can be easily and precisely controlled in use. It is also believed that it will be possible to build and operate such a vehicle quite economically.

For example, the vehicle may be designed so that the gas within the envelope provides sufficient lift to support the weight of the vehicle when unloaded. The fans means need then generate only sufficient thrust to be capable of lifting the load to the required altitude. In another case, the gas could provide positive buoyancy for the unloaded vehicle although this may then require the addition of means for tethering or anchoring the vehicle when unloaded.

The gas within the envelope is preferably, but not essentially, a lighter than air gas such as helium; for example, air could be used in the envelope. In this event means may be provided for heating the air to provide lift.

In a preferred embodiment of the invention, the vehicle includes means for controlling the direction of the thrust vector provided by the fan means, to control the attitude of the vehicle.

A further embodiment provides means for generating additional lift by the so-called swing effect of air flowing over the top surface of the envelope into the passageway through the envelope.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings which illustrate a number of preferred embodiments of the invention by way of example, and in which:

FIG. **1** is a perspective view from above of an air vehicle in accordance with a first embodiment of the invention;

FIG. **2** is an underneath perspective view corresponding to FIG. **1**;

FIG. **3** is a vertical sectional view through the vehicle shown in FIGS. **1** and **2**;

FIG. **4** is an underneath perspective view of a vehicle in accordance with a second embodiment of the invention;

FIG. **5** is a plan view corresponding to FIG. **1**, partly in section;

FIG. **6** is a vertical sectional view through the vehicle shown in FIGS. **4** and **5**; and,

FIG. **7** is a vertical sectional view on line **7**-**7** of FIG. **6**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIGS. **1** to **3** an air vehicle is generally denoted by reference numeral **20** and includes an envelope **22** having the general shape of a torus. A passageway generally denoted **24** extends between top and bottom surfaces **26** and **28** respectively of the envelope. The envelope contains a gas which is lighter than air (in practice, helium).

Fan means shown in FIGS. **1** and **3** and denoted generally **30** are carried by the envelope and arranged to direct air downwardly through passageway **24** to generate a downwardly vectored thrust for lifting the envelope. In this case, two fans **32** and **34** are provided and are driven individually by respective jet engines **36** and **38**. The engines can be controlled to vary the magnitude of the thrust and hence the height of the vehicle in flight, in known manner.

The vehicle is provided with a pair of propulsion units in the form of jet engines **42** and **44** which are carried by the envelope and arranged for propelling the vehicle generally laterally.

Referring now more specifically to FIG. **3**, the envelope **22** comprises essentially a non-rigid gas-impervious bag **46** having the general shape of a torus; the bag is normally maintained in an inflated condition by helium gas under pressure. Bag **46** is made of a polymeric material, in this embodiment the material sold under the trade mark MYLAR. A saddle, the shape of which can perhaps best be seen in FIG. **1** extends across the top of the bag and provides a support for the fans **30** and **32** and the engines by which they are driven. The saddle is generally indicated by reference numeral **48** and includes an elongate center portion **48***a* which extends generally diamentrally of the torus and by which the fans **32, 34** and the engines **36, 38** are supported. Continuations **48***b* of the center portion **48***a* extend part way down the sides of the bag and carry the engines **42** and **44**. The engines are disposed generally on a median plane through the torus. The saddle also includes an annular portion **48***c* which overlies the top of the bag **46** and in effect defines the top surface of the tours. As can best be seen in FIG. **3**, this annular portion **48***c* also extends partially down the inside surface of the torus defining the opening **24** to the edge denoted **48d** in FIG. **3**.

Adjacent the bottom of passageway **24** is a second annular member denoted **50** which is also of an arcuate shape in cross-section conforming generally to the curvature of bag **46**. The bag is secured by adhesive to the bottom member **50** and to the saddle **48** so that the member and saddle partially support the bag in its inflated condition.

Saddle **48** and member **50** are bonded structures typically formed from an epoxy resin matrix and aramid fibers such as those sold under the trade mark KEVLAR. Glass and/or carbon fibers may also be incorporated. Other alternative materials are aluminum and titanium.

An air bag **52** is provided inside the torus **22** and comprising a closed tubular structure disposed generally on the center line of the torus and maintained in position by supporting wires indicated at **54**. Bag **52** contains air and can be inflated or deflated to control the buoyancy of the envelope, as is conventional in air ships. When the air bag **52** is inflated the density of the helium within the bag **46** is increased, reducing its buoyancy. Conversely, deflation of air bag **52** allows the density of the helium to decrease, increasing its buoyancy. A suitable air pump, power source and control equipment will of course be provided in the vehicle for inflating and deflating the air bag **52**. This equipment will be carried from the saddle **48** of the vehicle but, for simplicity, has not been shown since it forms no part of the present invention and is similar to equipment conventionally used in air ships.

With continued reference to FIG. **3**, it will be seen that each of the lift fans **32, 34** is supported on saddle **48** above an associated duct, **56, 58** extending downwardly from the saddle. The two ducts **56, 58** merge at a circular chamber **60** generally at the center of the torus **22**. Chamber **60** contains two stacked, contra-rotating, free-wheeling fans **62, 64** rotatable about the center line of chamber **60**. These fans are designed to turn in opposite directions under the influence of air from the fans **32, 34** and serve to mix the air into a uniform, downwardly directed stream. That stream enters a discharge duct within a somewhat conically shaped duct member **66**, in the center of which is suspended a bell-shaped duct member **68**. The two members define therebetween a narrow duct **70** which is generally of hollow conical shape and which defines an annular air outlet nozzle **72** at the bottom of the torus. Accordingly, air leaves nozzle **72** in an annular stream or curtain around the perimeter of the bell member **68**.

Member **68** is suspended at its apex from a universal joint **74** carried at the lower end of a shaft about which the two fans **62** and **64** rotate. The universal joint **74** allows the bell member **68** to be deflected laterally with respect to the outer member **66** to vary the shape of nozzle **72** and hence the configuration of the curtain of air issuing from the nozzle. By changing the configuration of the air stream in this way, the attitude of the vehicle can be controlled in flight. This is accomplished by three actuators mutually spaced at 120° about the perimeter of nozzle **72**. Two of those actuators are visible in FIG. **3** and are donated by reference numeral **76**. Referring to the actuator which is seen at the right in FIG. **3**, each actuator is carried by the outer duct member **66** and includes an operating member **78** which extends inwardly and is coupled to the bell member at its outer end. Each actuator comprises a fast acting stepping motor operated by suitable control equipment (not shown) carried by the saddle **48** of the vehicle. In an alternative embodiment, the actuator **76** could be replaced by other forms of actuator, for example, hydraulic cylinders.

The duct assembly comprising the ducts **56, 58**, chamber **60** and the members **66** and **70** may all be formed as bonded structures from the same materials as the saddle **48** and bottom member **50**.

Guy wires **79** stabilize the duct assembly with respect to the saddle **48** and bottom member **50**.

The two jet engines **36** and **38** are located within respective housings **80** and **82** at the underside of the center portion **48a** of saddle **48** and have suitable vents **84** and **86**. The engines themselves are essentially conventional aircraft-type jet engines connected through suitable gearboxes to respective drive shafts **88** and **90** coupled to the asociated fans **32** and **34** respectively. Suitable angle drives **92** and **94** connect the drive shafts to the fan axles.

The universal joint **74** at the apex of the bell member **68** is also used as an attachment point for suspending loads from the vehicle. As shown in FIG. **3**, an attenuator **96** is suspended from the universal joint **74** and extends downwardly from the vehicle as indicated by line **98** for attachment of loads below the vehicle. Attentuator **96** takes the form of a hydraulic cylinder and performs a shock absorbing function in the suspensioin line. Typically, the attentuator will be quite short and a cable or other suspension element will extend downwardly from the attentuator for actually carrying the load.

The two engines **42** and **44** for propelling the vehicle laterally through the air are also essentially conventional jet engines and are positioned at diametrally opposite sides of the torus for use in maneuvering the vehicle. The engines are reversible.

Reference will now be made to FIGS. **4**, **5** and **6** in describing a second embodiment of the invention. In those views, primed reference numerals will be used to denote parts corresponding with parts shown in FIGS. **1** to **3**.

The vehicle shown in FIGS. **4** to **6** has the same principal components as the vehicle shown in the previous views, namely a torus-shaped envelope **22'** defining a central passageway **24'**, fan means **30'**, and propulsion means, in this case represented by four generally laterally directed jet engines individually denoted **100**.

Referring primarily to FIG. **6**, it will be seen that the torus-shaped envelope **22'** is generally similar to the envelope **22** of the previous views although of somewhat different cross-sectional shape, and that the saddle **48** of the previous embodiment has been omitted. The torus itself may be of the same construction as in the previous embodiments and may have an internal air bag as bag **52** if required. Instead of being disposed at the top of the passageway through the tours, the fan means **30'** in the embodiment of FIG. **6** is positioned at the bottom of the passageway and draws air downwardly through the passageway.

At the top of passageway **24'** is a member **102** having the general shape of an inverted cone with a concave profile and a flat base. The member is arranged so that its base is disposed generally in the same plane as the top surface of the torus for minimizing drag as the vehicle moves through the air. The member is located by guy wires **104** extending between it and the envelope **22'** and is positioned with its concave surfaces spaced from the opposing surfaces of the envelope **22'** so that the shape of passageway **24'** is in effect defined between the envelope and the member **102**. As seen in horizontal section, the passageway has an annular shape, the diameter of which gradually increases towards the top of the torus, where the passageway flares outwardly and merges smoothly with the top surface of the envelope. Member **102** is arranged so that the width of the annulus decreases somewhat towards the top surface of the torus generally in the regions indicated by arrows **106** in FIG. **6**, to achieve a venturi effect causing the velocity of the air entering the passageway **24'** to be accelerated. Thus, the air being drawn into the passageway by the fan means **30'** is drawn over the convex profile generally denoted **108** at the top of the torus and is accelerated, creating a low pressure area above surface **108** which tends to augment the lifting forces being imposed on the envelope. In other words, a "wing" effect is created, increasing the lifting forces acting on the vehicle.

Means may be provided for tilting member **102** to change the shape of passageway **24'**, to control the stability and/or pitch of the vehicle. These means may be essentially similar to the actuators used for duct member **68** in the preceding embodiment.

In an alternative embodiment, member **102** may be omitted.

The fan means **30'** of the vehicle is supported by a "gondola" structure **110** which is in turn carried at the lower end of a member **112** disposed within the passageway **24'** through the envelope **22'**. Member **112** has the general shape of an inverted cone, the upper end of which is of greater diameter than the minimum diameter of passageway **24'** when the envelope **22'** is fully inflated so that the member tends to be held in the passageway by the envelope. The lower end of member **112** defines a discharge opeing of passageway **24'** on the center line C of the vehicle. The envelope is also secured to the member by adhesive. The envelope extends to the lower edge of member **112** and accordingly has the general shape of a pear drop in this embodiment. This arrangement has been found to distribute stresses uniformly and directly to the envelope surface and avoids the need for guy wires secured to load patches on the envelope, as is conventional in the art. In an alternative enbodiment, the envelope could, in itself, be an incomplete torus shape and attached to the upper end of member **112** and the outer extremity of the gondula, for example at the points denoted A and B in FIG. **6**. Member **112** and the gondola would then have to be designed to, in effect, complete the torus. It is believed that this configuration would offer advantages in terms of lowering the maximum stress on the envelope because the stress would then be exerted over a larger diameter area.

Gondola **110** has a central opening **114** which has substantially the same diameter as the lower end of member **112**. The fan means **30'** takes the form of a fan **116** disposed with its axis of rotation coincident with the axis of member **112** and passageway **114**.

Fan **116** is supported by a "spider" structure **120** comprising four arms **122** disposed generally mutually at right angles and extending outwardly through the gondola **110** from the center of opening **114**. The structure is held in place by virtue of the fact that the arms **122** extend through the walls of the gondola as shown at the lefthand side of the gondola in FIG. **6**. It will be understood that the gondola is shown partly sectioned in that view about a section line **124**; the portion of the drawing to the right of the section line shows the external appearance of the gondola including part of one of the propulsion units **100** while the portion of the drawing to the left of the center line shows the gondola structure in section. This latter portion of the view clearly indicates the fact that the gondola includes an inner wall **110***a* which defines the opening **114**, and an outer wall **110***b* which extends upwardly and outwardly from the lower end of the inner wall **110***a*. The arms **122** of spider structure **120** extend through openings in both of those walls. If necessary, the arms may be retained by suitable retaining means (not shown).

The space between the two walls **110***a* and **110***b* of the gondola may be used to house control equipment, fuel tanks, power supplies, etc., or even for carrying passengers in larger vehicles. For the sake of illustration, windows have been shown at **125** but, of course, need not necessarily be present.

The gondola structure and member **112** are made as bonded matrix/fiber structures as discussed previously in connection with the preceding embodiment.

Each of the propulsion units **100** is mounted at the outer end of one of the spider structure arms **122**. FIG. **7** is a vertical sectional view through a typical one of those propulsion units. The unit includes a housing **126** surrounding a reversible electric motor **128** supported by struts **130** from the housing **126**. The motor has a drive shaft which projects from both ends of the motor housing and the shaft is fitted at each end with a propellor. The two propellors are denoted respectively **132** and **134** in FIG. **7** and are positioned at 90° with respect to one another. The blades of the propellors are designed to produce equal thrust in whichever direction the motor turns.

Reversible electric motors may not be suitable for large size vehicles. Alternatives are gas or jet engines with reversible transmission systems or arrangements using two engines. Another possibility would be to use a ducted air system (vectored thrust). A still further possibility is to use a non-reversible motor or engine with a variable pitch propeller capable of being controlled to provide thrust selectively in forward or reverse directions.

FIG. **4** shows the relative orientations of the four propulsion units **100**. It will be seen that the units are spaced mutually at 90° from one another about the vertical center line C of the vehicle and are oriented so that the thrust vector of each unit is generally tangential to a notional circle drawn on that center line and passing through all four units. It has been found that this orientation of propulsion units coupled with the feature of reversibility discussed above allows for substantial maneuverability of the vehicle in flight. In an alternative embodiment, three propulsion units equally spaced around the gondola could be used.

Again, suitable control equipment will have to be provided for the propulsion units but will be essentially conventional and, for that reason, has not been shown in detail.

In summary, a vehicle of the form described above derives lift forces both from the gas within the torus shaped envelope of the vehicle and from the lift fan or fans which provide readily controllable vectored thrust for varying the altitude of the vehicle. Independent control of all directions of lateral movement (including left, right and yaw) is also provided. In addition, the embodiment of FIGS. **5** to **7** provides additional lift by virtue of the "wing effect" of air flowing over the top surface of the torus.

It has been found in experiments that the resulting vehicle is stable and controllable and capable of lifting useful, significant payloads.

By way of example, it is envisaged that a vehicle in accordance with the invention may be constructed with an envelope diameter of 140 feet and an envelope height of 55 feet, an operating altitude of 4,000 feet and a maximum forward air speed of 40 m.p.h. These dimensions of course given by way of example only and may vary in practice. The vehicle could also be built to a relatively small scale for use as a toy.

It should of course be understood that the preceding description relates to a particular preferred embodiment of the invention only and that many modifications are possible within the broad scope of the invention. For example, the specific materials referred to previously are given by way of example only and are not to be considered as limiting. Obviously, variations may also be made in the manner in which the load is suspended from the vehicle; while suspension on the center line of the vehicle is to be preferred, the load could be suspended in other ways, for example from the saddle in the case of the first embodiment or from peripheral points on the gondola in the second embodiment.

In the illustrated embodiments, the envelope of the vehicle is formed of a MYLAR fabric and there is of course no limitation to this particular fabric; within the broad scope of the invention, the envelope could even be rigid.

In the embodiment of FIGS. **1**, **2** and **3**, the arrangement for controlling the attitude of the vehicle could be changed so that the outer duct member **66** would be displaceable with respect to the inner duct member **68** instead of the reverse arrangement shown.

The engines and motors used in the vehicle need not be of the types specifically described above. For example, the engines **36** and **38** in the first embodiment need not be jet engines.

Finally, the term "torus" as used herein is to be interpreted broadly. For example, the term includes shapes such as those shown in FIG. **6** and those which result in a section through the torus having an elliptical or flattened elliptical shape. In the latter case the torus would have a shape similar to that of a "flying saucer".

We claim:

1. An air vehicle comprising:

an envelope having the general shape of a torus extending about a passageway between top and bottom surfaces of the envelope, the envelope containing a gas which is lighter than air, said passageway being of inverted generally frusto-conical shape flaring outwardly adjacent its upper end and merging smoothly into said top surface of the torus, said passageway tapering inwardly toward said bottom surface of the torus to a discharge opening in said surface on a vertical center line of the vehicle;

fan means carried by the envelope and arranged to direct air downwardly through the passageway to generate a downwardly vectored thrust for lifting the vehicle, the fan means being controllable to vary the magnitude of the thrust and hence the altitude of the vehicle in flight;

propulsion means carried by the envelope and adapted for generally lateral propulsion of the vehicle; and,

a gondola suspended from said envelope at the lower end of said passageway and supporting said fan means for drawing air downwardly through the passageway and generating said thrust, the gondola defining a central opening which is on said center line of the vehicle and coincident with said discharge opening, and through which air is directed downwardly from the passageway.

2. A vehicle as claimed in claim **1**, wherein said propulsion means comprise at least three laterally directed propulsion units supported externally on the gondola.

3: A vehicle as claimed in claim **2**, wherein four said propulsion units are provided and are disposed generally on a circle centered on the vertical center line of the envelope and arranged to generate thrust vectors each extending generally tangentially with respect to said circle, the units being arranged in pairs with the units in each pair at the opposite ends of a diameter of said circle and said diameters mutually at right angles and the thrust vectors of each pair of propulsion units generally parallel.

4. A vehicle as claimed in claim **3**, further comprising a structure carried by the gondola and comprising four limbs disposed mutually at right angles and extending outwardly from said center line, each said limb carrying one of said propulsion units at its outer end, said structure carrying said fan means generally on said center line.

5. A vehicle as claimed in claim **1**, wherein said passageway includes a rigid member of inverted frustoconical shape coupled to the envelope, and from which said gondola is suspended.

6. An air vehicle comprising:

an envelope having the general shape of a torus extending about a passageway between top and bottom surfaces of the envelope, the envelope containing a gas which is lighter than air;

fan means carried by the envelope and arranged to direct air downwardly through the passageway to generate a downwardly vectored thrust for lifting the vehicle, the fan means being controllable to vary the magnitude of the thrust and hence the altitude of the vehicle in flight;

propulsion means carried by the envelope and adapted for generally lateral propulsion of the vehicle; and,

a saddle supported on said top surface of the envelope and including at least a portion extending generally diametrally across said top surface of the envelope and carrying said fan means, portions at opposite ends of said diametral portion extending at least partially down opposite sides of the envelope and each carrying a propulsion unit disposed generally on a horizontal median plane of the envelope, said propulsion units defining said propulsion means of the vehicle,

said fan means comprising first and second fans disposed side by side and arranged to discharge downwardly into duct means forming said passageway through the envelope, said duct means comprising respective first and second ducts, each receiving air from one of said fans, and a common chamber into which said ducts discharge, said chamber receiving a pair of stacked contra-rotating, freewheeling fans for mixing of the air received from said first and second ducts, said duct means further defining a discharge duct receiving air from said chamber and from which air is directed downwardly for creating said thrust for lifting the vehicle.

7. A vehicle as claimed in claim **6**, wherein said discharge duct is of annular shape in cross-section and is defined between respective inner and outer duct members forming an annular nozzle at the outer end of said discharge duct, one of said duct members being displaceable laterally with respect to the other duct member to vary the shape of said nozzle for controlling the attitude of the vehicle, the vehicle further including actuator means coupled to said displaceable duct member for controlling its position in use according to the required attitude of the vehicle.

8. A vehicle as claimed in claim **7**, wherein said inner duct member has the general shape of a bell and is suspended at its apex within said duct whereby the inner duct member is laterally displaceable to vary the shape of said nozzle, the actuator means comprising a plurality of individual actuators extending between said inner and outer duct members at positions spaced around said annular nozzle for controlling the position of the bell-shaped inner duct member with respect to the outer duct member, said outer duct member being fixed.

9. A vehicle as claimed in claim **6**, further comprising load suspension means extending downwardly from said inner duct member and suspended from its said apex.

10. An air vehicle comprising:

an envelope having the general shape of a torus extending about a passageway between top and bottom surfaces of the envelope, the envelope containing a gas which is lighter than air;

fan means carried by the envelope and arranged to direct air downwardly through the passageway to generate a downwardly vectored thrust for lifting the vehicle, the fan means being controllable to vary the magnitude of the thrust and hence the altitude of the vehicle in flight; and,

propulsion means carried by the envelope and adapted for generally lateral propulsion of the vehicle;

wherein said passageway is flared outwardly adjacent its upper end and merges smoothly into said top surface of the torus so that air entering said passageway flows inwardly over said top surface, and wherein the vehicle further comprises a member disposed centrally in said upper end of the passageway, and shaped so that said upper portion of the passageway is annular in cross-section and includes a narrowed annular section providing a venturi effect for causing accelerated flow of induced air over said top surface of the torus, for generating lift, said central member comprising a non-rigid inflatable member containing a gas which is lighter than air for contributing to the buoyancy of the vehicle.

11. A vehicle as claimed in claim **10**, wherein said central member has the general shape of an inverted cone with a concave profile and a flat base, said base being disposed generally in a plane containing the topmost surface of the envelope, for minimizing drag caused by said member in use.

* * * * *

United States Patent [19]

Ow

[11] **Patent Number: 4,773,618**

[45] **Date of Patent: Sep. 27, 1988**

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

[76] Inventor: **Gordon J. W. Ow,** 700 East Ocean Blvd., #1604, Long Beach, Calif. 90802

[21] Appl. No.: **5,696**

[22] Filed: **Jan. 21, 1987**

[51] **Int. Cl.**[4] **B64C 29/00;** B64C 39/06

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

[58] **Field of Search** .... 244/23 C, 23 R, 12.1, 244/12.2, 73 C, 17.11, 23 B, 23 D; 416/20 R, 20 A

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Assistant Examiner—Rodney Corl
Attorney, Agent, or Firm—King and Schickli

[57] **ABSTRACT**

A high-speed vertical take-off and land (HSVTOL) aircraft comprises a disk-shaped body with a annular rotor having a rotatable fan assembly driven by redirected jet exhaust gases. The rotatable fan assembly includes fan blades, each with movable airfoil portions, and stationary flap portions with nozzles located on the trailing edges. Low pressure inflatable O-ring seals and bearings are positioned along a labyrinth interface between the disk-shaped body and the rotor. The rotatable fan assembly of the rotor is connected to an annular plenum receiving the hot exhaust gases. For vertical flight, substantially all of the hot exhaust gases of the turbojet engines are redirected into the plenum by main bypass and control bypass doors. Converging ducts located in the rotor just upstream of the rotatable fan assembly receive and direct the hot exhaust gases from the plenum to radially extending feed tubes connected to the nozzles. The rotor rotates about the disk-shaped body by the reaction force created from the emission of the exhaust gases from the nozzles. Lift of the aircraft is principally provided by the action of the fan assembly; but also by the reaction force of the hot gas from the nozzles. The primary lift force in vertical flight comes from opening the movable airfoil portion of the blades scooping ambient air into the fan assembly and causing a downwash past the stationary flap portions, which in turn provides lift. The pitch of the movable airfoil portions of the fan blades may be changed to modulate the lift. For horizontal flight, the movable airfoil portions are gradually closed to create an aerodynamic, low drag disk. The bypass doors within the jet engines are opened to allow normal jet operation and cut off flow to the fan assembly. Sufficient rotational velocity of the fan assembly is maintained during horizontal flight to maintain gyroscopic stablility. Gyroscopic attitude control is achieved through all phases of aircraft flight, both vertical and horizontal. Specifically, eyeball valves are selectively and cyclically operated to regulate the hot exhaust gases being ejected from the nozzles along the lower edge of the blades causing the aircraft to pitch and roll, as required.

15 Claims, 6 Drawing Sheets

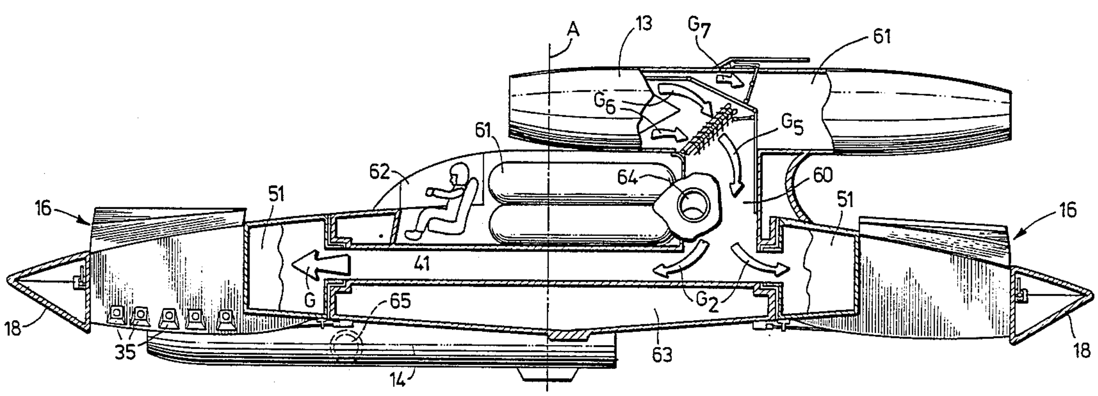


FIG.1

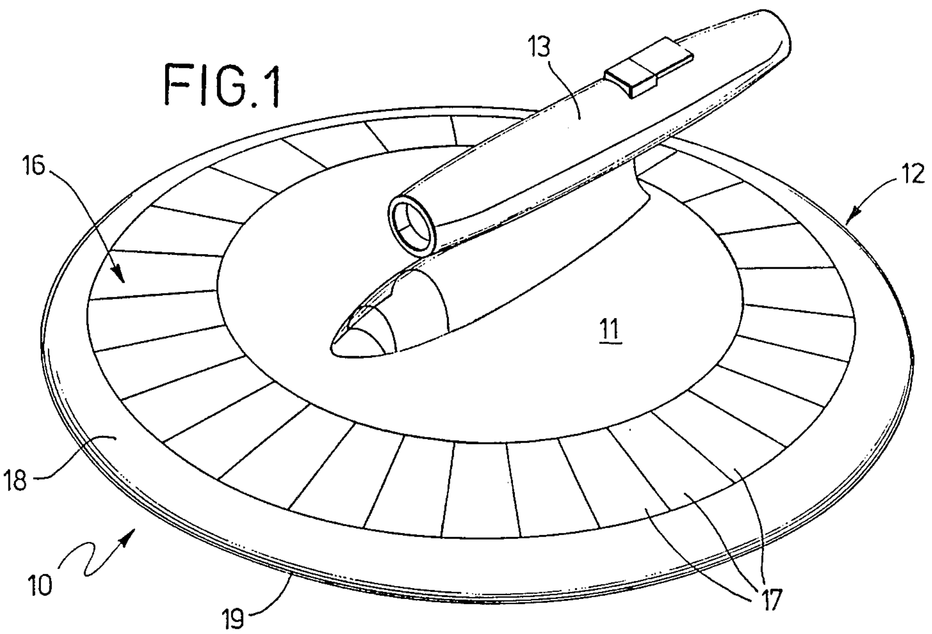
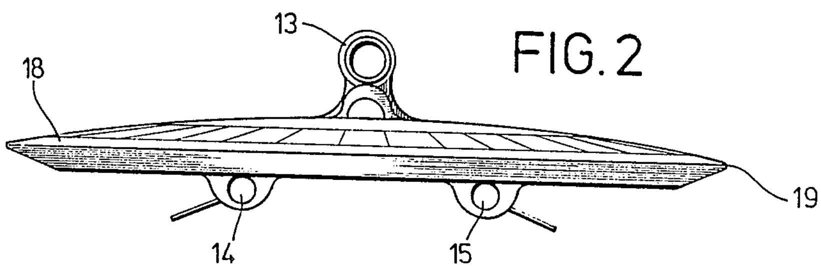


FIG.2



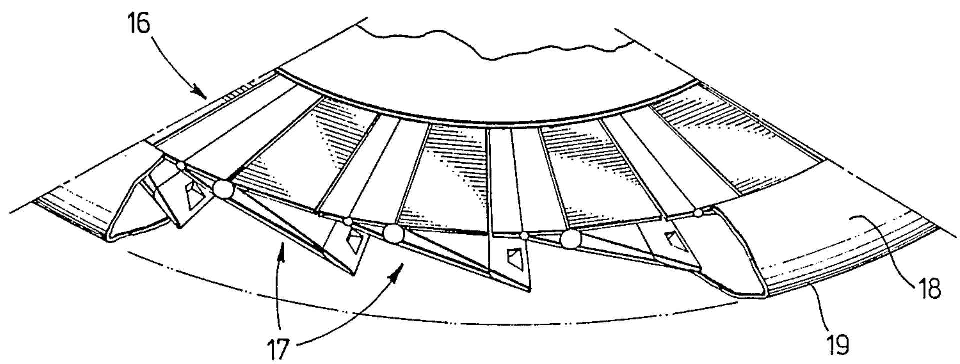


FIG.3

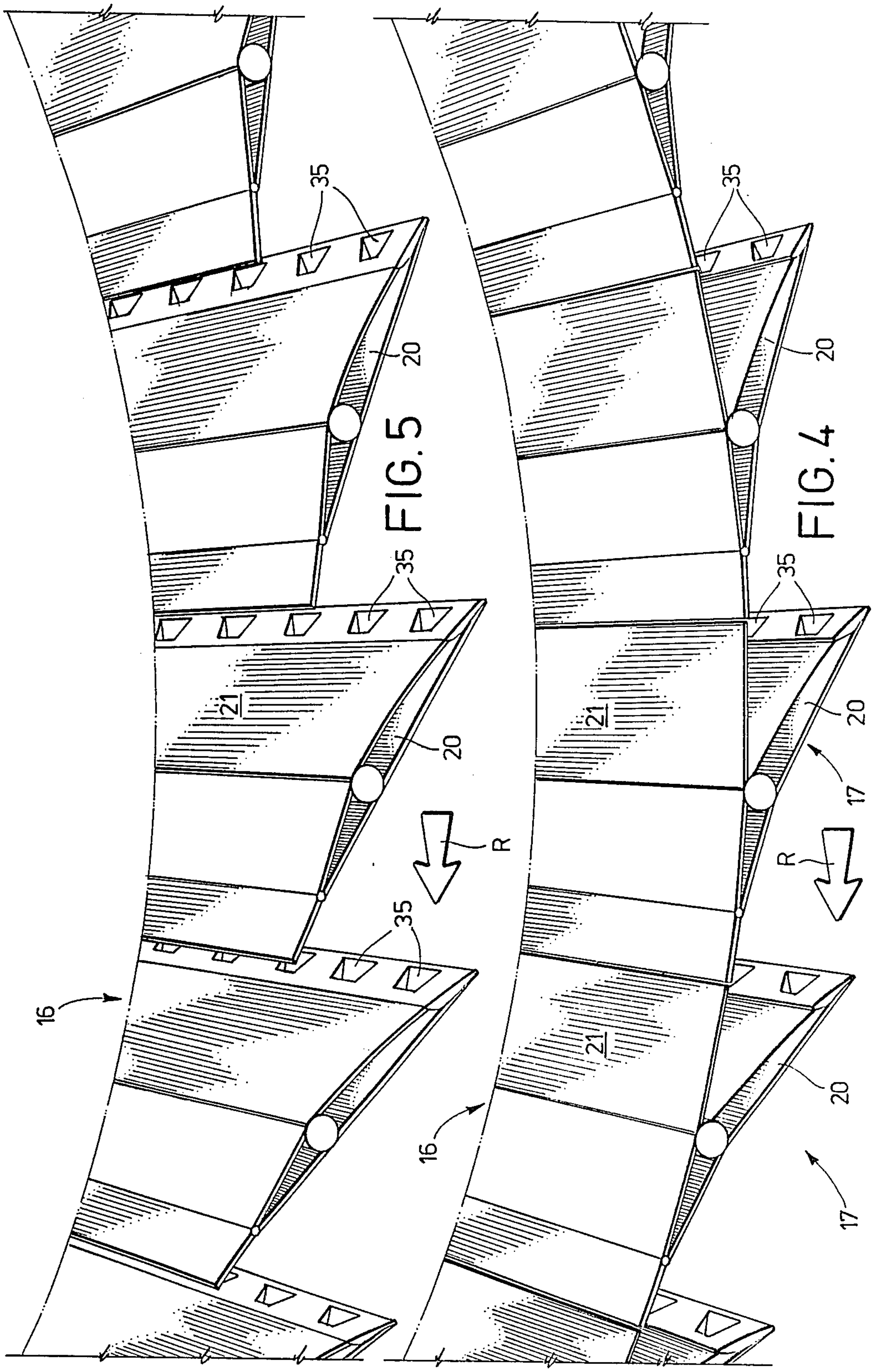


FIG. 5

FIG. 4

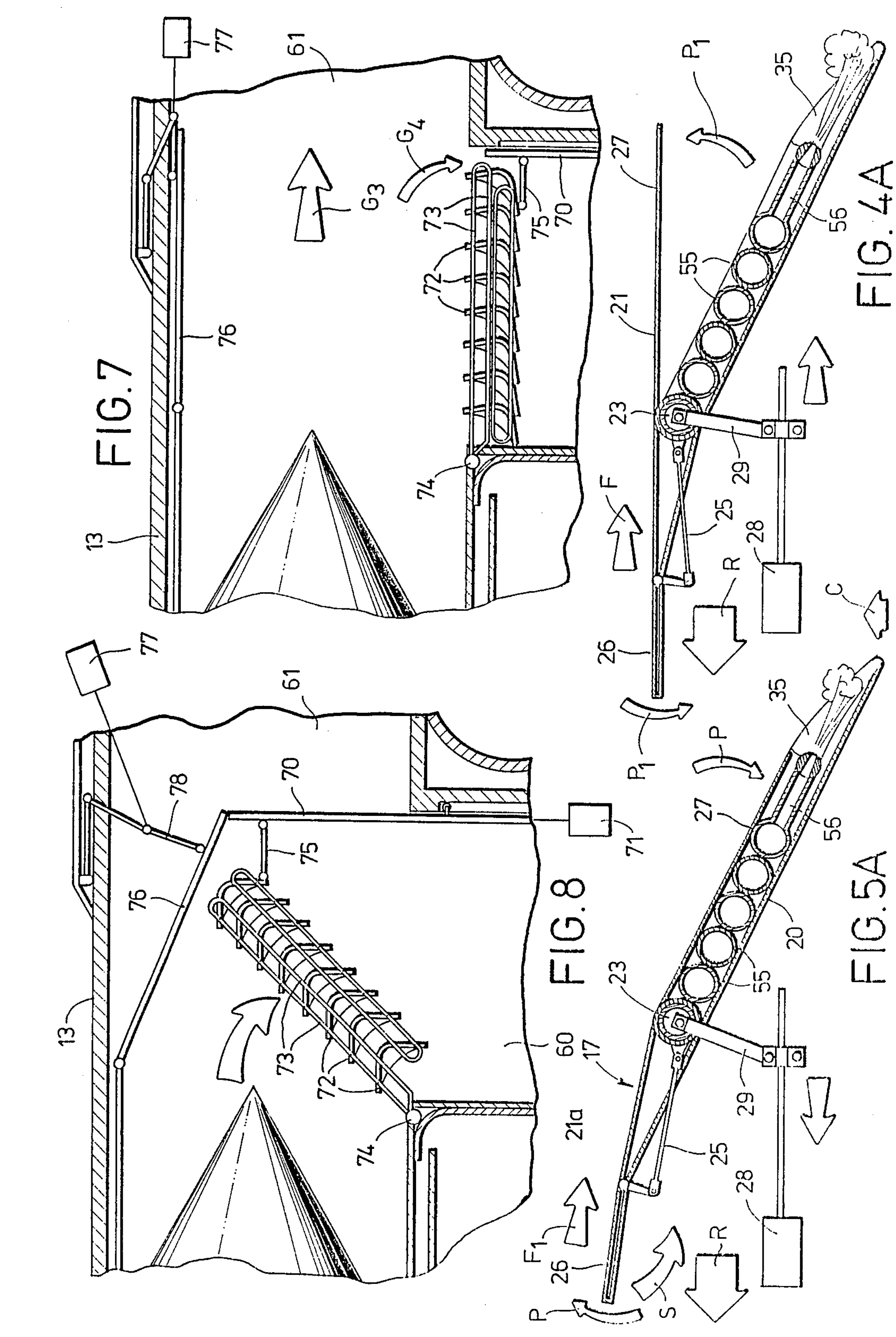


FIG. 7

FIG. 8

FIG. 4A

FIG. 5A

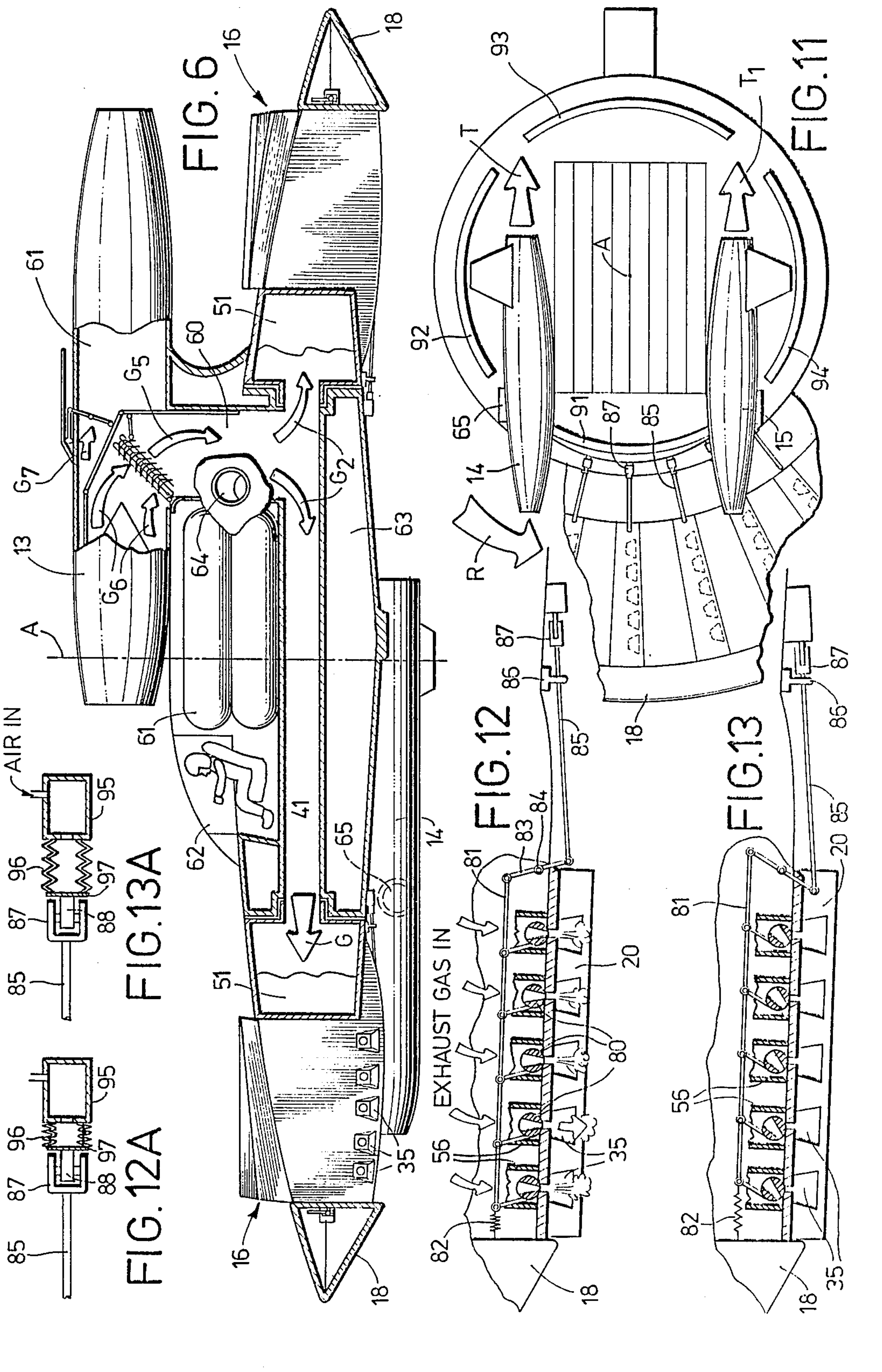


FIG. 6
FIG. 11
FIG. 12
FIG. 13
FIG. 12A
FIG. 13A
AIR IN
EXHAUST GAS IN

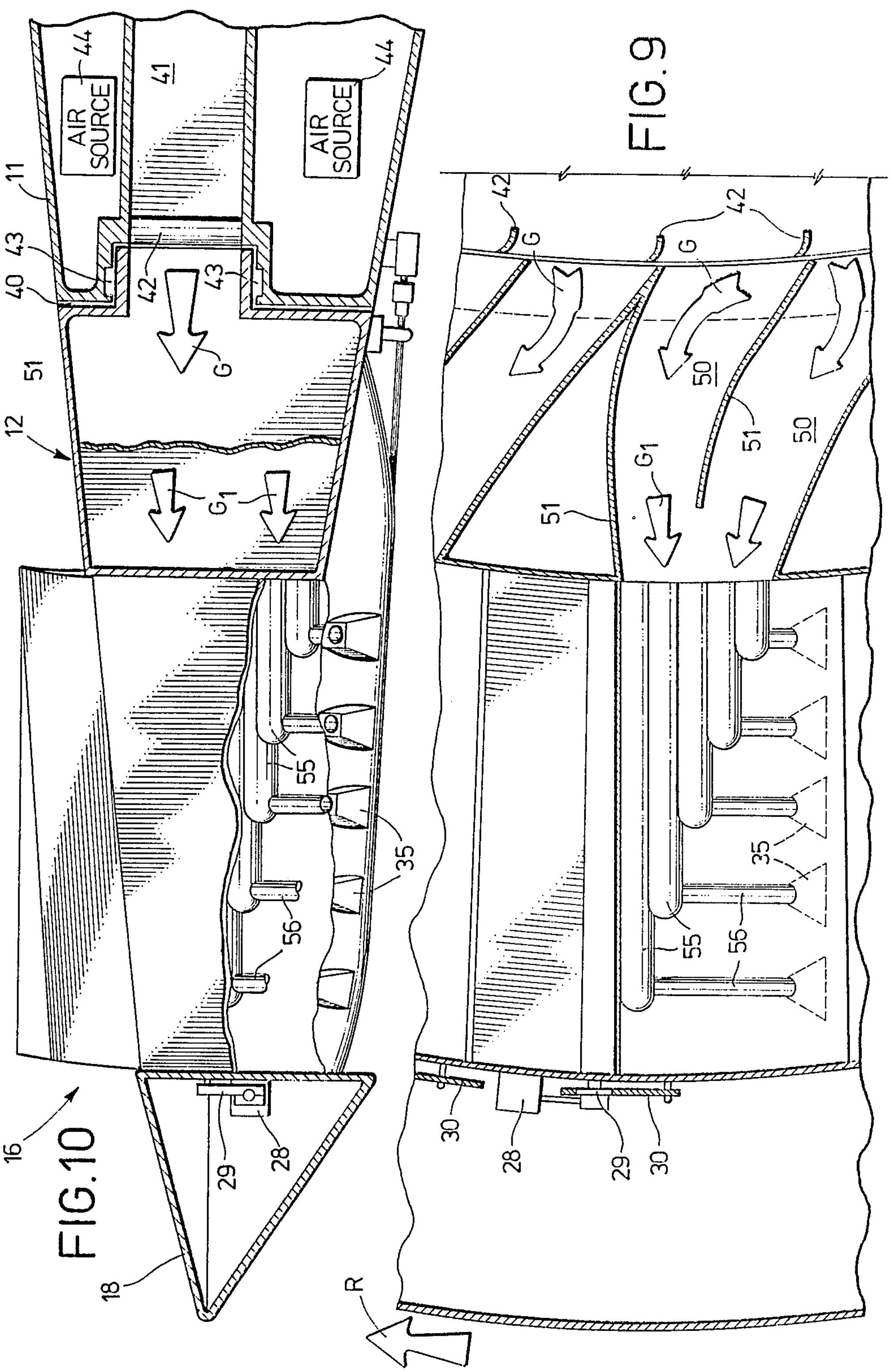


FIG.9
FIG.10
AIR SOURCE
AIR SOURCE
44
41
42
43
40
11
51
12
G
G1
50
55
56
35
28
29
30
16
18
R

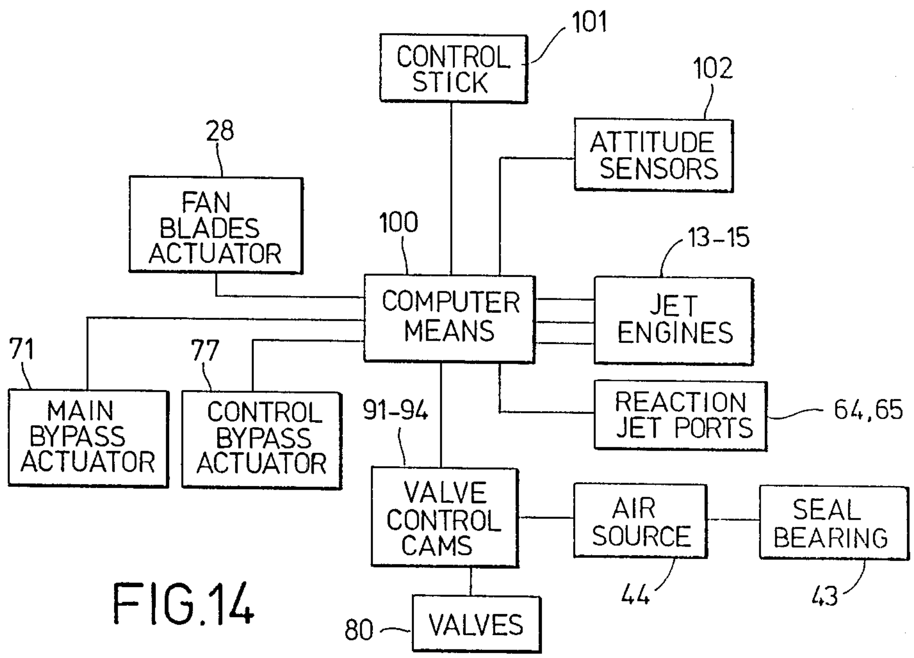

CONTROL STICK
101
ATTITUDE SENSORS
102
FAN BLADES ACTUATOR
28
COMPUTER MEANS
100
JET ENGINES
13-15
MAIN BYPASS ACTUATOR
71
CONTROL BYPASS ACTUATOR
77
REACTION JET PORTS
64,65
91-94
VALVE CONTROL CAMS
AIR SOURCE
44
SEAL BEARING
43
VALVES
80

FIG.14

HIGH SPEED VERTICAL TAKE-OFF AND LANDING AIRCRAFT

BACKGROUND OF THE INVENTION

The present invention relates to aircraft, and more particularly to an aircraft with vertical take-off and landing (VTOL) capabilities and high speed (HS) horizontal flight.

As is well known, conventional high speed winged aircraft require long runways for take-offs and landings. There are many significant disadvantages to the long runways required for take-off and landing. One such disadvantage is the vulnerability of air bases in combat zones. By simply destroying a portion of the runway, an enemy can effectively shut down an air base. This could have catastrophic effects since it removes the ability to attack from this location, often prevents those at the air base from leaving and stops incoming supplies.

Another significant military disadvantage is that conventional runways are costly and require considerable time to construct and, thus, most air bases are constructed a considerable distance from the battlefront. For this reason, considerable time and expense is required merely to fly the aircraft to the combat area.

With the need for a runway for take-off and landing, conventional aircraft must line up and wait to take off or land thus resulting in significant wastes of time in both military and domestic air travel.

Conventional aircraft are also susceptible to delays in inclement weather conditions as a direct result of the runway requirement. Traffic control is much more difficult, and snow and ice can even cause extended shutdowns of the runways.

With regard to domestic air travel, the noise created by and clearance required by ascending and descending aircraft has forced airports to be built considerable distances from the metropolitan areas that they serve. The large areas of land required for constructing the long take-off and landing runways have also forced airports to be constructed away from the metropolitan areas. In many cases, the metropolitan area has expanded to encompass the airport thus restricting growth of the airport as well as creating serious safety and health concerns.

Of course, the conventional helicopter, with its vertical takeoff and landing capabilities, overcomes these problems, but is not without its own shortcomings. Presently, helicopters are significantly restricted in their range capabilities. Helicopters also suffer generally severe payload restrictions compared to winged aircraft; and furthermore, fly at substantially less horizontal speeds than winged aircraft due to the greater aerodynamic drag created by their design.

Numerous schemes for vertical take-off and landing aircraft have been devised in an attempt to increase the horizontal speed capability. One such scheme is to have the aircraft take off in a vertical attitude similar to the Space Shuttle, and then rotate to a horizontal attitude for high speed flight. Another design is to allow the aircraft to take off and land in a horizontal attitude by providing separate engines for vertical and horizontal thrust. Take-off and landing in the horizontal attitude has also been obtained using the same engine for vertical and horizontal flight by vectoring the hot exhaust gases; i.e. either rotating the engine or redirecting the engine thrust. Several examples of existing designs for high speed vertical take-off and land (HSVTOL) aircraft as described, are the Vought TF-120, McDonnell Douglass 279-3 and General Dynamics E-7. In each case, the lift for vertical flight is obtained exclusively from the reaction force of the vectored exhaust gases.

Thus, although there are presently a relatively large number of HSVTOL designs, the prototype of these aircraft have not fully overcome the range, payload and speed shortcomings of the conventional helicopters. Furthermore, these HSVTOL or rotorcraft aircraft are not without their own inherent problems. One problem is that the thrust required for vertical take-off is more than twice the thrust needed for a conventional aircraft and, thus, the engines required are substantially twice as heavy with high fuel consumption, and are expensive to purchase and maintain. Some designs have proposed additional thrust while minimizing expense by utilizing afterburners. However, afterburners create a very hot exhaust which can shorten engine life and harm landing pad surfaces. Additionally, the heat from the exhaust is sometimes reflected upward and is sucked back into the engine causing a loss of power.

Another problem with current HSVTOL designs is the lack of efficient attitude control of the aircraft during both vertical and horizontal flight. The most widely used method to control the attitude presently is a pure reaction control system wherein the exhaust nozzle of the jets is simply moved. This redirects the hot exhaust gas in the manner necessary to pitch and/or roll the aircraft. Usually, this control system is coupled with a separate system of small, compressed air control jets. Because of the lack of stability of these prior aircraft, both are usually required. This increases the cost of the aircraft and is generally inefficient.

In order to attain vertical flight with current HSVTOL aircraft utilizing the reaction jets as described, it is necessary to have the jet engines located as close as possible to the center of gravity. This design requirement greatly increases the control problems and the drag on the aircraft during horizontal flight. Finally, during take-offs and landing, the concentrated vertical stream of exhaust gases being expelled directly from the jet engines causes loose objects on the ground to kick up resulting in damage to the aircraft, commonly referred to as foreign object damage (FOD).

SUMMARY OF THE INVENTION

Accordingly, it is the primary object of the present invention to provide an improved vertical take-off and landing aircraft with enhanced control capabilities in both vertical and horizontal flight, and high-speed, low-drag capability in horizontal flight including supersonic speeds.

Another object of the present invention is to provide a HSVTOL aircraft with the range and payload capability comparable to horizontal take-off and land conventional aircraft.

Another object of the invention is to provide an HSVTOL aircraft with enhanced vertical take-off capabilities with positive attitude control without utilizing primarily downwardly directed hot exhaust gases.

Another object of the present invention is to provide a HSVTOL aircraft including a peripheral rotor including a fan assembly with operable fan blades to provide the primary upward lift during vertical flight and minimizing foreign object damage.

Still another object of the present invention is to provide a HSVTOL aircraft capable of control based on gyroscopic principles in all phases of flight.

Another object of the present invention is to provide a VTOL aircraft that is stabilized by gyroscopic action during both vertical and horizontal flight operations.

Still another object of the present invention is to provide a HSVTOL aircraft wherein attitude control is obtained by differential thrust from nozzles on rotating fan blades resulting in gyroscopic precession of the aircraft.

Another object of the present invention is to provide a VTOL aircraft that can efficiently perform vertical and horizontal operations in the same attitude and operate with a smooth transition between the two operations.

Additional objects, advantages and other novel features of the invention will be set forth in part in the description that follows and in part will become apparent to those skilled in the art upon examination of the following, or may be learned with 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.

In order to achieve the foregoing and other objects, and in accordance with the purposes of the present invention as described herein, an improved aircraft particularly adapted for supersonic speed is provided with highly efficient vertical take-off and landing capabilities. In one aspect of the invention, a disk-shaped body is provided upon which jet engines are mounted. A feed duct extends from each of the jet engines into a plenum that receives and redirects the hot exhaust gases toward the outer periphery of the body. A rotor extends around the outer perimeter receiving the hot gases from the plenum.

The rotor includes a fan assembly having a plurality of airfoil-shaped blades which extend radially outward. Converging ducts in the rotor just upstream of the fan assembly receive the hot exhaust gases from the plenum for transfer to passages in the fan blades. The gases are then ejected from nozzles on the trailing edges of the fan blades. The emission of the hot exhaust gases from the nozzles provides the thrust for rotation of the fan assembly which in turn provides the lift for the aircraft in the vertical take-off/landing mode. Since the lift is primarily obtained by fan action, that is by the downwash of air causing lift on top of the fan blades, the adverse effects of using direct engine thrust, such as foreign object damage (FOD), suck down due to loss of power by the intake of hot exhaust gases and burning of the landing pad area, do not occur.

In another aspect of the invention, the fan blades include fixed and movable portions. The pitch of the movable portions may be varied in order to modulate the desired vertical lift. For horizontal flight, the movable portions of the fan blades are closed to create a low-drag, aerodynamic disk capable of supersonic speeds. Substantially all of the exhaust of the jet engines may be redirected through the engine exhaust nozzle to maximize the horizontal flight capability.

In a further specific aspect of the invention, valve means are provided for cyclically controlling the ejection of hot gases from the nozzles on the fan assembly providing attitude control of the aircraft. These valve means, preferably rotatable eyeball valves, are controlled by air actuated cams positioned in the quadrants around the periphery of the disk-shaped body. As the rotor rotates around the body, operating linkage activated by the cams cyclically controls the eyeball valves. The differential thrust provided by actuation of the valves provides gyroscopic precession of the aircraft axis. In accordance with gyroscopic principles, when the valves of one nozzle array are closed, the reduction in thrust in that particular quadrant coupled with the increased thrust in the other quadrants operates to provide a roll and/or pitch action in the quadrant spaced substantially 90 degrees therefrom.

The jet engines may be operated with differential thrusts in conjunction with reaction jet ports to provide the counter torque required to offset the spinning action of the rotor.

In still another aspect of the invention, main bypass and control bypass doors are provided in the jet engines to direct the hot exhaust gases into the feed duct and then into the plenum. Substantially all of the exhaust gases pass into the rotor and are ejected through the nozzle arrays on the fan blades providing maximum rotation to the rotor during the vertical operation sequences. The main bypass door closes first providing initial redirection of the gases and after the rotor picks up speed the control bypass door closes to provide for a smooth transition. Preferably, turning vanes are provided at the juncture between the feed duct and the jet engine nozzle to assist in redirection of the exhaust gases when the bypass doors are closed.

The rotor is connected to the disk-shaped body by a labyrinth seal that may include a low-pressure air-inflatable seal/bearing.

An outer ring on the rotor houses an operating crank and actuator for the movable airfoil portion of the fan blades. For maximum vertical lift, the airfoil portions are opened a maximum amount in order to increase the mass flow and velocity of the air. When open, the trailing section of the movable airfoil portion coincides with the upper surface of the stationary flap portion providing a highly efficient airfoil across the top of the entire fan blade. When closed, the movable blade portion seals the entire fan assembly area thus forming a low drag, aerodynamic surface across the entire upper surface of the disk-shaped aircraft.

Still other objects of the present invention will become readily apparent to those skilled in this art from the following description wherein there is shown and described a preferred embodiment of this invention, simply by way of illustration of one of the modes and alternative embodiments best suited to carry out the invention. As it will be realized, the invention is capable of other different embodiments, and its several details are capable of modifications in various, obvious aspects all without departing from the invention. Accordingly, the drawings and descriptions will be regarded as illustrative in nature and not as restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings incorporated in and forming a part of this specification, illustrate several aspects of the present invention, and together with the description serve to explain the principles of the invention. In the drawings:

FIG. **1** is a perspective view of the vertical take-off and landing aircraft of the invention illustrating the aerodynamic design of the disk-shaped craft and with the fan assembly completely closed for horizontal flight;

FIG. 2 is a front view of the aircraft of FIG. **1**;

FIG. **3** is a partial, front perspective view of the aircraft of the invention with the outer ring of the rotor broken away along the leading edge to illustrate the position of the fan blades when closed;

FIG. **4** is a much enlarged perspective view of the fan blades similar to that shown in FIG. **3** with the fan blades in the closed position and sealed along the upper surfaces of the aircraft;

FIG. **4A** is a cross-sectional view of the fan blade with the movable portion in the closed position;

FIG. **5** is a much enlarged view similar to FIG. **4** but with the fan blades shown in the open position for scooping ambient air into the fan assembly and providing lift as the air flows over the upper airfoil surface of the fan blades;

FIG. **5A** is a cross-sectional view of the fan blade showing the movable airfoil portion in the raised or open mode;

FIG. **6** is a side view of the aircraft partially in cross-section showing the body in the center and the rotor with the fan assembly around the outer perimeter with the fan blades in the open position;

FIG. **7** is an enlarged detail of the main and control bypass doors in the jet engine, positioned in the open position;

FIG. **8** is an enlarged view of the main and control bypass doors in a closed position to direct the hot exhaust gases into the feed duct of the aircraft;

FIG. **9** is an enlarged partial cross-sectional view taken along a substantially horizontal plane through the rotor;

FIG. **10** is an enlarged cross-sectional view taken along a substantially vertical plane of the rotor;

FIG. **11** is a bottom view of the aircraft showing a partial section only of the rotor and the positioning of the cams for cyclically controlling the hot gas ejection from the nozzles;

FIG. **12** is a cut-away sectional view showing the eyeball valves for controlling the ejection from the nozzles and the control linkage;

FIG. **12A** is an enlarged cross-sectional view of the control cam to position the valves in the open mode;

FIG. **13** is a partial cut-away view showing the eyeball valves in the position for cutting off the flow of exhaust gases;

FIG. **13A** is an enlarged cross-sectional view of the cam with the cam plate extended to effect the cut off of the eyeball valves; and

FIG. **14** is a schematic diagram in block form showing the control system of the aircraft of the present invention.

Reference will now be made in detail to the present preferred embodiment of the invention, an example of which is illustrated in the accompanying drawings.

DETAILED DESCRIPTION OF THE INVENTION

With reference now to FIG. **1** of the drawings, there is shown an aircraft **10**, including a central, disk-shaped body **11** and an outer annular rotor **12**. A turbojet engine **13** is mounted on top of the body **11**. With reference to FIG. **2**, a pair of jet engines **14**, **15** may be mounted on the underside of the body **11**.

As shown in FIG. **1**, and as more clearly shown in FIG. **3**, the rotor **12** includes an annular fan assembly **16** including a plurality of individual fan blades **17**. In both FIG. **1** and FIG. **3**, the blades are shown in the closed position providing a smooth upper surface of the aircraft **10** presenting a low drag, aerodynamic surface for efficient, high speed horizontal flight. An outer annular ring **18** presents an aerodynamic leading edge **19**, also contributing to the efficient high speed horizontal flight (see also FIG. **2**).

As best shown in FIGS. **4** and **4A**, the individual fan blades **17** of the fan assembly **16** include a stationary flap portion **20** and a movable airfoil portion **21**. In the closed position of the blades, the air flow is straight across the upper surface of the airfoil portion **21**, as shown by the flow arrow F in FIG. **4A**. As is evident in FIG. **4**, this air flow F is thus not interrupted as it moves from the leading edge **19** back across the disk-shaped body **11**. In this manner, the aerodynamic upper surface of the aircraft **10** is maintained for efficient flight in the horizontal or cruise mode. As will be more evident below, during this mode, the fan assembly does continue to rotate, but at a considerably reduced rotational velocity than that during vertical flight, as depicted by the rotation arrow R, selected to be in the clockwise direction of the preferred embodiment.

To switch the fan assembly to the maximum lift mode for vertical flight, the movable airfoil portion **27** is pivoted on the support shaft **23** in the direction of pivot arrows P (see FIG. **5A**). This opening of the fan blades **17** allows ambient air along the upper aerodynamic surface to be scooped into the fan assembly **16**, as shown by the arrow S in FIG. **5A**. This scooping action causes downwash of the air and increased velocity air flow F_1 over the adjacent upper surface of the airfoil portion **21**. This lift force thus provides the primary lift of the aircraft **10** in a unique and efficient manner.

Secured to the support shaft **23** is a fixed linkage **25** that provides a slight downward angle to the leading section **26** of the movable airfoil portion **21***a* in the open position of the fan blade. This pivoting action of the forward section **26** provides a more efficient airfoil shape and thus more lift to each of the fan blades. When the shaft **23** is rotated in the opposite direction to return the movable airfoil portion to the sealed position, or the closed position of the fan blade **17** (see FIG. **4A**), the leading section **26** is brought back into substantial alignment with the remainder of the airfoil portion **27** (see pivot arrows P_1).

Advantageously, in order to further improve the aerodynamics of the fan blades **17**, the trailing section **27** is designed to mate with a recess in the upper surface of the stationary flap portion **20** (compare FIGS. **4A** and **5A**). The pivoting action P, P_1 is caused by a suitable hydraulic or electrical actuator **28** moving a lever **29** for closing/opening action (see FIGS. **4A** and **5A**, respectively). As best shown in FIG. **10**, the fan blade actuator **28** is preferably mounted in the outer ring **18**. The actuators **28** may be provided individually for the fan blades **17**, or several blades can be operated from a single actuator. In either case, the operation of the blades are synchronized by a circular connector, such as a cable **30**, shown in FIG. **9**, but broken away for clarity.

Formed in the trailing edge of each of the stationary flap portions **20** of the fan blades **17**, is a plurality of thrust nozzles **35** (note in particular FIGS. **4**, **4A**, **5**, **5A**). It is the hot exhaust gases from the jet engines **13**–**15** redirected through the aircraft **10** that are emitted from the nozzles **35** to provide the driving force for the fan assembly **16** causing the rotation R. As will be realized, the substantial volume of hot gases from the engines is divided substantially equally among the array of nozzles **35** on each blade **17** and of course divided by the number of blades. With this in mind, it can be recognized that a substantial rotating force for turning the rotor **12** of the aircraft **10** is generated, but that the concentrated thrust from any one individual nozzle **35** is minimized. With the lift being generated by the fan action and the thrust from the hot gases being dispersed over the large number of nozzles **35**, the aircraft **10** of the present invention is much less susceptible to foreign object damage and the other shortcomings of the same type generally experienced by previous HSVTOL designs, as described above. However, the upward lift due to the thrust of the hot gases being emitted from the nozzles **35** is successfully utilized in attitude control of the aircraft, as will be explained in more detail below.

A labyrinth interface **40** is formed between the disk-shaped body **11** and the rotor **12**, as best shown in FIG. **10** of the drawings. The hot exhaust gases from the engines **13-15** is flowing from a circular plenum **41** at this point around an annular opening that is defined by a plurality of stator blades **42**. If necessary, a combined inflatable O-ring seal/air bearing **43** may be included at the interface **40** supplied by a suitable air source **44**. As shown in FIG. **10**, upper and lower seal/air bearing combination may be provided.

The fan assembly **16** is connected to the plenum **41** by converging transfer ducts **50** formed by curved vanes **51** (see FIGS. **9** and **10**). Thus, these converging ducts **50** positioned just upstream of the fan assembly **16** receive and direct the hot exhaust gases from the plenum **41** and into the stationary flap portion of the individual blades **17** (note gas flow arrows G, G_1 in FIGS. **9** and **10**). The hot exhaust gases then enter a plurality of progressive length feed tubes **55** extending transversely across the flap portion **20** of the blades. Each of the feed tubes **55** is connected to the respective nozzles **35** through outlet tubes **56** (see primarily FIGS. **4A**, **5A**, **9** and **10**).

The hot exhaust gases G are supplied to the plenum **41** through a feed duct **60** extending from the jet engine **13**, as best shown in FIG. **6** of the drawings. The feed duct **60** that extends from the exhaust nozzle **61** of the engine **13** to the plenum **41** redirects the exhaust gases, as shown by the gas flow arrows G_2. Immediately forward of the feed duct **60**, fuel tanks **61** are shown; and immediately forward of these is cockpit **62** for the pilot. The main payload area **63** is positioned beneath the disk-shaped plenum **41**.

If found necessary or desirable, a reaction jet port **64** may be provided in communication with the feed duct **60** to provide thrust counterbalancing of the rotational effect of the rotor **16**. Additional jet ports, such as jet port **65** in the exhaust nozzle of the jet engine **14** may be provided as necessary (see FIG. **11**). The jet engines **14**, **15** can also be operated with differential thrust from their respective exhaust nozzles in order to provide some counterbalancing, as shown by thrust arrows T, T_1 in FIG. **11**.

With reference to FIGS. **7** and **8** of the drawings, a fuller understanding of the redirection of the hot control gases to the plenum **41** for feeding the thrust nozzles **35** can be more fully understood. As previously explained, the feed duct **60** supplies the exhaust gas into the plenum **41**, as shown by the arrows G_2 (see FIG. **6**). It is noted that the additional jet engines **14**, **15** also include feed ducts extending into the disk-shaped body **11** in the same manner as feed duct **60**; however, for simplicity of the description these additional ducts have not been illustrated. Extending down into feed duct **60** is a main bypass door **70** which is slidable along a suitable track along the rear face of said duct. When the door **70** is withdrawn into the duct **60**, the exhaust nozzle **61** of the jet engine **13** is fully open and the hot exhaust gas can flow directly out of the engine to provide thrust for the aircraft **10** in the cruise mode (see exhaust gas arrow G_3 in FIG. **7**). During the cruise mode some hot exhaust gas is supplied into the feed duct **60** as shown by the smaller gas flow arrow G_4 (FIG. **7**). The exhaust gas flow G_4 is sufficient to maintain the rotation of the fan assembly **16**, at a reduced speed, to provide continuous gyroscopic stability to the aircraft in the cruise mode. As will be further explained below, this gyroscopic action even during horizontal flight does, in addition to providing stability, allow for attitude control of the aircraft.

With reference to FIG. **8**, when the aircraft is ready for vertical flight, either during transition from the cruise mode or horizontal flight to the landing mode or for take-off, the main bypass door **70** is first raised to block a portion of the passage of the exhaust nozzle **61**. The bypass door **70** is raised by a suitable main bypass actuator **71**. As shown in FIG. **8**, approximately **60** percent of the exhaust nozzle **61** is blocked by the main bypass door **70**. In the transition mode from horizontal flight, the main bypass door is raised first and as will be realized this leaves approximately **40** percent of the nozzle open for continued forward thrust. In this manner, the aircraft can be slowed and then brought into a hover or vertical flight mode in a very efficient manner.

In order to best provide redirection of the hot exhaust gases into the feed duct **60** just upstream of the main bypass door **70**, there is provided a gang of turning vanes **72** mounted on a movable support frame **73**. The frame is supported at the lower end by a pivot **74** and is connected to move with the bypass door **70** by a single pivoted link **75** (see FIG. **8**).

The remaining **40** percent of the exhaust nozzle **61** is adapted to be blocked by control bypass door **76** in response to control bypass actuator **77** operating elbow linkage **78** (see FIG. **8**). In operation, with the control bypass door **76** and the main bypass door **70** closed, as shown, substantially all of the hot exhaust gas is directed into the feed duct **60** for transfer to the nozzles **35** where it can then be used for spinning of the rotor **12** and converted into vertical lift. As shown in FIG. **6**, this exhaust gas is shown by flow arrow G_5. Exhaust gas G_6, just upstream of the turning vanes **35** includes all of the output of the engine **13** except for a small amount G_7 entering the exhaust nozzle **61** to assist in maintaining stability of the craft.

It is to be understood that the hot exhaust gas flow from the jet engines **14**, **15** to supplement that shown with respect to jet engine **13** is substantially the same and thus need not be described in detail. The feed ducts from these two additional engines would feed into the plenum **41** and supply additional rotational power to the rotor **12** providing the substantial vertical lift that characterizes the aircraft **10** of the present invention. Significantly, the jet engines **13-15** do not have to be oversized thus providing significant weight savings and more efficient hovercraft operation.

As previously indicated, the primary function of the nozzles **35** ejecting the hot exhaust gases is to spin the rotor **12** providing lift to the aircraft **10** by the air flow F_1 across the airfoil portions **21** of the fan blades **17** (see

FIG. 5A). In addition to providing the spinning thrust for the rotor **12**, there is also some upward lift provided by the reaction force of the escaping exhaust gas. Assuming that the stationary flap portion **20** is extending at a 30-degree angle from the horizontal, in addition to the thrust providing the rotation R (see FIG. 5A) the exhaust gases from the nozzles **35** provide an upward reaction lift component C (see FIG. 5A also). This lift component C is significant in providing attitude control of the aircraft by varying the exhaust gas being emitted from one or more of the arrays of nozzles **35** on the blades **17**. The manner in which this control is effected, will now be described in detail.

As best shown in FIGS. **12** and **13**, the array of nozzles **35** extending along the trailing edge of the stationary flap portion **20** includes a corresponding plurality of eyeball valves **80**, suitably mounted in the base of the outlet tubes **56**. Each of the valves **80** is gang coupled to an operating linkage **81** including a tension spring **82** tending to force the valves **80** to the open position, as shown in FIG. **12**. The operating linkage **81** is shifted by a crank lever **83** pivoted at point **84**. An actuator rod **85** slidable in a suitable guide **86** carries a cam follower **87** on its distal end. As shown in FIG. 12A, the cam follower includes a roller **88** or other suitable element to engage the cam operator.

As will be clear, each of the eyeball valves **80** remains open under normal conditions unless the actuator rod **85** is shifted in the guide **86** (to the left in FIG. **12**). Thus, unless some control is required, during vertical flight the maximum lift force is available around the full periphery of the aircraft. The spinning rotor **12** provides gyroscopic stabilization tending to keep the aircraft level at all times. Those attitude changes that must be made during the flight are uniquely carried out in accordance with the present invention by the mounting of four cams, one in each quadrant of the aircraft, and illustrated in FIG. **11** on the bottom view of the aircraft. Cam **91** is on the forward quadrant; cam **92** is on the left side quadrant; cam **93** is on the rear or aft quadrant; and cam **94** is on the right quadrant. As shown in this bottom view, the direction of rotation R is still assumed to be in the clockwise direction.

For illustrative purposes, the cams **91–94** include a hollow cam body **95** for receiving compressed air from the air source **44**. An expansable chamber is formed along the outer perimeter of the body **95** by a bellows **96** supporting a cam plate **97** that engages the roller **88**. In order to provide the eyeball valves **80** in the open position, the cam plate **97** is retracted, as shown in FIG. **12A**, and the full thrust of the escaping exhaust gases is realized on each of the fan blades **17** in that particular quadrant. As shown in FIG. **11**, the fan blades **17** in the right, left and rear quadrants, where the cams **92**, **94** and **93**, respectively, are not actuated, the full reaction thrust and lift component C (see FIG. 5A) is realized.

However, the cam **91** along the forward quadrant is actuated by entry of compressed air into the body **95** and expanding the bellows **96** to project the cam plate **97** in the outward direction against the cam follower **87** and roller **88**. The rod **85** is thus shifted against the spring **82** causing the valves **80** to close, as shown in FIG. **13**. When this occurs, the lift component C is reduced along the leading edge of the aircraft. In accordance with gyroscopic control principles, this reduction in lift causes a shifting of the aircraft at a position 90 degrees from the correction. In FIG. **11**, remembering that this is a bottom view and that the rotation R is in the clockwise direction, the axis A of the aircraft is induced by gyroscopic precession to shift so that the left side of the aircraft is subject to a lift force. Thus, during operation, if a roll correction is required to raise the left side of the aircraft, then through gyroscopic control the cam **91** is actuated, reducing the reaction lift along the leading edge of the aircraft and providing the corrective action as desired. The reaction thrust from the nozzles **35** is designed to assure sufficient differential thrust to gyroscopically control the attitude of the aircraft by induced precession of the axis A. Pitch is controlled in a similar manner by operating one of the cams **92, 94**.

Under operational conditions of the aircraft **10**, a computer means **100** is employed to control the cams **91–94** and thus operate the valves **80**, cyclically in the proper manner (see the schematic diagram in FIG. **14**). The pilot provides the input to the computer **100** through a control stick **101** so that the aircraft **10** can also be maneuvered by actuation of the cams **91–94** to thus give the proper attitude change. The computer means **100** is designed to maintain the stability of the aircraft by making automatic changes in response to strategically located attitude sensors **102**. The manner in which the computer means **100** also controls the jet engines **13–15**, the reaction jet ports **64**, **65**, the actuators **71**, **77** for the bypass doors and the fan blades actuator **28** is also shown in FIG. **14**.

From the foregoing description of my invention, it will be realized that significant advantages flow from the design of the aircraft **10**. With substantially less bulk and weight, and with significantly less power requirement, the aircraft is capable of pure vertical flight, as well as horizontal flight that may be high speed, and even supersonic, if desired. The lift during vertical flight is provided by rotation of the rotor **12** including the fan assembly **16**. The blades **17** are opened to scoop ambient air in between the adjacent blades and provide downwash under the aircraft and lift as the air flows over the airfoil portion **26**, **21*a*** and **21** of the blades **17**. The hot exhaust gases are directed from an array of nozzles **35** on the trailing edge of each stationary flap portion **20** of the blades **17** (see FIGS. 4A and 5A). The hot exhaust gases are provided through a unique system including a feed duct **60**, a plenum **41** and passages within the rotor **12** (see FIG. **6**). The bypass doors **70**, **76** may be operated in a unique manner in order to drive the fan assembly **16** when required and then provide maximum forward thrust when horizontal flight is desired. The arrangement provides for a smooth transition through sequential operation of the doors **70**, **76** that each block a portion of exhaust nozzle **61** of the engine **13**. Because of the absence of high intensity, direct exhaust extending downwardly into the landing area, the aircraft is significantly more stable and the problem of foreign object damage and such down of the aircraft are minimized.

Control of the attitude of the aircraft is by cyclic control of the reaction thrust being emitted from the nozzles **35** in response to the cams **91–94** positioned in the quadrants of the aircraft (see FIG. **11**). The computer means **100** processes the signals from the control stick **101** as well as from attitude sensors **102** positioned on the aircraft in order to provide the desired more efficient control. The end result is not only a highly stable aircraft **10**, but also one that is characterized by superior maneuverability.

The foregoing description of a preferred embodiment of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Obvious modifications or variations are possible in light of the above teachings. The embodiment was chosen and described to provide the best illustration of the principles of the invention and its practical application to thereby enable one of ordinary skill in the art to utilize the invention. Utilization can be in various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims appended hereto.

I claim:

1. A high-speed vertical take-off and land aircraft comprising:

a disk-shaped body;

a jet engine including an exhaust nozzle mounted on said body;

duct means for receiving and redirecting the hot exhaust gases from the jet engine;

an annular rotor having a rotatable fan assembly concentric with the body;

said fan assembly including a plurality of blades to provide vertical lift for said aircraft; said blades being airfoil-shaped and operative to scoop ambient air causing a downwash to maximize the lifting forces;

passage means in said blades for receiving the hot exhaust gases from said duct means; and

nozzle means connected to said passage means located on said blades to eject said exhaust gases to provide rotation to said fan assembly; whereby primary lift for the aircraft is provided by lift forces on said blades upon rotation of said fan assembly.

2. The high-speed vertical take-off and land aircraft of claim **1**, wherein said blades include a movable airfoil portion; and means for moving said airfoil portion to open the fan blades to scoop air and provide lift over the upper surface of said airfoil portion and also to close the blades and allow low drag, horizontal flight.

3. The high-speed vertical take-off and land aircraft of claim **2**, further comprising:

fixed flap portions extending downwardly to provide the downwash of air and the lift of the aircraft in vertical flight; said nozzle means including a plurality of nozzles formed on the trailing edge of said flap portion.

4. The high-speed vertical take-off and land aircraft of claim **1**, wherein said duct means includes a feed duct extending from the jet engine to receive substantially all of the exhaust gas from the exhaust nozzle of the jet engine;

plenum means for receiving the gas from the feed duct; and seal/bearing means between said plenum and the rotatable fan assembly to allow efficient transfer of the exhaust gas to the nozzle means.

5. The high-speed vertical take-off and land aircraft of claim **4**, wherein said annular rotor includes transfer ducts for feeding said exhaust gas to the passage means in said blades and ejection of exhaust gases from said nozzle means.

6. The high-speed vertical take-off and land aircraft of claim **5**, wherein said nozzle means includes a plurality of nozzles on the trailing edge of each of said blades, passage means in said blades formed by a series of progressively elongated feed tubes;

outlet tubes connected to said feed tubes to provide the exhaust gases to respective nozzles.

7. The high-speed vertical take-off and land aircraft of claim **1**, wherein is provided valve means in said passage means for controlling the flow of exhaust gases from the nozzles.

8. The high-speed vertical take-off and land aircraft of claim **1**, wherein said duct means for directing the exhaust gases comprises

a feed duct extending from the jet engine;

bypass door means in said jet engine for closing the exhaust nozzle and directing the flow to said feed duct;

actuator means for moving said bypass door means; and

turning vane means adjacent said bypass door means for redirecting the gas into the feed duct.

9. The high-speed vertical take-off and land aircraft of claim **8**, wherein said bypass door means includes a main bypass door to block at least a portion of the flow from the engine exhaust nozzle; a separate control bypass door to block an additional portion of the flow from the engine; and actuator means for separately moving said bypass doors, whereby the bypass of hot gases can be made progressive for transition between vertical and horizontal flight.

10. A high-speed vertical take-off and land aircraft comprising:

a disk-shaped body;

a jet engine on said body; a rotor extending around the periphery of the body;

a fan assembly including a plurality of fan blades on said rotor for providing downwash of ambient air providing lift to the aircraft;

nozzle means in said blades to provide turning of the rotor;

duct means for feeding hot exhaust gases from said jet engine to said nozzle means;

valve means for selectively regulating the flow of exhaust gases from said nozzle means; means to provide a differential thrust on opposite sides of the aircraft;

said flow providing sufficient differential thrust to gyroscopically control the attitude of said aircraft by induced precession of the axis of the aircraft.

11. The high-speed vertical take-off and land aircraft of claim **10**, wherein said nozzle means includes a plurality of nozzles on the trailing edge of said fan blades; and

said valve means includes a valve for each of said nozzles; and means for actuating said valves together to provide exhaust gases from said nozzles.

12. The high-speed vertical take-off and land aircraft of claim **11**, wherein said actuating means includes a cam extending around substantially a quadrant of the perimeter of said body;

means for varying the cam plate of said cam to operate said valves;

whereby the differential thrust provided by activation of a quadrant cam provides gyroscopic precession of the axis of the aircraft and control of the attitude thereof.

13. The high-speed vertical take-off and land aircraft of claim **12**, wherein each of said cams includes a hollow cam body; a bellows extending along one side of said cam body and forming an expansible chamber;

a cam plate extending along the free side of said bellows;

and means for pressurizing the cam body and said bellows to position the cam plate for actuation of said nozzles;

a cam follower engaging the cam plate and connected to operating linkage with said valves;

whereby the thrust from said nozzles is varied in accordance with the extension of said cam plate from said cam body to vary the attitude of the aircraft.

14. A high-speed vertical take-off and land aircraft comprising:

a disk-shaped body;

a jet engine mounted on said body;

duct means for receiving and redirecting the hot exhaust gases from the jet engine;

an annular rotor having a rotatable fan assembly concentric with the body, said rotor including inner converging transfer ducts for the exhaust gases, an outer ring on the opposite side of said rotatable fan assembly, and actuator means in said outer ring for changing the pitch of the fan blades to modulate the vertical lift;

said fan assembly including a plurality of blades to provide vertical lift for said aircraft; said blades being airfoil-shaped and operative to scoop ambient air causing a downwash to maximize the lifting forces;

passage means in said blades for receiving the hot exhaust gases from said duct means;

nozzle means connected to said passage means located on said blades to eject said exhaust gases to provide rotation to said fan assembly; whereby primary lift for the aircraft is provided by lift forces on said blades upon rotation of said fan assembly.

15. The high-speed vertical take-off and land aircraft of claim **14**, wherein is further provided

valve means for controlling the ejection of exhaust gases from each nozzle; and

actuator means for cyclically operating the valves at selected positions around the periphery of the disk-shaped body.

* * * * *

United States Patent [19]

Wright et al.

[11] **Patent Number: 4,778,128**

[45] **Date of Patent: Oct. 18, 1988**

[54] **FLYING DISC AIRCRAFT**

[76] Inventors: **Herbert H. Wright; Marcus A. Wright,** both of 6415 Cabin Branch Ct., Capital Hts, Md. 20743

[21] Appl. No.: **836,418**

[22] Filed: **Mar. 5, 1986**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 723,723, Apr. 17, 1985, abandoned, which is a continuation of Ser. No. 430,707, Sep. 30, 1982, abandoned.

[51] **Int. Cl.**[4] **B64C 39/06**

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

[58] **Field of Search** .... 244/23 R, 23 C, 12.2, 244/34 A, 52

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Primary Examiner—Sherman D. Basinger
Assistant Examiner—Rodney Corl
Attorney, Agent, or Firm—Wigman & Cohen

[57] **ABSTRACT**

A flying disc aircraft includes a symmetrical body housing pilot and/or passenger seating apparatus above, a thrust-generating apparatus below, and a rotation inertia disc located therebetween. The disc rotates within the body in a plane normal to the axis of symmetry, and provides inertial stability for the aircraft through a gyroscopic effect. Directional control is achieved by means of mechanical linkage elements connecting a control stick at the pilot seating apparatus with the thrust-generating apparatus, the linkage allowing the pilot to orient the thrust at various angles relative to the aircraft axis of symmetry. Lift occurs when ambient air is induced, by virtue of the thrust-generating apparatus, to flow over the disc. In an alternate embodiment, lift is generated by the thrust-generating apparatus, and a shroud located beneath the apparatus is employed for redirecting resulting thrust to therefore facilitate directional control of the aircraft.

15 Claims, 7 Drawing Sheets

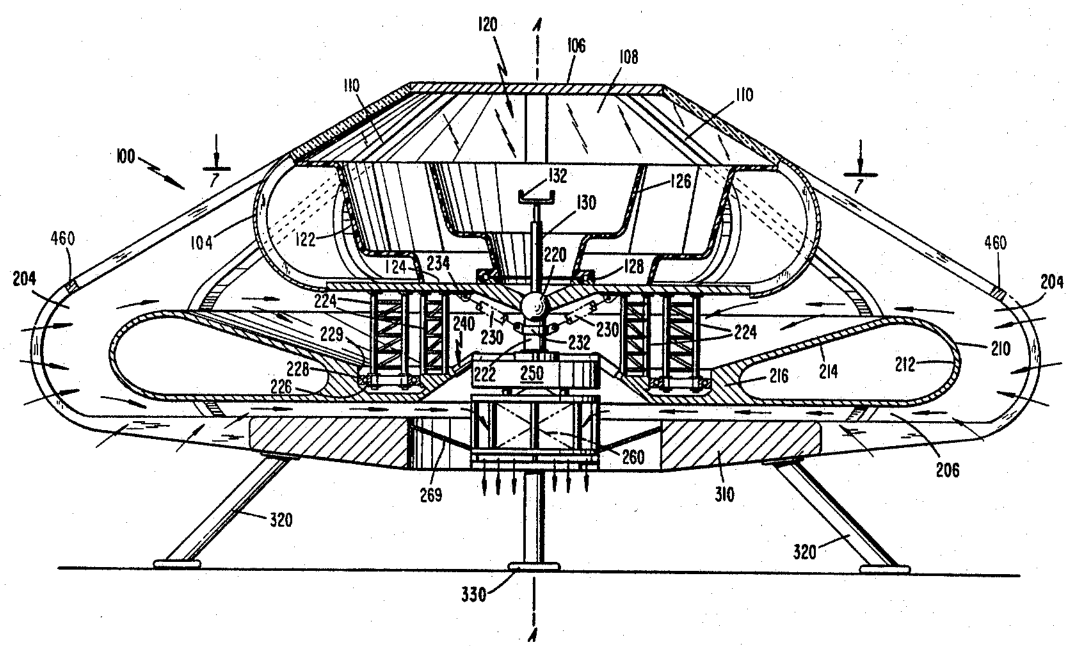

FIG. 1

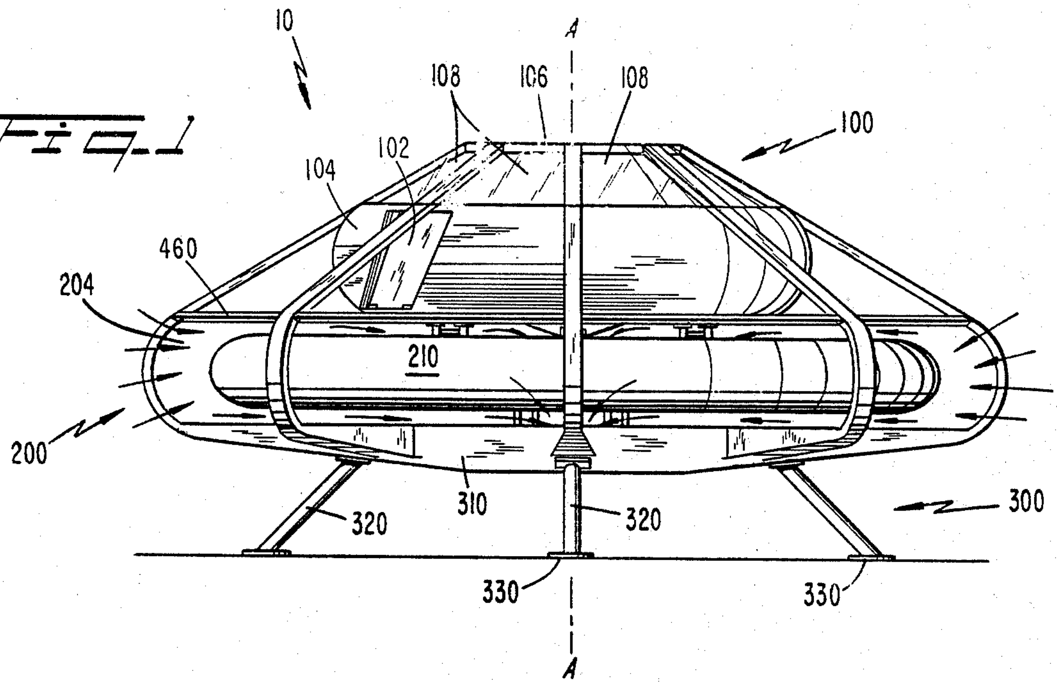
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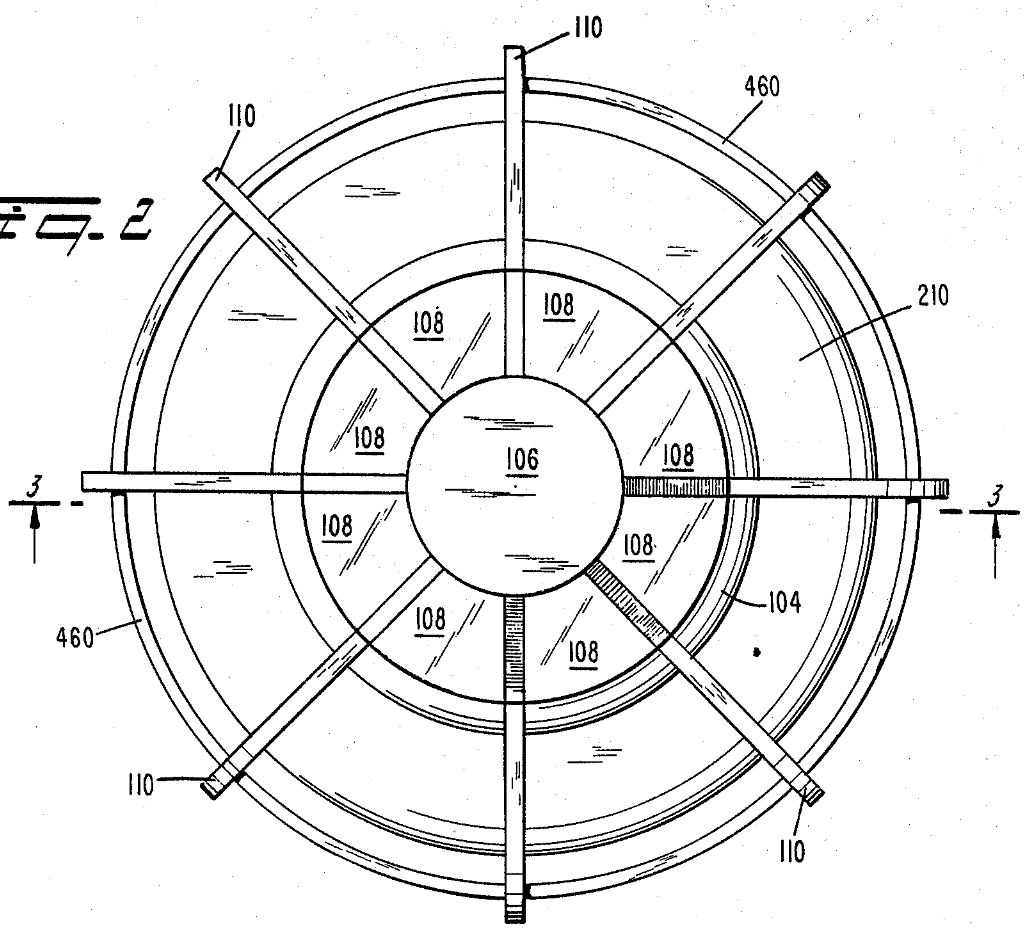
FIG. 2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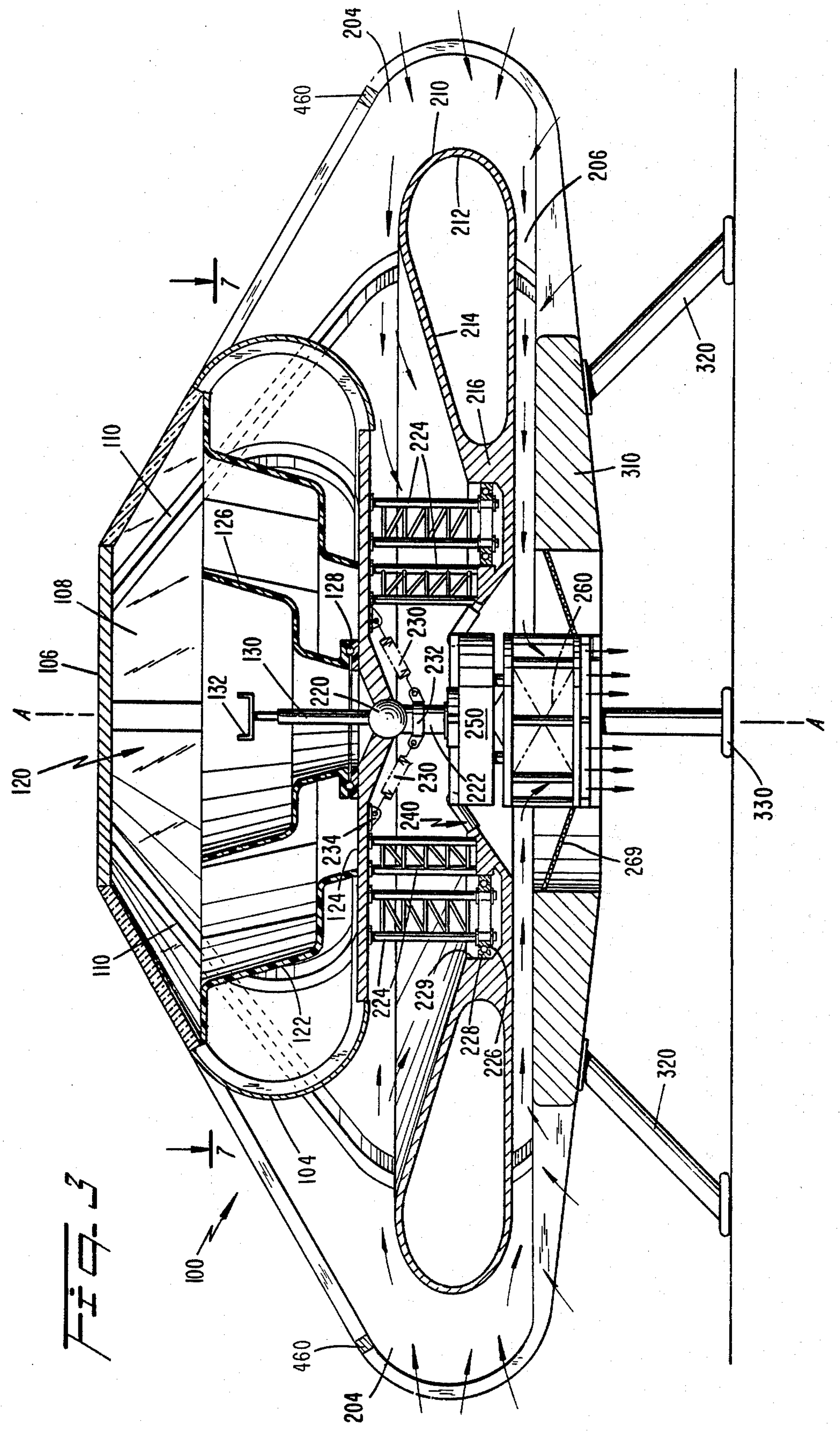
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120
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7
100
460
204

FIG. 3

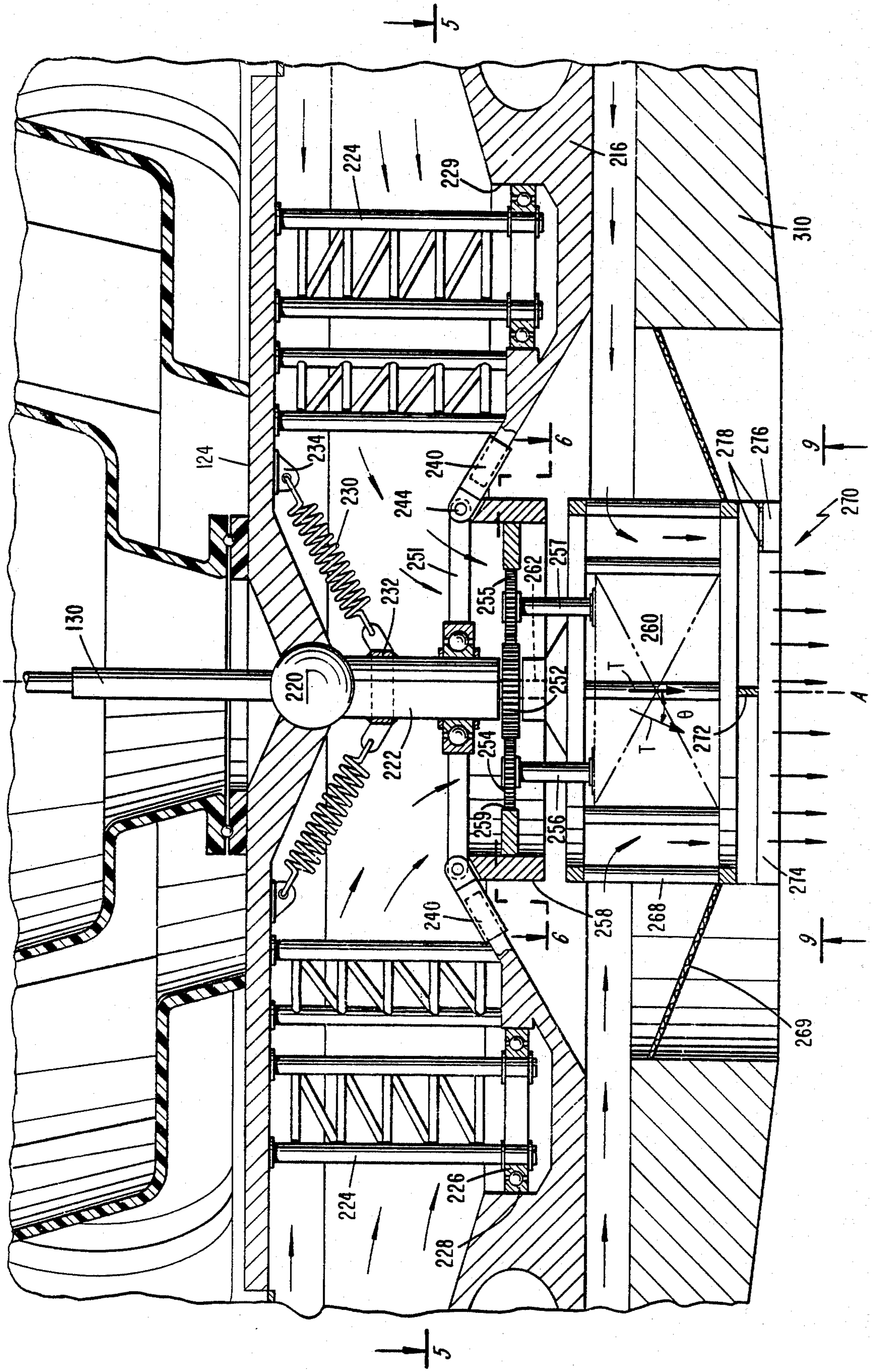

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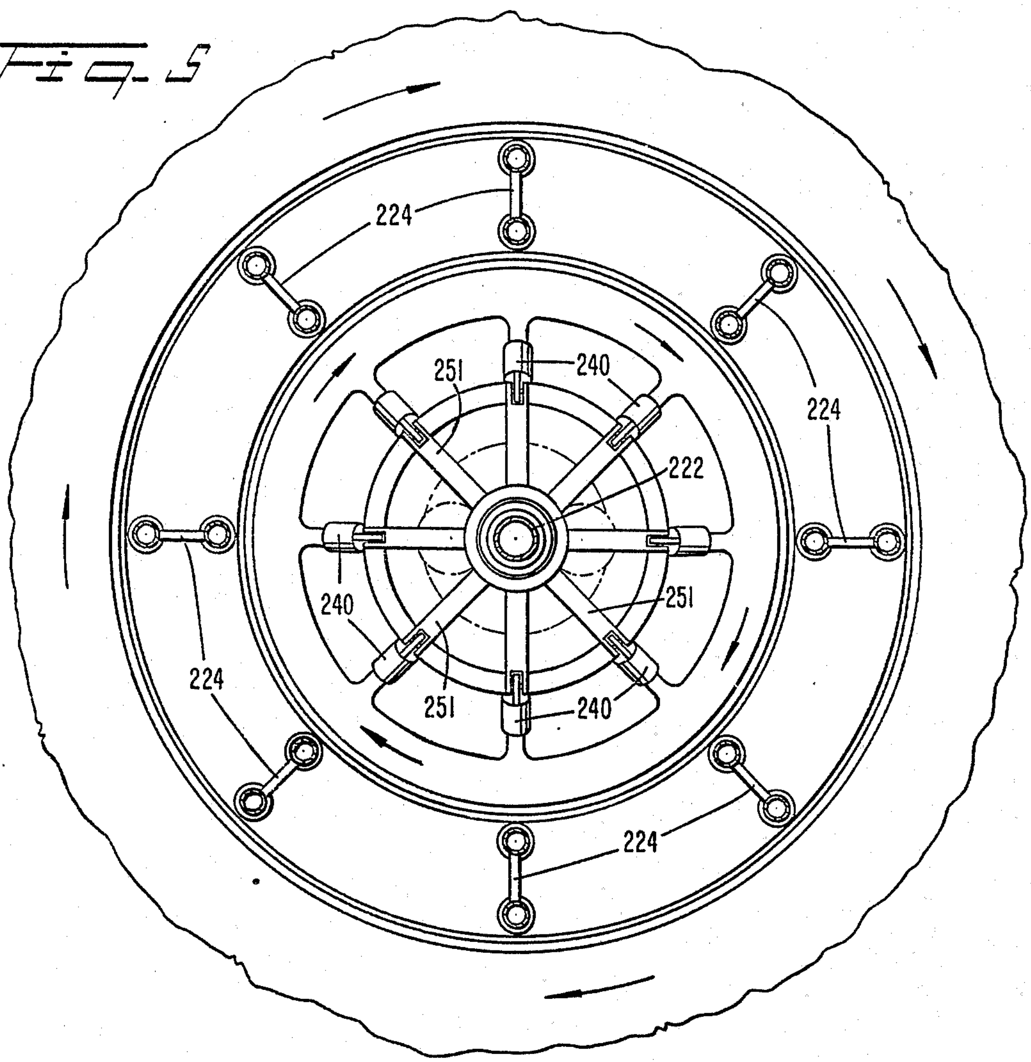
FIG-4

FIG. 5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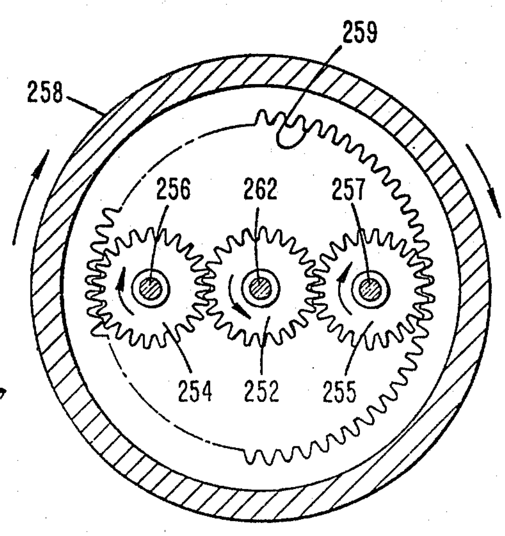
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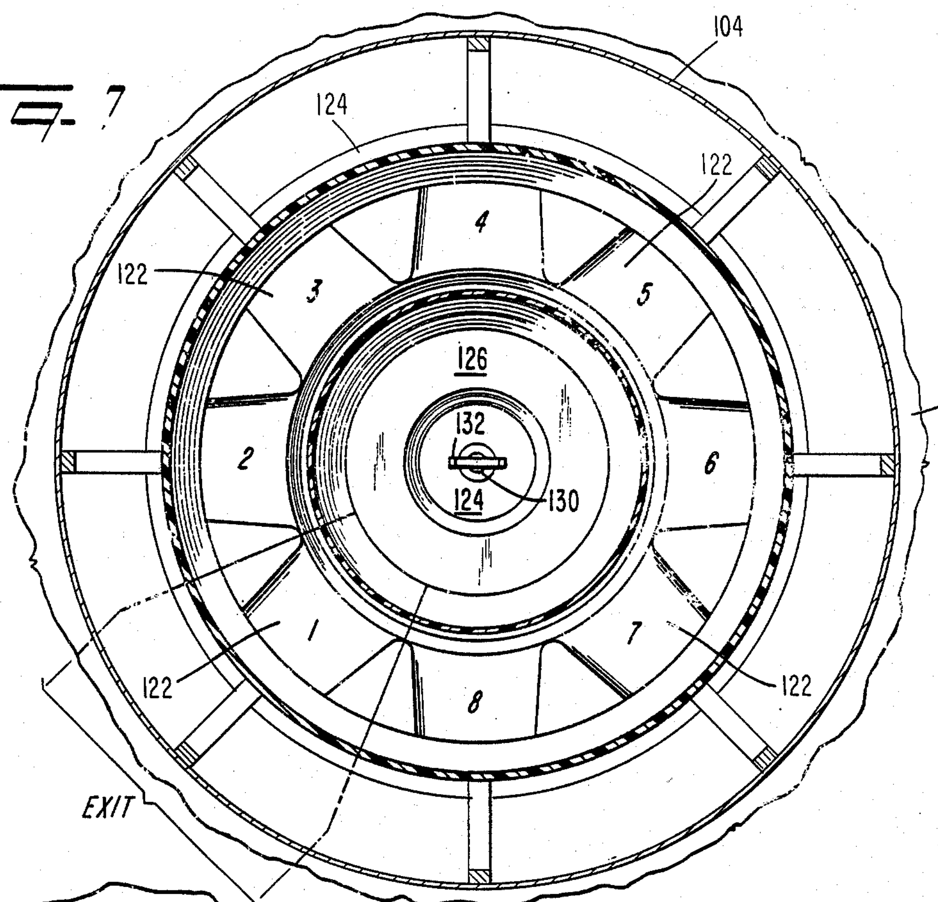
FIG. 6

Fig. 7



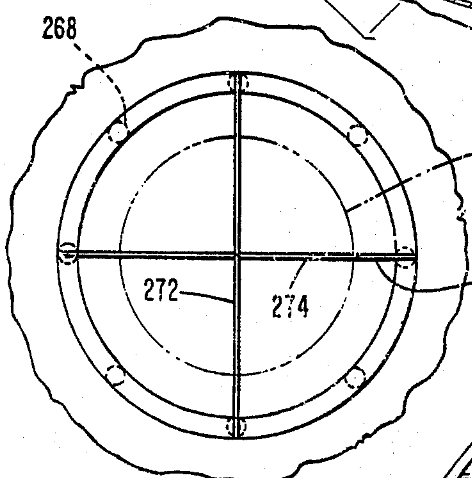


Fig. 9

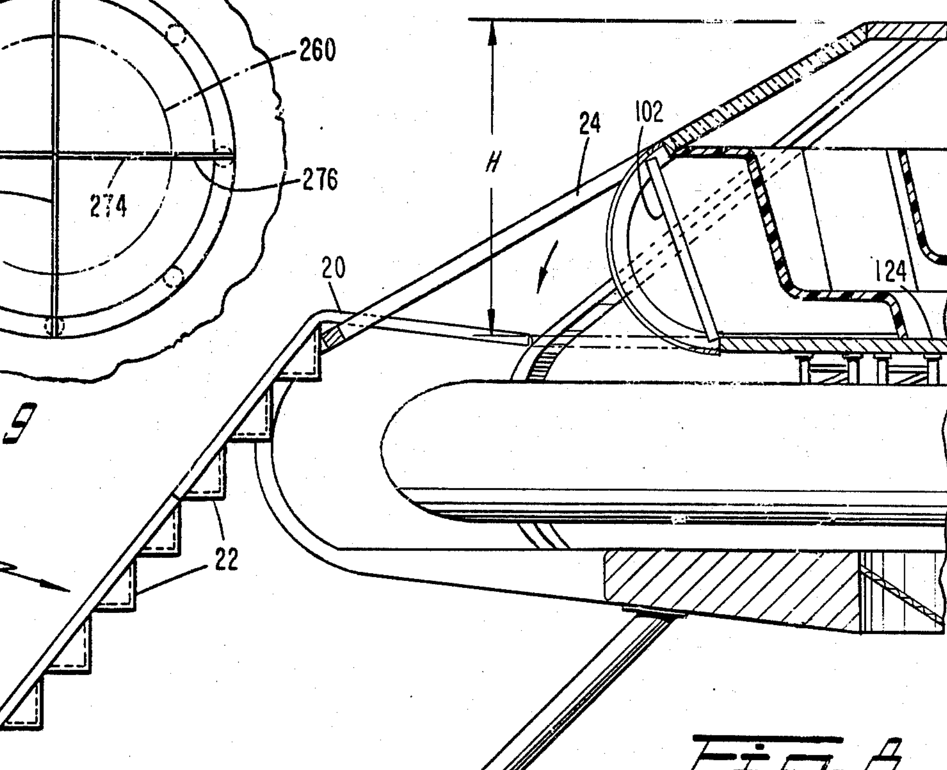


Fig. 8

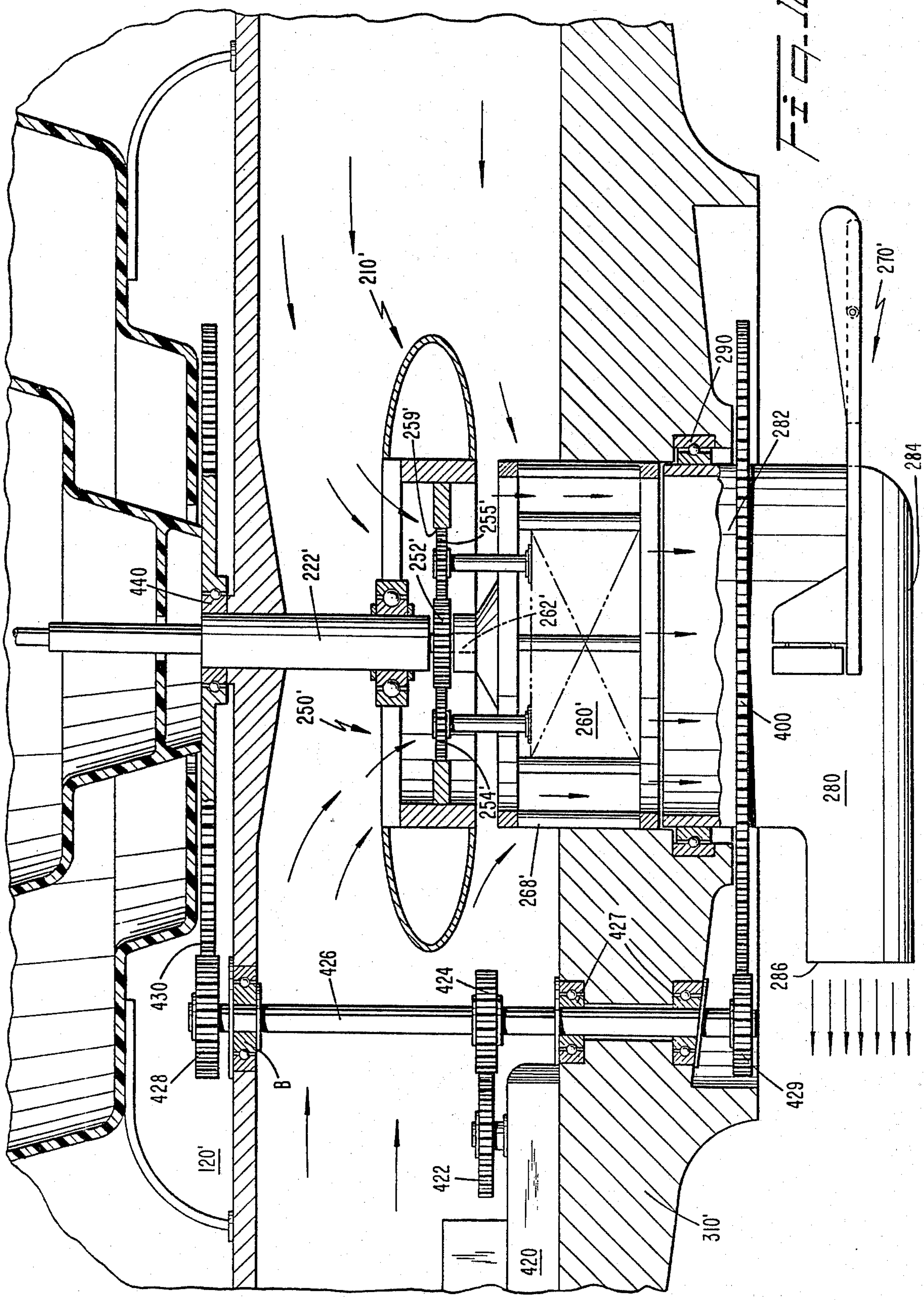

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FIG. 10

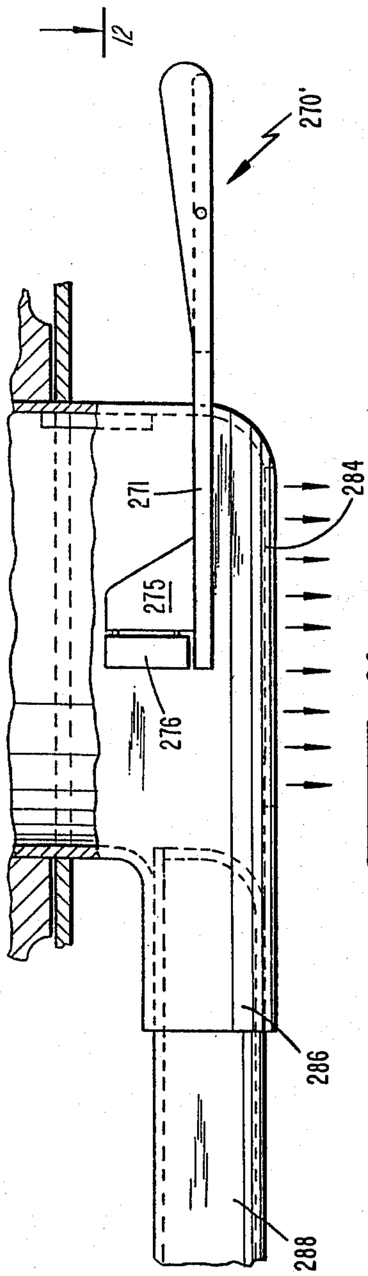
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FIG. 11

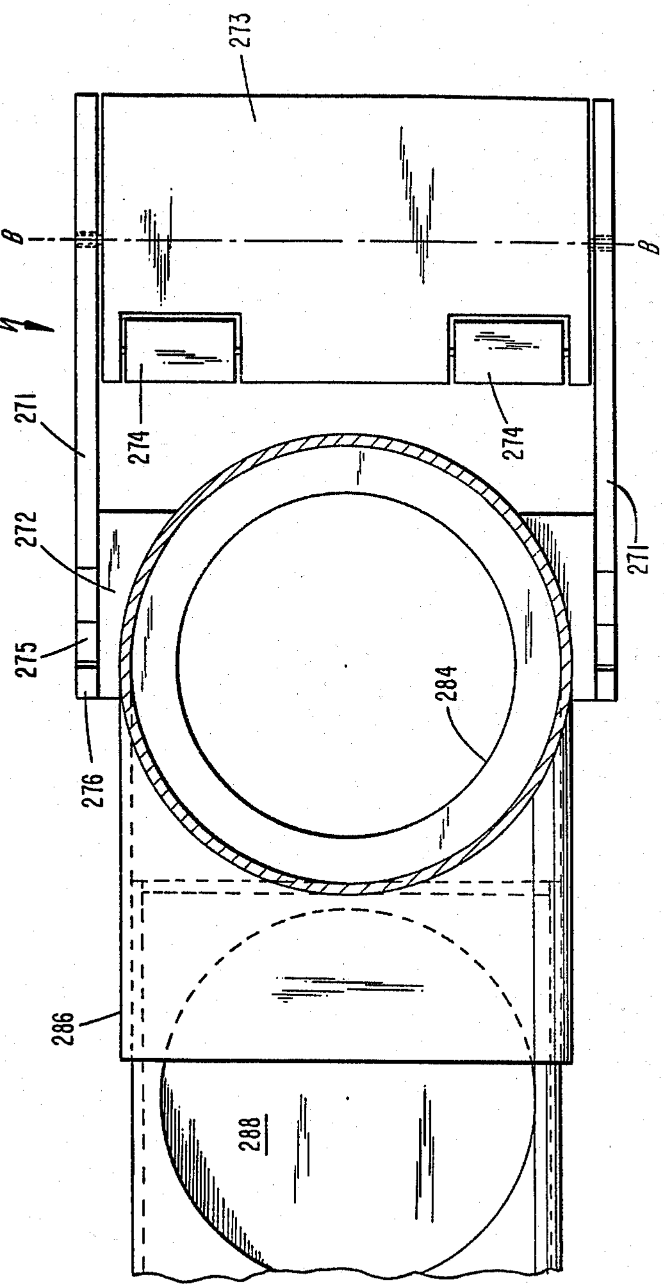
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FIG. 12

FLYING DISC AIRCRAFT

CROSS REFERENCE TO RELATED APPLICATIONS

This present application is a continuation-in-part of U.S. Ser. No. 723,723, filed Apr. 17, 1985, which in turn is a continuation of U.S. Ser. No. 430,707, filed Sept. 30, 1982 (both now abandoned).

BACKGROUND OF THE INVENTION

The present invention relates to aircraft, and more particularly to heavier-than-air flying craft housing a propulsion unit and a rotating airfoil. The airfoil has the effect of generating inertial stability during rotation thereof, and has a configuration which cooperates with air flow induced through the aircraft to generate lift in a direction parallel to the axis of rotation of the air-foil.

In the past, various attempts have been made to produce lift for an aircraft by providing air flow over the surface of a rotating disc or airfoil.

For example, the patent to SCHELLIN (U.S. Pat. No. 3,831,884) shows an apparatus for generating lift which includes a rotating impeller located within a cavity. Upon rotation of the impeller, air enters the cavity to drive the blade assembly **27** in rotation. The air passing over blades **31** generates a pressure differential between the top and bottom surfaces thereof thereby producing lift.

In the PHILLIPS patent (U.S. Pat. No. 3,612,445), an aircraft is disclosed wherein lift is produced by directing air over the upper surface of an airfoil in a radial direction while the airfoil rotates.

Various other examples include the MUELLER patent (U.S. Pat. No. 3,525,484), which discloses a craft **10** having a disc-shaped wing and a propeller to induce flow of air over the wing thereby creating lift; the CLOVER patent (U.S. Pat. No. 3,383,073), which discloses an aircraft having a tiltable impeller for producing lift and propulsion; the McMASTERS patent (U.S. Pat. No. 3,321,156), which discloses a tiltable engine for generating upward thrust as well as directional movement; and the HAWKINS patent (U.S. Pat. No. 3,297,278), which shows an aircraft having an impeller to direct ambient air over the top of an airfoil to produce a lifting effect.

None of these patents disclose heavier-than-air flying vehicles in which both a propulsion source, and a lift producing apparatus are located within the perimeter of the aircraft body, and in which the lift-producing apparatus takes the form of a rotating airfoil for not only cooperating with air-flow induced by the propulsion unit to flow over the lift-producing surfaces of the airfoil to generate lift, but also to provide inertial stability for the vehicle when the latter is in flight.

OBJECTS OF THE INVENTION

It is therefore an object of the present invention to provide a heavier-than-air flying craft having a single element which both facilitates generation of lift, and contributes to the stability of the craft.

Another object of the present invention is to provide a heavier-than-air flying craft in which all moving parts are located entirely within the aircraft framework.

Still another object of the invention is to provide an aircraft having moving parts protected by a framework so that damage to such parts, through collision with stationary or moving objects, will be prevented.

Still another object is to provide an aircraft having complete internal symmetry.

Another object of the invention is to permit the pilot of an aircraft having an axis of symmetry to alter the direction of aircraft travel by reorienting the propulsive thrust relative to the axis of symmetry.

Yet another object of the invention is to provide for correspondence between the pilot's cabin in an aircraft and the direction of travel so that the former can be aligned with apparatus for altering the direction of thrust of the aircraft whereby the pilot can continuously observe where the aircraft is headed.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the present invention will become apparent from the following detailed description of the invention when considered in connection with the accompanying drawings, in which:

FIG. **1** is a side perspective view of the aircraft of the present invention;

FIG. **2** is a top view of the aircraft of FIG. **1**;

FIG. **3** illustrates, in partial section, the aircraft of FIG. **1** taken along section line **3—3** of FIG. **2**;

FIG. **4** is an enlarged sectional view of the power plant assembly and transmission assembly of the aircraft;

FIG. **5** shows the support and suspension apparatus for the power plant assembly, and is a view, partly in section, taken along section lines **5—5** in FIG. **4**;

FIG. **6** is a view, partly in section, of the gear assembly shown in FIG. **4**, taken along section lines **6—6** in FIG. **4**;

FIG. **7** is a partial sectional view of the cabin of the aircraft of the present invention, taken along section lines **7—7** of FIG. **3**;

FIG. **8** illustrates, partly in section, the cabin with an entrance/exit hatch shown in its boarding mode of use;

FIG. **9** is a view, taken in the direction of arrows **9—9** in FIG. **4**, of the rudder assembly at the underside of the aircraft;

FIG. **10** illustrates, in partial section, a second embodiment of the present invention;

FIG. **11** is a side view, partly in section, of the rudder-and-trim assembly of the second embodiment; and

FIG. **12** is a view of the bottom of the rudder-and-trim assembly of FIG. **11**, shown partly in section.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Referring now to the drawings in which like reference numerals correspond to similar or like parts, there is shown in FIGS. **1-9** the aircraft **10** of the present invention which includes a body or frame having an exterior of substantially trapezoidal profile symmetrical about an axis of symmetry A—A, and presenting a substantially saucer-like configuration. The air-craft, as shown, includes an upper passage-carrying section **100**, a middle lift, propulsion and stability section **200** and a lower support section **300**.

The upper section includes an entrance/exit hatch or door **102** connected to the aircraft in some conventional manner, a body or shell **104**, a roof **106** and a plurality of panes or panels **108** of glass or other transparent material disposed circumferentially about the aircraft just below the roof. The plurality of panes or panels provide an operator (pilot) and crew with a viewing area of substantially 360° and therefore virtually eliminates any blind spot which might otherwise result.

The middle section **200** includes an air intake area **204** located at the widest diameter of the aircraft body. The vertical extent of the intake area is delimited by circumferentially extensive rail **460** at the upper extreme and by the plate member **310** at the lower extreme, while the intake opening is delimited by a plurality of ribs **110** extending radially from roof **106** and positioned at equally spaced locations about the circumference of the body. As shown in FIG. **3**, a rotating wing or airfoil is housed within the body of the aircraft in region **206**.

The lower section of the aircraft includes bottom plate member **310**, a plurality of supporting legs or struts **320** extending downwardly from the plate member **310**, and landing shoes **330**, which terminate legs or struts **320**, and on which is supported the aircraft. The shoes may take the form of wheels, pontoons, tires or other landing devices suitable for a particular terrain which the aircraft might reasonably be expected to encounter during its use.

In the upper section, the lateral edges of the ribs **110** desirably include mounting grooves or other mounting arrangements for holding, between adjacent ribs, the panes **108**. The ribs in the middle section function as strengthening elements, and are preferably symmetrically disposed about the circumference of the aircraft.

FIG. **3** illustrates a sectional view of the aircraft taken along section line **3**—**3** in FIG. **2**. The upper section **100** is shown to include a cabin **120** housing passenger seating accommodations **122**, such as, for example a molded contoured seat made of a lightweight synthetic material. The passenger seating accommodations are preferably nearly circular in configuration, are positioned concentric with the axis of symmetry of the aircraft, and are fixedly secured to the floor **124** of the cabin. Concentric with the passenger seating accommodations and disposed interiorly thereof is a pilot's seat **126**, also of nearly circular configuration. The pilot's seat is mounted on the cabin floor via a bearing assembly which permits rotation of the seat about axis of symmetry A—A through a full 360°. This rotation is effected by conventional switching, motor and servo means, located for example in the cabin **120**. Concentric with the pilot's seat and positioned substantially coaxially with the axis of symmetry of the aircraft is control stick **130** which facilitates directional control of the aircraft, as described in more detail below. Control stick **130** includes a rudder-and-trim control handle **132** positioned directly above and connected to the stick, which in turn is mounted directly above, and interconnected with, ball joint assembly **220** firmly secured in the cabin floor on the axis of symmetry.

Rotating wing or airfoil **210** comprises a hollow, doughnut-shaped, continuous airfoil mounted for rotation about outer shaft **222** in a plane substantially normal to the axis of symmetry of the aircraft, the outer shaft **222** being substantially coincident with the axis of symmetry. The airfoil configuration, as shown, has its greatest height at its leading edge **212** (in a direction parallel to the axis of symmetry) at its greatest radial extent. The lift-producing section **214** of the airfoil is located radially inwardly of the leading edge and extends between the axis of symmetry and the central support section **216** of the airfoil.

As shown in FIGS. **3** and **4**, a plurality of stiffening members **224** are positioned radially outwardly of, and about, shaft **222**. Each stiffening member is rigidly fixed at its upper end to the underside of cabin floor **124**, and includes at its lower end a bearing assembly **226** which cooperates with a bearing assembly **228** carried by the support section **216** of the airfoil. These cooperating bearing assemblies permit the airfoil to be supported for rotation in a substantially horizontal plane. Each bearing assembly **228** may be positioned within well **229** for movement parallel to the shaft **222** along the walls of the well so that vibratory forces generated in the airfoil during rotation thereof may be accommodated without structural damage to the airfoil, the shaft, or the stiffening members. Additionally, damping apparatus is provided for minimizing vibratory forces which might otherwise be transmitted to the outer shaft **222** and then to the aircraft. A plurality of stability springs **230** interconnect a stability collar **232** with connection points **234** secured to the underside of floor **124**. Preferably, at least two stability springs are provided, with the total number of springs being symmetrically positioned about shaft **222**. The central support section **216** of the airfoil is also connected, albeit indirectly, to the shaft **222**, via an assembly of shock absorbers **240**. Each shock absorber interconnects the radially innermost portion of the airfoil central support section **216** with a pivot point **224** located on airfoil gearing housing struts **251** (see also FIGS. **4** and **5**). In FIG. **5**, eight shock absorbers and stiffening members are shown, but the number employed may be more or less depending on predetermined design requirements.

The gearing housing **250** is positioned below stability collar **232** on shaft **222** within the vertical extent of the airfoil, and contains (see FIGS. **4** and **6**) a main or sun gear **252** fixedly secured to a portion of rotating drive shaft **262** and concentric therewith. The drive shaft **262** is, as seen most clearly in FIG. **4**, housed within outer shaft **222**. The main gear **262** drives secondary or planet gears **254**, **255** (only two gears have been shown for exemplary purposes), each of the planet gears being rotatably supported on respective gear shafts **256**, **257** at a height appropriate for intermeshing with main gear **252**. The side wall **258** of housing **250** is cylindrical in horizontal cross-section (as shown in FIG. **6**), and includes an orbiting gear **259** on the inner surface thereof for engagement with the teeth of secondary gears **254**, **255**.

Through this gearing arrangement, rotary motion or torque generated in the power plant **260** is transmitted via shaft **262** to main gear **252**. The rotation of the main gear drives the secondary gears which in turn drive the orbiting gear, and hence the gear housing **250**. Thus rotary motion or torque generated in power plant **260** is transmitted to the airfoil or wing **210** via its interconnection with the gearing housing through shock absorber assembly **240**. The range of speeds of revolution of airfoil **210** can, of course, be optimized not only by an appropriate selection of the power plant, but also by an appropriate design or selection of the gears.

Power plant **260**, which may take the form of any conventional thrust-producing means (as for example a propeller or jet), functions both as an energy source for rotatably driving airfoil **210** as well as a means for providing the aircraft with thrust. The power plant, as seen in FIG. **4**, is housed within a cage **268** and is rigidly connected via the shafts **256**, **257** which support secondary gears **254**, **255**, in alignment with gearing housing **250**. In order to provide directional thrust other than in purely upward and purely downward directions, the power plant has the capability of being tilted relative to the axis of symmetry so that, whereas the thrust axis T of the power plant is normally parallel with the aircraft axis of symmetry, when directional thrust is desired, the thrust axis T is displaced some angle θ from the axis of symmetry. In this way, the necessary components of horizontal and vertical thrust can be developed to attain the desired directional thrust. Through the linkage described above, the power plant can be directed at an angle θ to the axis of symmetry.

At the lowermost edge of cage **268** is attached a flexible air barrier **269** of elastic material. The barrier extends 360° around cage **268** upwardly toward an upper portion of the aircraft bottom plate **310**.

Located below power plant **260** and attached to cage **268** is the rudder assembly **270** which, as shown in greater detail in FIG. **9**, includes a first rudder **272**, second rudder **274** and trim flap **276**. The first and second rudders are disposed one above the other, respectively, and at right angles to one another. Trim flap **276** lies in the plane of the second rudder **274** when inoperative, and is supported by hinges **278**, **278** for angular displacement on the hinges to either side of the second rudder when the flap is operative. The purpose of trim flap **276** is to impart refined directional control to the aircraft by directing a portion of the thrust developed by the power plant away from the main thrust component.

FIG. **5** is a view, partly in section, showing the appropriate spatial relationships between the airfoil, the stiffening members, the shock absorbers, the gearing housing struts, the shaft bearing **228**, the outer shaft **222** and the drive shaft **262**.

FIG. **7** shows the passenger and pilot seating accommodations in the aircraft of the present invention. At the center of FIG. **7** is control stick **130** with the rudder-and-trim control handle **132**. These control devices are secured through the cabin floor to the ball joint assembly **220** (see FIG. **3**). Located radially outwardly of control stick **130** is the pilot's seat **126**, and radially outwardly of the pilot's seat is the passenger seating accommodations **122**, here shown divided, for example, into eight separate benches, all being unitarily interconnected with one another. Disposed radially outwardly of the passenger seating accommodations, between the circumferentially extending body wall **104**, is the cabin floor **124**. In FIG. **7**, exit hatch **102** is shown positioned above that passenger seating bench denoted by the numeral "1", but its exact location is not critical. Moreover, it is not critical to have eight, or for that matter, any specific number of, discrete benches, and it would be most desirable to have either one of the benches temporarily destructible or foldable, or to have one less than a full complement of benches, so that ingress and egress to the aircraft seating accommodations could be attained.

FIG. **8** shows a ladder L having steps **22** by which the pilot and passengers can gain access to the seating accomodations of the aircraft. The ladder, in facilitating entrance to, and exit from, the aircraft cabin, includes a hook portion **20** in addition to steps **22**. FIG. **8** clearly is not drawn to scale; access opening **24** as shown erroneously suggests that to enter or exit, the pilot and passengers must be very short or be on hands and knees. In fact, the aircraft upper section may be designed so that its height H may accommodate persons entering or exitng in an erect posture, and thus the height of the access opening may be selected in accordance with predetermined design requirements or expectations.

OPERATION OF THE PREFERRED EMBODIMENT

In nearly all heavier-than-air craft, in order to get off the ground and thus fly, lift must be developed to the extent that the weight of the craft is overcome. The same is true for the aircraft of the present invention. As best seen in FIG. **3**, when the power plant **260** is operational, and downward thrust is generated, the air in region **206** upstream of, or just above, power plant **260** is moved through the power plant and in region **206**, as a result of which ambient air is sucked or induced into the region at the intake areas **204** located peripherally about the circumference of the craft. After entering the region, the air encounters, and passes over and under, airfoil **210** creating, as a result of the sectional configuration in the vicinity of sloping surface **214**, a negative pressure gradient thus resulting in the aerodynamic phenomena of lift relative to the region **206**. In addition, rotation of the airfoil is effected by the linkage and gearing connecting it with the power plant **260**. This rotation, at a predetermined speed, creates a stabilizing gyroscopic force.

To raise the craft off the ground, an appropriate thrust developed by power plant **260** is coupled with the lifting effect generated across rotating airfoil **210**. Directional control of the craft is achieved by manipulation of control stick **130**, rudder-and-trim control handle **132** and through appropriate linkages and servos interconnecting the control stick assembly with the power plant, so that angular orientation of the power plant relative to the craft axis of symmetry, as well as adjustment of the trim flap, can be facilitated.

DETAILED DESCRIPTION OF THE SECOND EMBODIMENT OF THE PRESENT INVENTION

Referring now to FIGS. **10–12**, there is shown a second embodiment of the inventive aircraft in which all components and elements shown are identical to those described above except where mentioned below. In this embodiment lift is achieved solely by the generation of downward thrust through power plant **260'**, stability achieved by rotation of a gyro **210'** (which comprises a substantially solid ring-shaped element rigidly supported on shaft **222'** at the same location at rotation wing or airfoil **210** was located), and directional control attained by means of a combined exhaust shroud **280** and rudder-and-trim unit **270'**.

As shown in FIG. **10**, and in a manner similar to that described above in connection with FIGS. **3**, **4** and **6**, torque generated by power plant **260'** is transmitted through drive shaft **262'** to main gear **252'**. Rotation of the main gear drives secondary gears **254'**, **255'** which in turn drives orbiting gear **259'** and hence the gear housing **250'**.

In this embodiment, directional control of the aircraft is achieved by altering the direction of thrust developed by power plant **260'**, not through tilting of the power plant as described in connection with the preferred embodiment, but rather through redirection of the thrust relative to the aircraft axis of symmetry. The exhaust shroud **280** is provided to effect this result, and comprises an L-shaped elbow pipe having an upper portion **282** rotatably supported, through bearing assembly **290**, in bottom plate member **310**. The upper portion is located directly below power plant cage **268'**, and has a substantially cylindrical configuration. The cage is fixed within bottom plate member **310'** in an appropriate mounting opening coaxial with the axis of symmetry of the aircraft and the axes of the cage and the upper portion are in axial alignment. Mounted on the shroud about the exterior surface of the upper portion is shroud gear **400**. The axis of rotation of the gear is, as shown, coincident with the aircraft's axis of symmetry. The lower portion of the exhaust shroud is disposed substantially normal to the upper portion and includes first exhaust valve **284**, second exhaust valve **286** and rudder-and-trim unit **270'**.

As shown in greater detail in FIGS. **11** and **12**, first exhaust valve **284** comprises a substantially symmetrical opening located in the surface of the shroud most remote from the power plant and preferably directly beneath it. Slidably telescoped within second exhaust valve **286** is sleeve **288** which has a substantially cylindrical configuration with a cross-section congruous with the cross-section of the second exhaust valve.

When it is desired to lift the aircraft off the ground, sleeve **288** is telescoped outwardly from the second exhaust valve to its fully extended position thereby fully opening first exhaust valve **284**. This permits purely downward thrust to be developed.

To generate horizontal components of thrust, the sleeve is moved toward its fully retracted position within the second exhaust valve, whereby the first exhaust valve becomes completely closed. The extent of retraction, and hence the extent to which the first valve is blocked off, determines the proportionate amount of thrust converted to a horizontal force component.

Rudder-and-trim unit **270'** comprises side support frames **271, 271** extending oppositely away from the second exhaust valve and being attached at a first end thereof to mounting bracket **272** firmly affixed to the lower portion of the exhaust shroud. Spanning the second end of the support frames is wing **273** rotatable about axis B-B which extends substantially normal to the aircraft axis of symmetry. The wing is tiltable generally toward and away from the exhaust shroud upper portion. Carried by the wing along the edge adjacent the exhaust shroud are two flaps **274, 274** rotatable into and out of the plane of the wing. Positioned at the first ends of the side support frames and upstanding therefrom are fixed rudders **275, 275** and pivoting rudders **276, 276**; the pivoting axes are substantially parallel with the aircraft axis of symmetry.

Directional control of the aircraft of this embodiment is also effected by reorienting the exhaust shroud about the axis of symmetry. This is accomplished by the provision of motor means **420**, such as an electric motor, which turns motor gear **422**. The motor gear in turn drives shaft gear **424**, which is supported in a conventional manner on a shaft **426** spanning the passenger and pilot's cabin **120'** with the bottom plate member **310'**, with bearing assemblies **427** being provided in appropriate places (two being shown by way of example). In the cabin, shaft **426** supports upper gear **428** which drives seating gear **430**, the latter being supported on shaft **222'** for rotation by bearing assembly **440**. In the bottom plate member **310'**, shaft **426** supports lower gear **429** which drives shroud gear **400**. Preferably, both the seat gear and the shroud gear are of the same diameter and thus are rotatably driven by motor **400** simultaneously at the same speed. As with the preferred embodiment described above, all movement of the rudder-and-trim unit, as well as movement of this shroud sleeve is effected through appropriate linkages and servos interconnecting the pilot's control stick and other necessary apparatus with the power plant.

Having described in this manner the fundamentals of the present invention and the manner in which it can be brought to practical use, I claim as my exclusive property the invention based on the following claims:

What is claimed is:

1. An aircraft, comprising:

a frame having an axis of symmetry, and including means for delimiting an interior region communicating with ambient air;

a rotatable body, including lift-generating surfaces, supported within said interior region with the axis of rotation of said body being substantially coincident with the axis of symmetry of said frame,

thrust producing means, supported in said interior region beneath said body, and defining means for inducing movement of said ambient air through said interior region and over said lift-generating surfaces, whereby a lift force is generated which acts to overcome the weight of, and raise, the entire aircraft relative to the ground;

means, coupled between said rotatable body and said thrust producing means, for driving said rotatable body in rotation about said axis of rotation;

said body, when rotating, providing inertial stability for said aircraft; and

means for altering direction of flight of said aircraft;

said thrust producing means, said rotatable body, said driving means and said altering means all being disposed entirely within said frame.

2. The aircraft of claim **1**, wherein

said thrust-producing means produces a thrust component having a direction generally away from said interior region;

said rotatable body comprises an annular airfoil having an axis of symmetry coincident with the axis of symmetry of said frame, and

said interior region is symmetrical about said frame axis of symmetry.

3. The aircraft of claim **2**, wherein

said thrust-producing means is supported for pivoting movement relative to said frame axis of symmetry;

and said altering mans comprises means for pivoting said thrust-producing means about said axis of symmetry to alter the direction of said thrust component relative to said axis of symmetry.

4. The aircraft of claim **3** further including

pilot accommodations including seat means;

and means for rotating said seat means about said frame axis of symmetry in direct correspondence to the altered direction of propulsion of said aircraft.

5. The aircraft of claim **1** further including

pilot seat means, and means for rotating said seat means about said frame axis of symmetry;

wherein said altering means comprises means for controlling the direction of flight of said aircraft,

said pilot seat means being rotatable in a direction corresponding to the direction of flight.

6. The aircraft of claim **5** further including passenger seat means coupled to said pilot seat means for rotation therewith.

7. The aircraft of claim **1** wherein

said altering means includes a shroud supported below said thrust-producing means, said shroud including means for directing thrust froms aid thrust-producing means in a first direction parallel to said axis of symmetry, means for redirecting said thrust in a second direction substantially normal to said first direction, and means, reciprocating in said shroud, having one position wherein said redirecting means is blocked, and at least one other position in which said redirecting means is at least partially open.

8. The aircraft of claim 7, wherein

said shroud comprises tubular means having a portion extending substantially normal to the frame axis of symmetry, and

said reciprocating means is telescopically supported for movement between said one position and said at least one other position.

9. The aircraft of claim 7 wherein

said frame includes means for rotating said shroud about the axis of symmetry of said frame.

10. The aircraft of claim 9 further including

pilot seat means, and

means for rotatably supporting said pilot seat means within said frame,

wherein said rotating means rotatably drives said pilot seat means in direct correspondence to rotation of said shroud.

11. The aircraft of claim 1 wherein

said altering means includes rudder means disposed beneath said thrust-producing means.

12. The aircraft of claim 11 wherein said rudder means is symmetric about said frame axis of symmetry.

13. The aircraft of claim 1 wherein

said aircraft includes means below said thrust-producing means for redirecting thrust produced by said thrust-producing means,

said rudder means being supported by said redirecting means.

14. The aircraft of claim 11 wherein

said rudder means comprises a first portion disposed in a plane normal to the frame axis of symmetry and a second portion disposed in a plane normal to plane of the first portion.

15. An aircraft, comprising:

a frame having an axis of symmetry, and including means for delimiting a region located entirely within said frame communicating with ambient air;

an annular body including lift-generating surfaces, said annular body being supported for rotation within said region and having an axis of rotation which is substantially coincident with the axis of symmetry of said frame;

means, supported in said region beneath said annular body, for producing a thrust component having a direction generally away from said region, said thrust component producing means constituting means for inducing movement of air from the ambient into, and through said region within, said frame, and over said lift-generating surfaces of said annular body so that a lifting force is generated which acts to overcome the weight of and impart lift to, the entire aircraft;

means, coupling said annular body with said thrust component producing means, for driving said annular body in rotation about said axis of rotation,

said body, when rotating, providing inertial stability for said aircraft; and

means for altering said direction of said thrust component relative to said axis of symmetry to control direction of flight of said aircraft;

said driving means including means for maintaining said axis of rotation substantially coincident with the axis of symmetry of said frame when said annular body is rotating, and when said altering means is operative to alter the direction of said thrust component relative to said axis of symmetry;

said thrust component producing menas, said annular body, said driving means and said altering means all being disposed entirely within said region.

* * * * *

United States Patent [19]

Moller

[11] **Patent Number: 4,795,111**

[45] **Date of Patent: Jan. 3, 1989**

[54] **ROBOTIC OR REMOTELY CONTROLLED FLYING PLATFORM**

[75] Inventor: **Paul S. Moller**, Dixon, Calif.

[73] Assignee: **Moller International, Inc.**, Davis, Calif.

[21] Appl. No.: **15,100**

[22] Filed: **Feb. 17, 1987**

[51] **Int. Cl.**[4] **B64C 29/02**

[52] **U.S. Cl.** .... **244/23 C**; 244/12.2; 244/12.5; 244/100 R; 244/23 D; 244/17.19

[58] **Field of Search** .... 244/17.11, 17.19, 17.21, 244/23 C, 12.2, 23 A, 12.3, 17.17, 23 D, 219, 34 A, 100 R, 73, 12.5, 26

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Primary Examiner—Galen Barefoot

Attorney, Agent, or Firm—Rosenblum, Parish & Bacigalupi

[57] **ABSTRACT**

A flying platform, propelled by at least one ducted fan causing a vertically downwardly directed airstream in and through a cylindrical duct. A vane system in the duct has two mutually perpendicular pairs of diametrically opposite first vanes, each extending in from the duct rim toward the center of the duct. Each pair of first vanes provides a pair of generally vertical walls parallel to a diametral line across the duct, and they define duct passages between the pairs of vanes and define quadrants between adjacent pairs. Each first vane has an upper, fixed, rigid portion and a variable camber flap depending therefrom. A first servomotor with linkages vary the camber of each pair of flaps, so that the camber of the flaps of each pair is at all times the same amount but in opposite directions. Preferably, there are also four second vanes, one bisecting each quadrant, and a symmetric pair of spoilers is mounted on each second vane. Each pair of spoilers is independently movable, as a pair continuously between a position substantially blocking airflow through the outer portion of said quadrant and a position permitting substantially full airflow therethrough. A second servomotor with linkages symmetrically varies the position of its spoilers. There may be a radio receiver responsive to remote control signals for actuating each servomotor and its linkages.

19 Claims, 7 Drawing Sheets

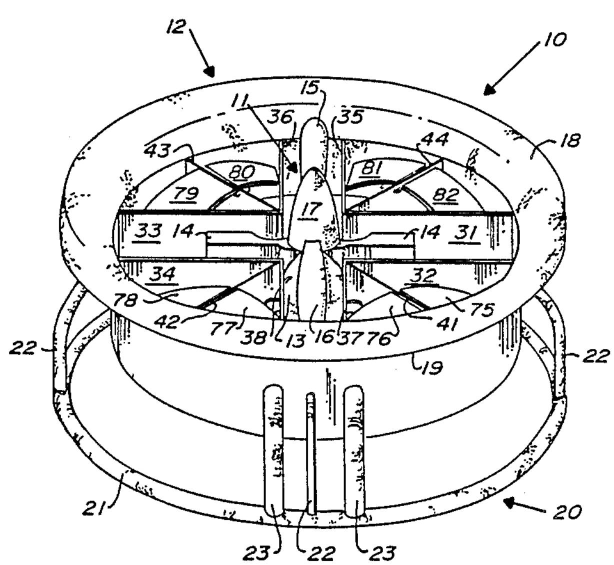

FIG. 1

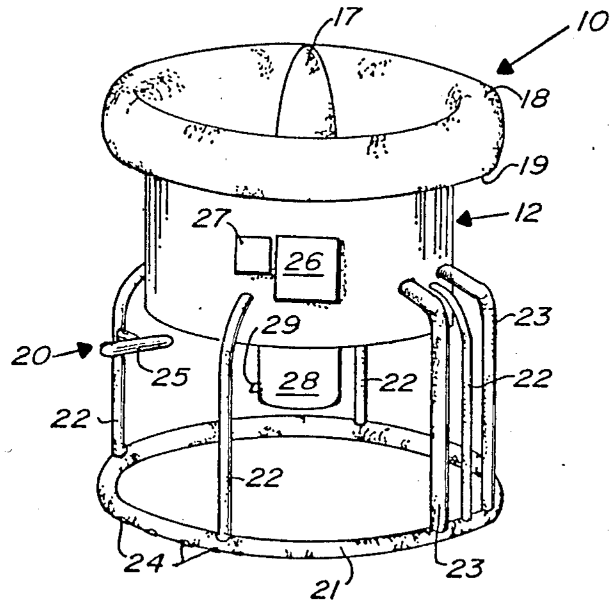
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FIG. 2

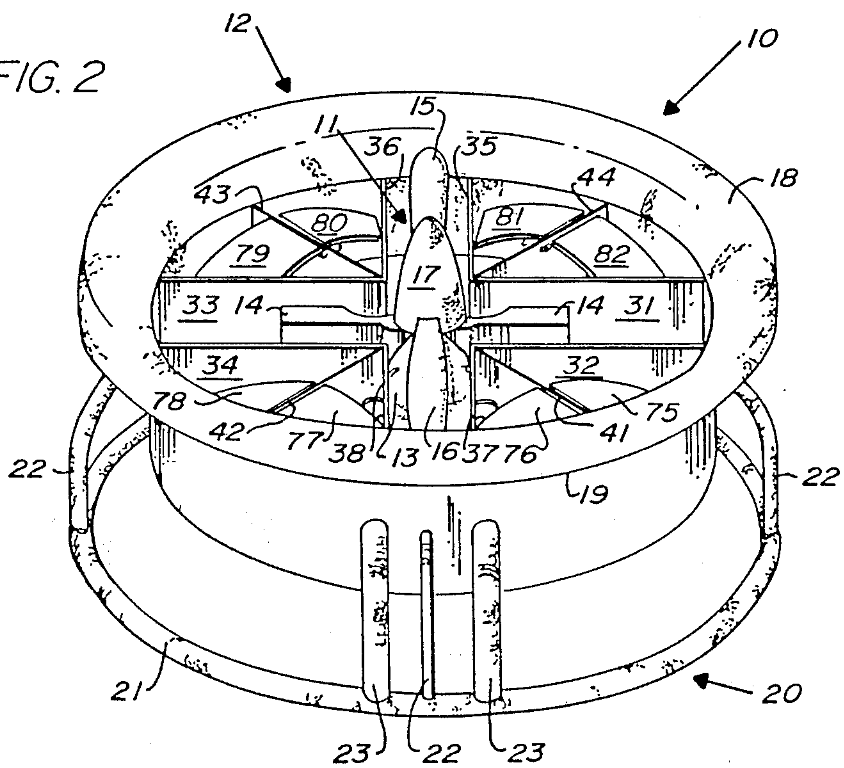
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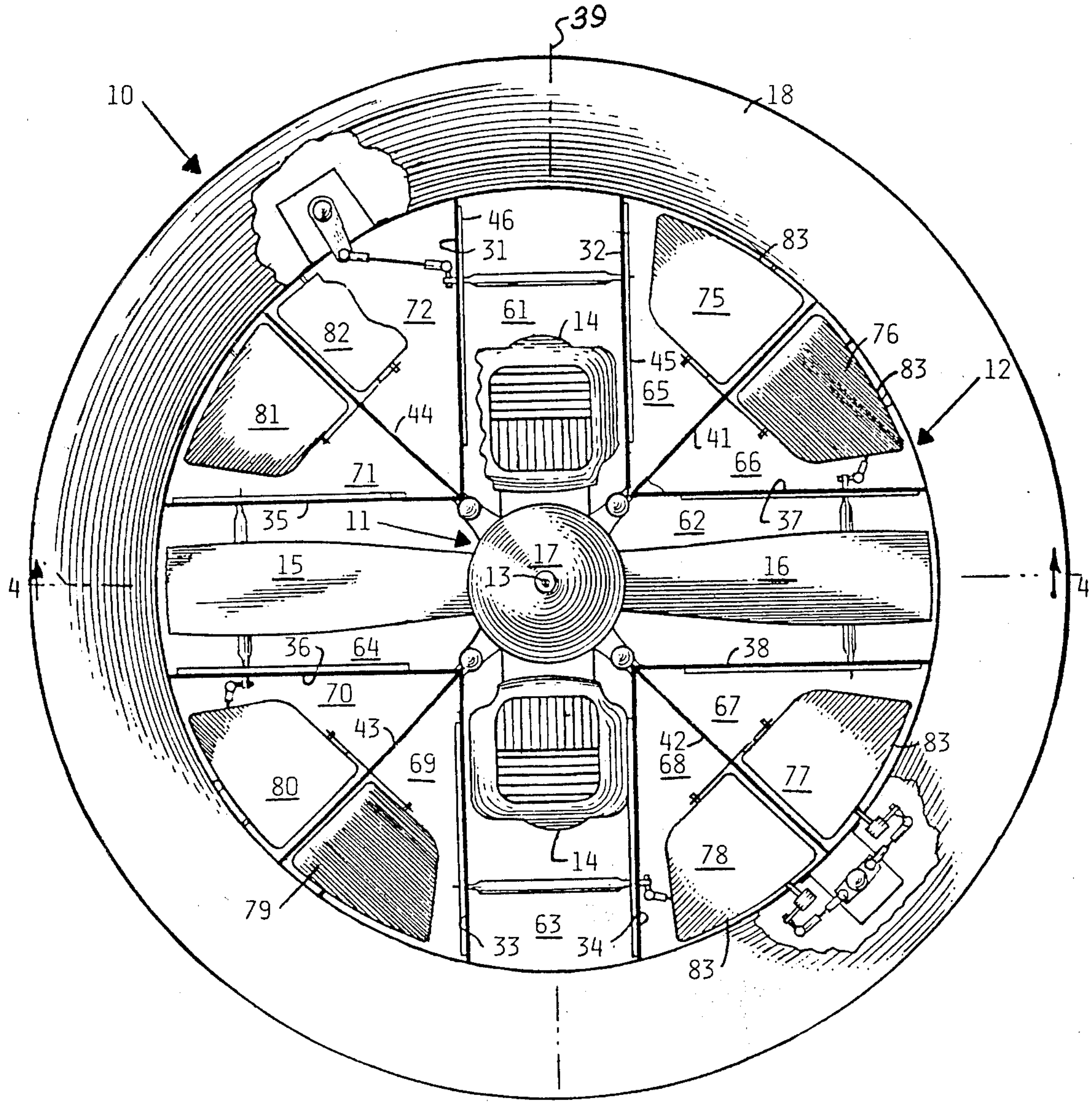
FIG. 3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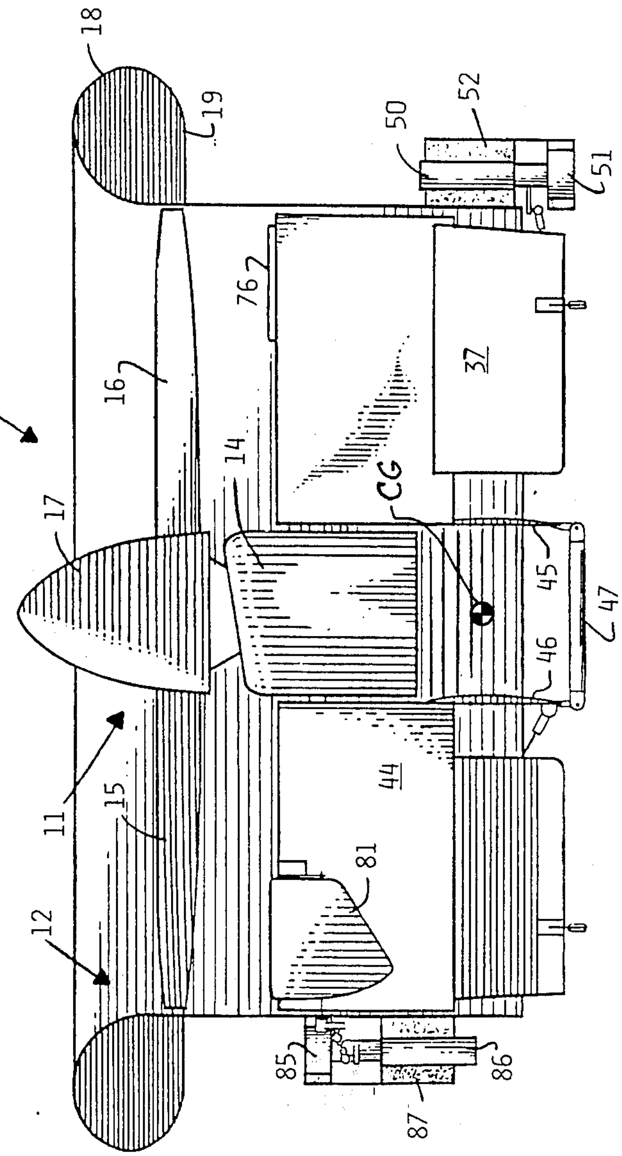

FIG. 4

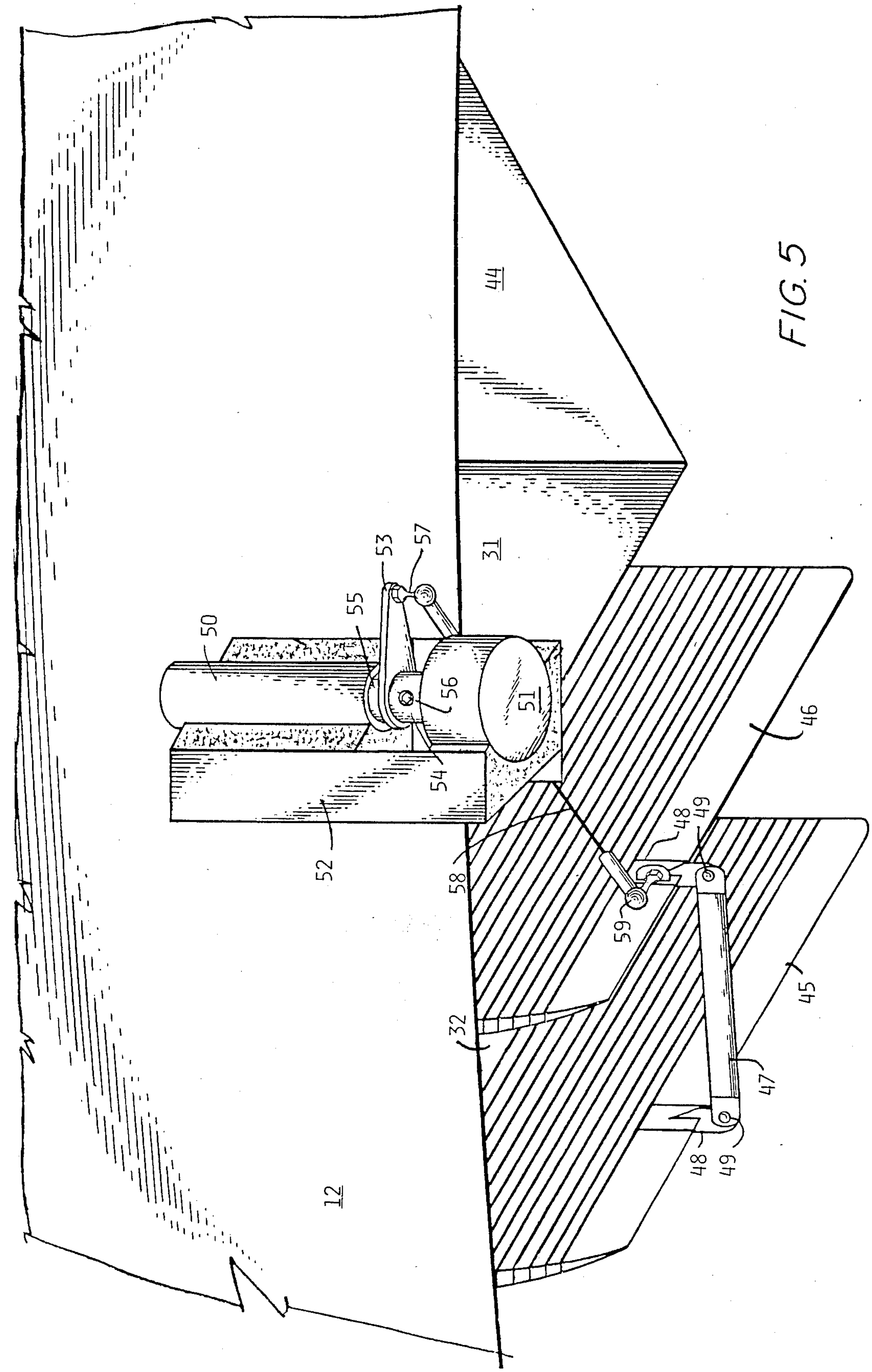

FIG. 5

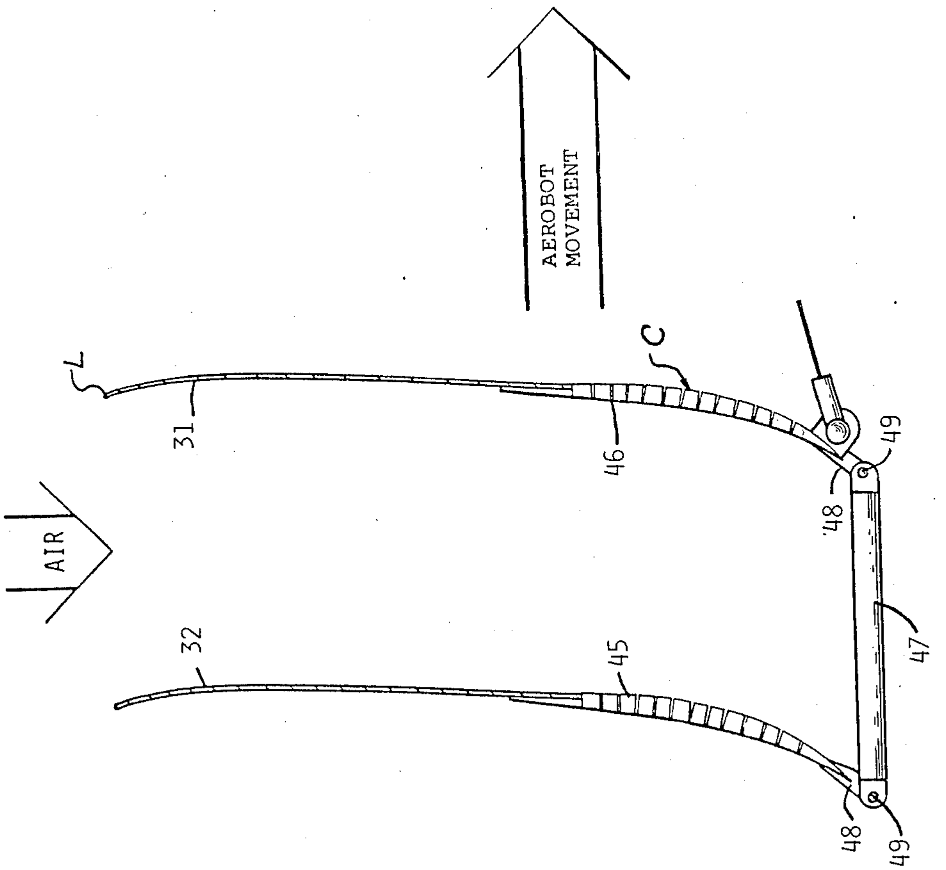
AEROBOT MOVEMENT
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FIG. 7

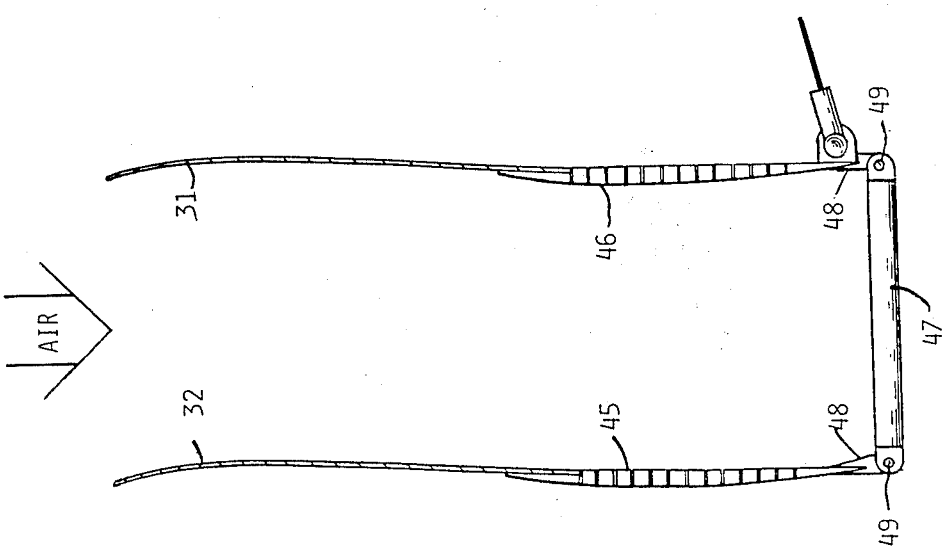
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FIG. 6

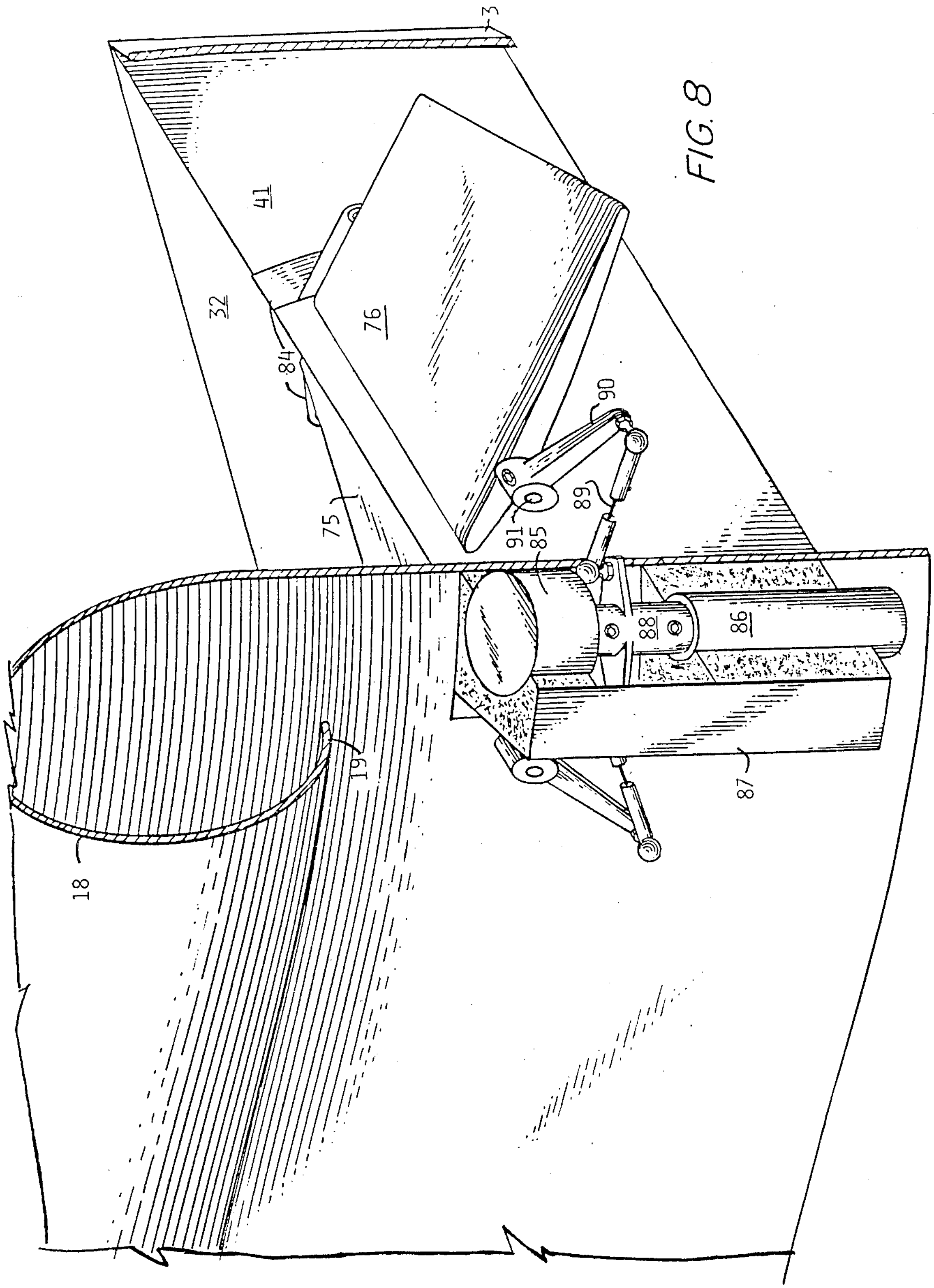

FIG. 8

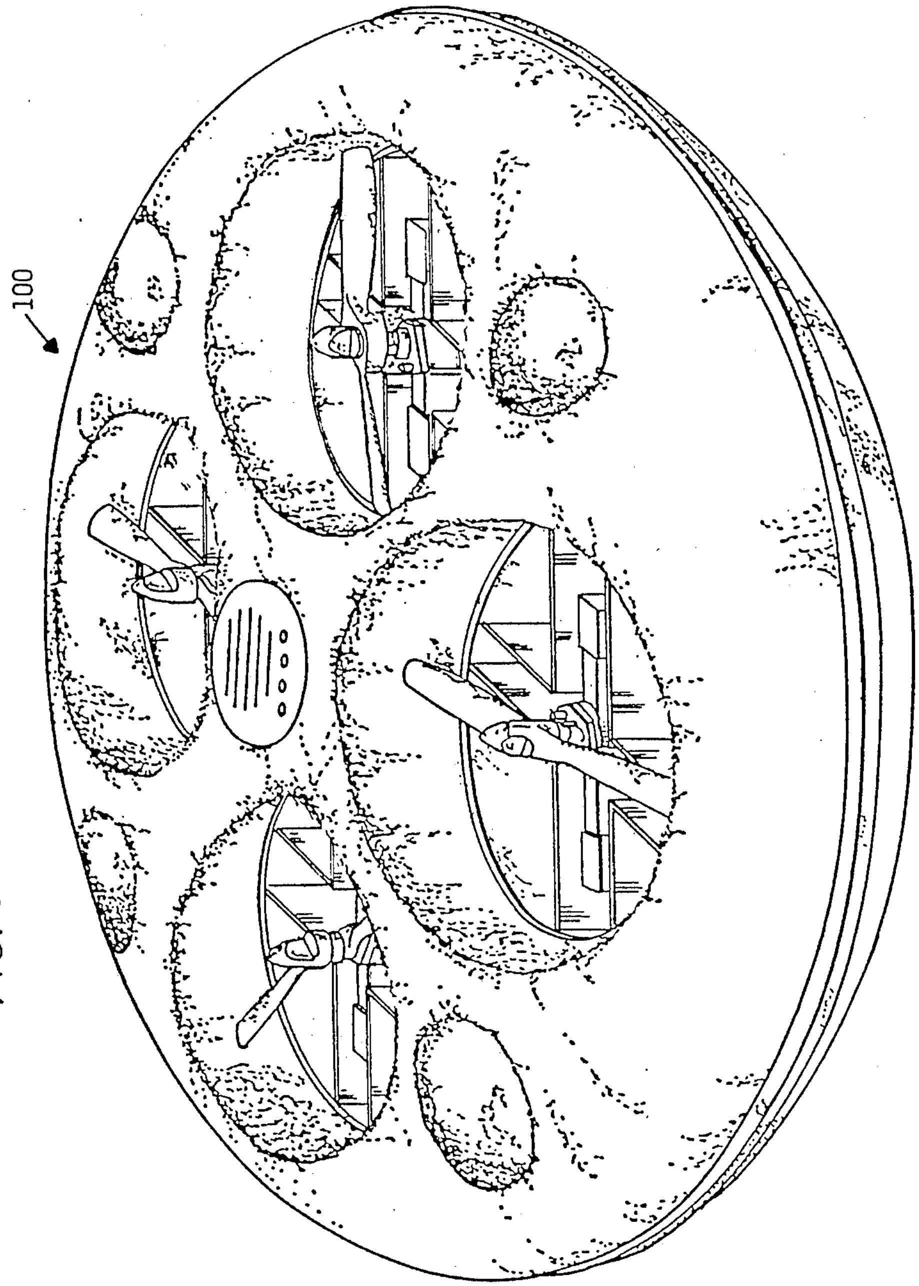

FIG. 9

ROBOTIC OR REMOTELY CONTROLLED FLYING PLATFORM

This invention relates to a flying platform which may be robotic or remotely controlled. The invention pertains more particularly to VTOL aircraft of the type employing one or more ducted fans.

BACKGROUND OF THE INVENTION

Even a single-engine ducted-fan, VTOL aircraft can deliver modest payloads by air, remotely and inexpensively. For example, the payload may be a task-performing arm for cleaning high-voltage insulators that are located in positions high above ground level and are difficult to get at. The payload may be a data acquisition package for use in such environments as prisons or along a military front. For example, these ducted-fan VTOL aircraft may help guards in prison security situations, or may serve to seek out and even destroy military tanks, for tanks can be destroyed with very light munitions. Such VTOL devices may also be used to clean or inspect apparatus in high, remote, and/or dangerous areas, and for data acquisition, even in hostile environments. They may be used for remote painting or for traffic surveillance. They can perform such simple tasks as routine inspection and simple cleaning. They may be used in cattle range operations.

These, of course, are only examples of where such aircraft may be used. These aircraft need not carry a person, although, in large embodiments, that becomes possible. They may be controlled entirely robotically or by remote control via electrical cables or by radio.

The main difficulties with such apparatus heretofore have been to obtain precise control and to do so in a relatively inexpensive manner that is easy for an operator to employ.

Heretofore, most of the efforts to control such vehicles have relied on the tilting of vanes in the slip stream. Depending on their position or deflection, such vanes have been able to provide a moderate degree of control. For example, a vane well below the center of gravity tended to rotate the vehicle about its center of gravity, thereby shifting the vertical lift vector away from the gravitational direction and creating a lateral thrust component enabling movement of the vehicle in the direction of the tilt of the lifting vector. However, in this instance a secondary counteracting effect was also generated, because the vane forces were at right angles to the vane's chord and in the opposite direction from the desired direction of motion; as a result, this counteraction reduced the effectiveness of the principal action as a control means. When the vanes were mounted closer to the center of gravity, this counter force became even greater and tended to equal the force generated by the rotating lift vector, so that there was no control power whatever.

Because of this fact, such vanes have generally been mounted quite far behind the propeller or fan, thereby requiring a long duct or resulting in a system that had a reduced translational speed due to its increased drag. Experience has shown that such type of control was only marginally effective, except at low speeds and in calm conditions. In a crosswind, parasitic drag, due to the components below the center of gravity, tended to make the aircraft difficult to orient and to control.

An additional factor that hampered control of single engine ducted fan type of aircraft was that there were gyroscopic moments due to the rotating fan and to its engine components. If control was to be obtained by tilting the vehicle, then these gyroscopic forces tended to interfere with the vehicle's action. These gyroscopic forces were very time-dependent and prevented control of a tilting aircraft when the required rate of correction of the tilt was high, as, for example, in turbulent air. While counterrotating fans might have helped, these would have been expensive, heavy, and inefficient.

An alternative control means used spoilers in the airstream. For example, if one desired to move the VTOL aircraft to the left, spoilers on the left side of the duct would be employed in the airstream and would reduce the thrust on that side. The left side would then drop, so that the vehicle would tilt and would then translate to the left. While this was a more positive type of control, it had two serious negative effects:

(1) it tended to reduce significantly the overall lift capability of the vehicle, especially if a modest to high translational speed was needed, or if station holding was required in even a modest crosswind;

(2) there was a sizable coupling between the pitch-and-roll axis and the vertical or heave direction. In other words, as the spoilers were engaged and disengaged, the vehicle fell and rose.

Also, in spoiler types of control, gyroscopic moments continued to present a problem.

Significant spoiling of the airflow also adversely affected the efficiency of the fan and increased the noise generated by the fan.

Other proposed control methods include differential control of the fan blade angles. While this might be effective and efficient, it would also be heavy, reducing the pay load, and very expensive. This technique is employed by helicopters, where it is appropriate. With small single-duct aircraft, the gyroscopic moments would increase with systems employing vane or spoiler controls, and, in fact, would become prohibitively heavy and expensive in connection with pitch control.

Extensive testing of both deflection-vane and spoiler systems and combinations of both, has resulted in the conclusion that single-engine designs requiring the vehicle to tilt, to generate control power, or to provide translation, were not practical except in ideal environments and at low translational speeds.

SUMMARY OF THE INVENTION

The present invention, whether utilizing a single-engine ducted fan or utilizing a plurality of such ducted fans, provides pitch-and-roll control seperate from translational control. The invention employs vanes and spoilers, but in a different way. The spoiler system is automatically driven by an on-board inertial reference system, and the spoilers are deployed only for the purpose of keeping the vehicle lift axis parallel to or coincident with the gravitational axis. The moment of inertia about the pitch-and-roll axis and the response time of the spoilers are both minimized, so that only very low forces are required from the spoilers. The result is that there is little loss of lift; hence, there is little coupling between the pitch-and-roll control and the heave or vertical movement. The remote pilot can trim to level the vehicle, but trimming is not used for controlling maneuvers about the pitch-and-roll axis.

All of the spoilers in this invention are paired in each quadrant. This insures that no torque or force is generated which might rotate the vehicle about the vertical or yaw axis when the spoilers are employed. The pivot axis of each spoiler vane is chosen to coincide with the position where the torque on the spoiler is minimized as a function of its angular position. This positioning reduces the amount of torque required to deploy the pair of spoilers and hence reduces the size of the servomotors required.

Most of the spoiler surface is concentrated near the maximum duct diameter, in order to maximize the resulting control moment. Preferably, the spoilers are made of extremely light material in order to minimize their inertia and to obtain rapid spoiler response with minimum servo-motor power.

Translational control is obtained by use of a different type of vane, a flexible vane instead of a pivoted rigid vane. In a deflection vane system, it is important to recognize that a rigid vane generates two major problems when used to deflect a slip stream:

(1) The forces generated by swinging a rigid vane are highly nonlinear relative to the changing angle of the vane, and particularly when the aircraft is near the stall condition.

(2) The stall condition is reached by rigid vanes at fairly low angles of vane deflection, generally less than 15°. However, for significant translational forces, such as those which are required to move a vehicle of this type at a velocity greater than one-third of the slip stream velocity, the slip stream deflection required becomes significant and is greater than 15°. It is very difficult, if not impossible, to achieve such deflection with a rotating rigid vane without stalling the vane.

Therefore, the present invention employs a variable-camber vane or flap, which is attached to the trailing edge of fixed anti-torque vanes that serve to remove the swirl introduced by the fan.

The invention thus obtains translational control by redirecting the slip stream with vanes that are provided with flexible camber portions or flaps extending downwardly from an upper fixed rigid portion, and the vanes are mounted so that the center of lift or force providing the transverse force is at or as close as possible to the center of gravity of the vehicle. This mounting ensures that deflection of the variable-camber vane or flap does not generate significant moments about the center of gravity; such moments, if generated, would have to be overcome by the spoiler system. Small coupling moments are automatically dealt with by the spoiler system and result only from forces produced about the pitch-and-roll axis, due to translational control.

This vane system is one of the most important elements of the success of this design. If the flexible portion of the vane is equal in size to the rigid upstream portion, then the transverse force (or center of pressure) of the rigid-flexible deflector vane occurs at approximately the three-quarter chord position back from the leading edge. Put another way, the center of pressure or lift appears to occur near the center of the flexible portion of the vane. In fact, this position is a function of the amount of vane deflection. For greater deflections this position is probably correct. For small deflections this center of pressure will be farther forward. Ideally, the center of left on the vane is at the center of gravity of the vehicle, on the vertical axis.

The variable-camber vanes of this invention act like a flap (or aileron) on a wing. Such a flap may involve comparatively small forces and be small in size relative to the forces it can generate. Thus, when a variable-camber vane system employs two or more vanes in parallel, a cascade vane effect is created. This cascade effect continues to deflect the slip stream up to 90°, if that should be necessary. However, it is unlikely that deflection greater than 30° will ever be required.

More succinctly summarized, the invention comprises a robotic or remotely controlled flying platform. There is least one ducted fan, comprising power means, a horizontally mounted fan connected to and driven by the power means for causing a vertically and downwardly directed airstream, and a cylindrical duct that extends around and beneath the fan, for confining the airstream. In the duct is a vane system comprising two mutually perpendicular pairs of diametrically opposite generally rectangularly shaped duct segments, each defined and bounded by a pair of generally vertical stationary walls extending across the duct parallel to a diametral line thereacross. Each pair of these walls also defines one boundary of a quadrant shaped duct segment located between adjacent wall pairs. Each duct segment forming a wall includes an upper, rigid portion having a variable-camber flap portion affixed to its lower extremity. A first set of remotely controlled servo motors is employed for varying the camber of each of the flaps. In each pair of variable vanes, the flap camber is at all times the same in amount and direction for both flaps.

There are also additional rigid vanes bisecting the quadrants. Each such additional vane has mounted thereon a symmetric pair of spoilers, so that there is one spoiler in each half-quadrant. Each pair of spoilers is independently movable (as a pair) continuously between a position substantially blocking airflow through its quadrant and a position enabling substantially full airflow therethrough. A second set of remotely controlled servomotors is used to control the positioning of the respective pairs of spoilers.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view in perspective of an aerobotic single-engine ducted VTOL aircraft embodying the principles of the invention, looking slightly from above.

FIG. **2** is another view in perspective, looking from a higher viewpoint, of the aircraft of FIG. **1**.

FIG. **3** is a top plan view thereof.

FIG. **4** is a view in section taken along the line **4—4** in FIG. **3**, with one spoiler shown vertical and one horizontal. (This is for illustrative purposes only; the pair of spoilers always act together.)

FIG. **5** is an enlarged fragmentary view in perspective of a portion of the aircraft of FIG. **1**, looking from below, showing a portion of the camber vane control.

FIG. **6** is a simplified fragmentary view in elevation of one duct portion, showing two non-activated camber vanes.

FIG. **7** is a view similar to FIG. **6** with the camber vanes actuated.

FIG. **8** is an enlarged fragmentary view in perspective of a portion of the aircraft of FIG. **1**, showing a pair of spoilers and their control linkages.

FIG. **9** is a view in perspective of a modified form of aircraft embodying the invention, having four propellers and four ducts and no spoilers.

DESCRIPTION OF PREFERRED EMBODIMENTS

FIGS. **1** through **8** show a single-engine ducted-fan VTOL aircraft **10** with a propeller **11** and a duct **12**. The fan or propeller **11** is mounted horizontally on a shaft 13 and is powered by a single engine 14 below it. The illustrated propeller 11 has two blades 15 and 16 and a nose 17.

The circular duct 12 has a curved flange 18 at its upper end and has a planar lower edge 19. As shown in FIGS. 1 and 2 the duct 12 may have a support member 20 with a hollow bottom or base ring 21 and four support columns 22. The ring 21 also serves as a muffler and is connected by a pair of vertical exhaust tubes 23 to the exhausts from the engine 14, there being two such exhaust tubes for a two-cylinder engine 14. The exhaust gas goes down the tubes 23 into the ring 21 and passes out from the ring 21 at exhaust openings 24, spaced around the ring 21 at distances beginning about 90° away from the tubes 23 and extending downwardly at about 45°.

An antenna 25 may be mounted on one support column 22 to pick up control signals sent by a remote-control transmitter, not shown. Mounted on the exterior face of the duct 12 is a series of control devices, each a standard type of electronic device, including a detector and receiver 26, and various programmed control initiators 27, which control the engine 14 and the various lever systems described below. The engine 14 itself may be a gasoline engine, and may have a fuel tank 28 below it; to one side lies an air inlet 29. For small aircraft 10, a two-cylinder engine 14 may be used; for larger aircraft a radial engine may be used.

In the duct 12 are twelve fixed vanes 31, 32, 33, 34, 35, 36, 37, 38, 41, 42, 43, and 44.

The eight identical vanes 31, 32, 33, 34, 35, 36, 37, and 38 are disposed along two mutually perpendicular axes; that is, there are four vanes 31, 32, 33, 34 arranged as two diametrically opposite pairs 31, 32 and 33, 34 parallel to one diametral line 39 (FIG. 3), and there are two other diametrically opposite pairs of vanes 35, 36 and 37, 38 parallel to a diametral line 41 perpendicular to the line 39. Each pair of vanes forms a generally rectangularly shaped duct segment and adjacent pairs form generally quadrant shaped duct segments. These eight vanes 31–38 are preferably not simply vertical planes but are preferably shaped as shown in FIGS. 6 and 7, and they each have a variable-camber flap 45 or 46 attached to their lower or trailing edge.

For yaw control, or control about the vertical axis, the flaps 45 and 46 of all eight of these vanes 31 through 38 move together in the same rotational direction, resulting in torque about the vertical axis. For translational control, the flaps 45 and 46 of two diametral pairs move together (See FIG. 7), while the flaps 45 and 46 of the other diametral pairs either do not move or move in a direction or directions. As a result, a force is generated for accelerating the vehicle 10 horizontally at a speed up to a point where its aerodynamic drag equals its ventable translational force.

Preferably, each camber flap 45–46 is equal in area to its respective vane 31–38. As a result the center of pressure of the vane-flap combination occurs at the three-quarter chord position C back from the leading edge L, i.e., near the center of the camber flap 45 or 46, and this is where the center of pressure of the vanes occurs. This center of pressure is kept as close as possible to the position along the vertical-axis occupied by the center of gravity of the aircraft 10 and is preferably within the limits of the vertical extremities of the flaps 45–46.

Each pair of flaps 45 and 46 is joined together by a tie rod 47 having a clevis clip 48 at each end pivoted to it by a pin 49, controlled, as shown in FIG. 5, by a servomotor 50. The servomotor 50 is actuated by a remotely controlled potentiometer 51, and both are in a foam-rubber fitted housing 52. The servomotor 50 acts on the tie rod 47 through the vane control arm 53, having a sleeve 54 held on a servomotor shaft 55 by a recessed Allen-head screw 56. The arm 53 may act through a ball-and-socket joint 57 on a drag linkage 58, which operates on the tie rod 47 through another ball-and-socket joint 59.

The other four vanes 41, 42, 43, and 44 (FIG. 2) are rigid and extend in from the wall of the duct 12 to bisect the right angles made by the mutually perpendicular vanes 32, 37 and 38, 34 and 33, 36 and 37, 31 (FIG. 3). In other words the vanes 41, 42, 43, and 44 lie at an angle of 45° to the eight diametral vanes 32, 37 and 38, 34 and 33, 36 and 35, 31. Preferably, these four vanes 41, 42, 43, and 44 are not simply vertical planes but are shaped like the rigid upper portions of the vanes shown in FIGS. 6 and 7 (but without the attachment of variable-camber vanes).

Between the vanes 31 and 32 is a generally rectangular duct segment or passage 61; between the vanes 33 and 34 is a diametrically opposite rectangular passage 63. At right angles to these openings are a rectangular passage 64 between the vanes 35 and 36 and a rectangular passage 62 between the vanes 37 and 38. Thus, between the vanes 32 and 37 is a quadrant divided into two equal passages 65 and 66 by the vane 41; between the vanes 38 and 34 is a quadrant shaped duct segment divided into two equal passages 67 and 68 by the vane 42; between the vanes 33 and 36 is a quadrant shaped segment bisected into two passages 69 and 70 by the vane 43; and between the vanes 35 and 31 is a quadrant shaped segment bisected into two passages 71 and 72 by the vane 44.

Each vane 41, 42, 43, and 44 preferably supports a pair of spoilers 75, 76 or 77, 78 or 79, 80 or 81, 82, one for each passage 65, 66, 67, 68, 69, 70, 71 and 72. The spoilers 75–82 each have a circular-arc outer rim 83 concentric with the duct 12 and are otherwise generally trapezoidal in shape to fill most of the outer portion of their respective passages 65–72 when in the fully closed or horizontal position, as depicted in FIGS. 2 and 3. When rotated down to their fully open or vertical position, they lie generally parallel to their respective vanes 41–44, as shown at 81 in FIG. 4, and take up very little room in the passages 65–72.

The spoilers 75–82 are each supported by their associated vanes 41–44 through a tension bracket 84 and are operated, as shown in FIG. 8, via a remotely activated system embodying a potentiometer 85 supported with a servomotor 86 inside a housing 87. The servomotor 86 operates, like the servomotor 50, through a linkage arm 88 and a drag linkage 89 having a ball-and-socket joint at each end, and a lever arm 90 that rotates on shaft 91.

In each quadrant, a single servomotor 86 operates the pair of spoilers 75, 76 etc.; so that in each quadrant the spoilers are paired. Moreover, the pivot axis of each spoiler lies along and coincides with the position where the torque on its spoilers is minimized as a function of its angular position; thereby the torque required to deploy that pair of spoilers is reduced, and the size of the servomotors 86 is kept small. Since each spoiler 75–82 has its surface concentrated near the duct wall, the resulting control moment is maximized. Each spoiler may be made from lightweight wood, to minimize its inertia and provide rapid response to its servomotor 86.

The functional mixing of yaw and translation forces is preferably done electronically by the control circuits **27**, with the vehicle **10** employing eight separate servomotors **50** and **86** for control. Thus, there are four servomotors **50** for yaw or translational controls and four servomotors **86** for pitch-and-roll controls. One servomotor controls one parallel set of yaw vanes or one pair of spoilers.

This system for controlling the flight of the vehicle **10** has the additional capability of being able to trim the vehicle **10** into a nonvertical position and holding that position through the use of translational control power. This may be a very important advantage when a rigidly attached TV camera is used and is directed in the plane of vision by gimballing the vehicle rather than gimballing the camera. The importance of this can be seen from the fact that the gimbal used in the Aquila RPV military surveillance drone costs more than the aircraft and the other electronics on it, all taken together.

The means of control through separation of pitch-and-roll control from translational control is also appropriate to manned aircraft as well as unmanned aircraft.

If the aircraft employs a plurality of ducts, as in the case of the aircraft **100** shown in FIG. **9**, then the spoiler approach can be augmented or even replaced by a system that alters the thrust in the individual ducts, either by individual fan pitch control or individual throttle engine control.

To those skilled in the art to which this invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the spirit and scope of the invention. The disclosures and the descriptions herein are purely illustrative and are not intended to be in any sense limiting.

What is claimed is:

1. A flying platform, including in combination:

at least one ducted fan comprising power means, a horizontally mounted propeller having blades and connected to and driven by said power means for causing a vertically downwardly directed airstream, and a cylindrical duct having an outer rim extending around and beneath said propeller for confining said airstream, and

a vane system in said duct comprising four pairs of first vanes, the vanes of each pair being parallel to each other and to a diametral line across the duct end extending in from said rim toward the center of the duct, each said pair of first vanes providing a pair of generally vertical walls defining generally rectangularly shaped duct passages and the walls of adjacent pairs defining quadrant shaped duct passages, each said first vane having an upper, fixed, rigid portion and a variable camber flap depending therefrom, and first servomotor and linkage means for varying the camber of each of said flaps, so that the camber of the flaps associated with a particular pair of said first vanes is at all times the same amount said flaps being positioned along the vertical axis of said duct so that the center of gravity of said platform lies within the limits of the upper and lower extremities of said flaps whereby said flaps may be used to provide yaw and translational forces to said platform without imparting significant pitch and roll moments about said center of gravity.

2. The flying platform of claim **1** including, four second vanes, one bisecting each said quadrant shaped passage,

symmetric pairs of spoiler means disposed in each said quadrant shaped passage and mounted on one of said second vanes, each said pair of spoiler means being independently movable between a position substantially blocking airflow through the outer portion of said quadrant shaped passage and a position permitting substantially full airflow therethrough, and

second servomotor and linkage means for selectively and symmetrically varying the position of the flaps of each said pair of spoiler means.

3. The platform of claim **2** having receiving means responsive to remote control signals for actuating each said servomotor and linkage means.

4. The platform of claim **1** wherein the area of each said first vane and the area of each said camber flap are substantially equal.

5. The platform of claim **1** wherein the vertical height of each said flap is approximately equal to the vertical height of its associated said rigid portion.

6. The platform of claim **1** having a ground support assembly which also serves as an exhaust and muffler system for said power means, said power means being a combustion engine having exhaust ports, said support assembly comprising:

a base hollow ring lying in a plane parallel to the upper and lower ends of said duct,

support columns connecting said ring to said duct, and

exhaust tubes connecting the interior of said ring to said exhaust ports;

said ring having exhaust ports therefrom at least 90° around said ring from the nearest exhaust tube, said ring exhaust ports being directed downwardly at about 45° from the plane of said ring.

7. The flying platform of claim **1** having a plurality of said ducted fans, each with a said vane system.

8. A robotic or remotely controlled flying platform, including in combination:

at least one ducted fan comprising power means, a horizontally mounted propeller having blades and connected to and driven by said power means for causing a vertically downwardly directed airstream, and a cylindrical duct having an outer rim extending around and beneath said propeller for confining said airstream,

a vane system in said duct comprising two mutually perpendicular pairs of diametrically opposite first vanes, each extending in from said rim toward the center of the duct, each said pair of first vanes providing a pair of generally vertical walls parallel to a diametral line across said duct, said walls defining duct passages between the pairs of said first vanes and defining quadrants between adjacent pairs, each said first vane having an upper, fixed rigid portion and a variable camber flap depending therefrom, and first servomotor and linkage means for varying the camber of each pair of said flaps, so that the camber of the flaps of each pair of first vanes is at all times the same amount,

four second vanes, one bisecting each said quadrant,

a symmetric pair of spoiler means in each said quadrant mounted on one said second vane, each pair being independently movable continuously between a position substantially blocking airflow through the outer portion of said quadrant and a position permitting substantially full airflow therethrough,

second servomotor and linkage means for each said pair of spoiler means for symmetrically varying the position of its said spoiler means, and

receiving means responsive to remote control signals for actuating each said first and second servomotor and linkage means.

9. The platform of claim **8** wherein the area of each said first vane and the area of each said camber flap are equal.

10. The platform of claim **9** wherein the vertical height of each said flap is approximately equal to the vertical height of its associated said rigid portion.

11. The platform of claim **8** having a ground support assembly which also serves as an exhaust and muffler system for said power means, said power means being a combustion engine having exhaust ports, said support assembly comprising:

a base hollow ring lying in a plane parallel to the upper and lower ends of said duct,

support columns connecting said ring to said duct, and

exhaust tubes connecting the interior of said ring to said exhaust ports;

said ring having exhaust ports therefrom at least 90° around said ring from the nearest exhaust tube, said ring exhaust ports being directed downwardly at about 45° from the plane of said ring.

12. A flying platform, comprising in combination:

at least one ducted fan including power means, a horizontally mounted propeller having blades connected to and driven by said power means for causing a vertically downwardly directed airstream, and a cylindrical duct having an outer rim extending around and beneath said propeller for confining said airstream; and

a vane system in said duct including a plurality of first vanes each extending inwardly from said rim toward the center of the duct, each said first vane providing a generally vertical wall which cooperates with adjacent walls to define vertically extending duct passages, at least some of said first vanes having an upper, fixed, rigid portion and a lower portion including a variable camber flap, and first servomotor and linkage means for varying the camber of each of said flaps, said flaps being positioned along the vertical axis of said duct so that the center of gravity of said platform lies within the limits of the upper and lower extremities of said flaps, whereby said flaps may be used to provide yaw and translational control forces to said platform without imparting significant pitch and roll moments about said center of gravity.

13. The flying platform of claim **12** further comprising:

a plurality of symmetric pairs of spoiler means affixed to at least four orthogonally extending vanes, with each spoiler means extending into an adjacent duct passage, each said pair of spoiler means being independently movable between a position interfering with airflow through the associated duct passage and a position permitting substantially full airflow therethrough; and

second servomotor and linkage means for symmetrically varying the position of each said pair of spoiler means.

14. The platform of claim **13** wherein the area of each said first vane and the area of each said camber flap are substantially equal.

15. The platform of claim **13** wherein the vertical height of each said flap is approximately equal to the vertical height of its associated said rigid portion.

16. The platform of claim **12** having a ground support assembly which also serves as an exhaust and muffler system for said power means, said power means being a combustion engine having exhaust ports, said support assembly comprising:

a base hollow ring lying in a plane parallel to the upper and lower ends of said duct;

support columns connecting said ring to said duct; and

exhaust tubes connecting the interior of said ring to said exhaust ports;

said ring having exhaust ports disposed at least 90° around said ring from the nearest exhaust tube, said exhaust ports being directed downwardly at about 45° from the plane of said ring.

17. The flying platform of claim **12** having a plurality of said ducted fans, each with a said vane system.

18. The flying platform of claim **13** having a plurality of said ducted fans, each with a said vane system.

19. A flying platform, comprising in combination:

at least one ducted fan including power means, a horizontally mounted propeller having blades connected to and driven by said power means for causing a vertically downwardly directed airstream, and a cylindrical duct having an outer rim extending around and beneath said propeller for confining said airstream; and

a vane system in said duct including a plurality of vanes each extending inwardly from said rim toward the center of the duct, each said first vane providing a generally vertical wall which cooperates with adjacent walls to define vertically extending duct passages, and means associated with said vanes for providing yaw control forces to said platform;

a plurality of symmetric pairs of spoiler means affixed to at least four orthogonally extending vanes, with each spoiler means extending into an adjacent duct passage, each said pair of spoiler means being independently movable between a position interferring with airflow through the associated duct passage and a position permitting substantially full airflow therethrough; and

second servomotor and linkage means for symmetrically varying the position of each said pair of spoiler means.

* * * * *

United States Patent [19]

Harmon

[11] **Patent Number: 4,804,156**

[45] **Date of Patent: Feb. 14, 1989**

[54] **CIRCULAR AIRCRAFT**

[76] Inventor: **Rodney D. Harmon,** 4288 Burnett Rd., Lincoln, Calif. 95648

[21] Appl. No.: **78,905**

[22] Filed: **Jul. 28, 1987**

[51] **Int. Cl.**[4] **B64C 39/06**

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

[58] **Field of Search** .... 244/12.2, 23 R, 23 C, 244/58, 60

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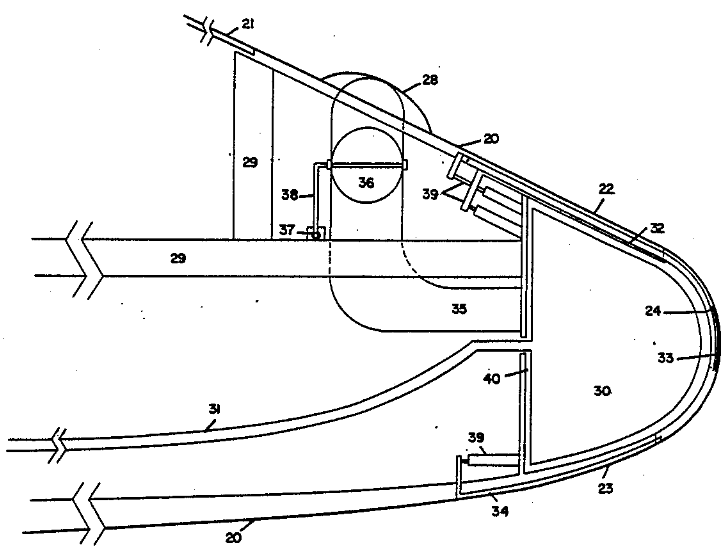
Primary Examiner—Galen Barefoot
Assistant Examiner—Rodney Corl

[57] **ABSTRACT**

The invention relates to circular aircraft and in particular to circular aircraft having an impeller for providing horizontal and vertical thrust. Internal frameworks are provided for defining an outer circumference of convexo-convex shape, an impeller housing, a control, passenger and cargo section and an appendage bracket. Controls are provided on the aircraft for directional control and control of counter-rotation. Electrical power sources are provided to drive the impeller, as well as an alternate power supply in the form of an internal combustion engine.

1 Claim, 4 Drawing Sheets



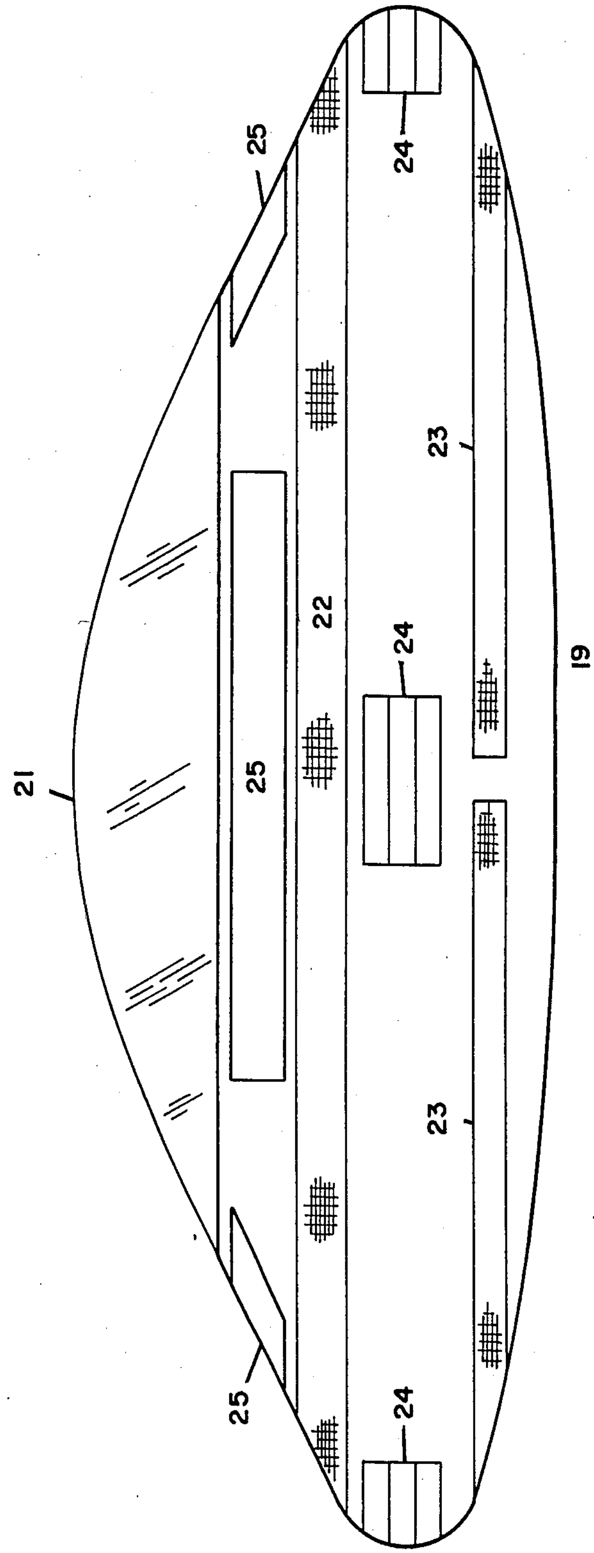


FIG. 1

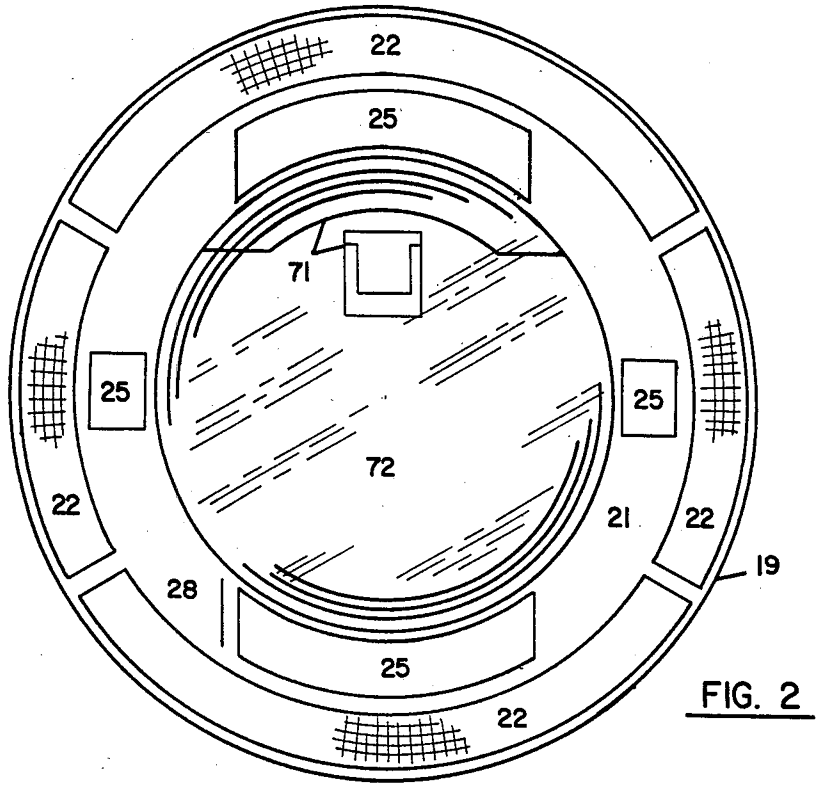


FIG. 2

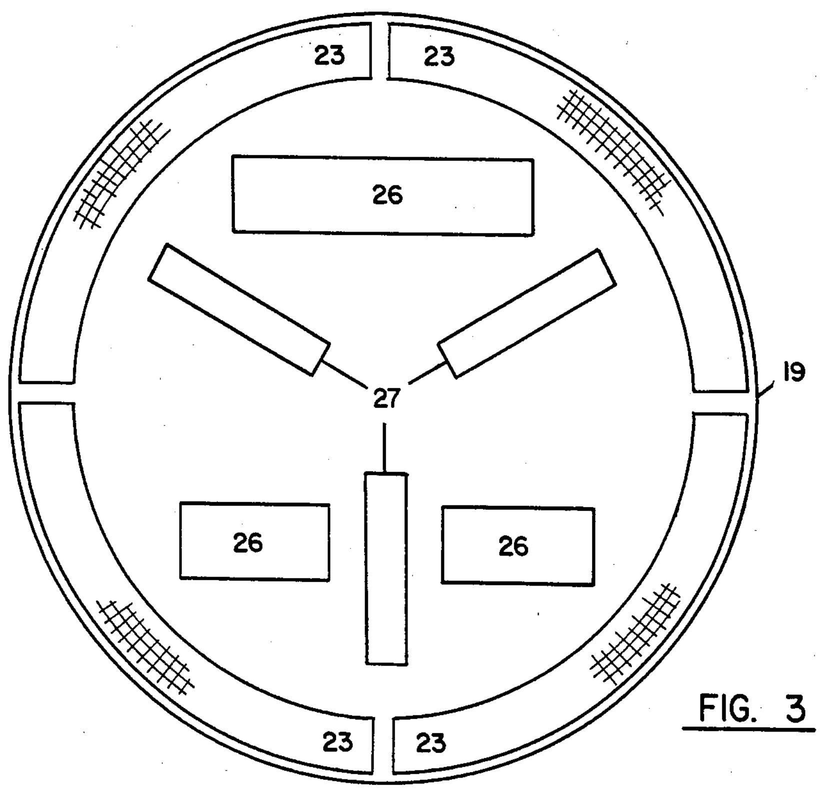


FIG. 3

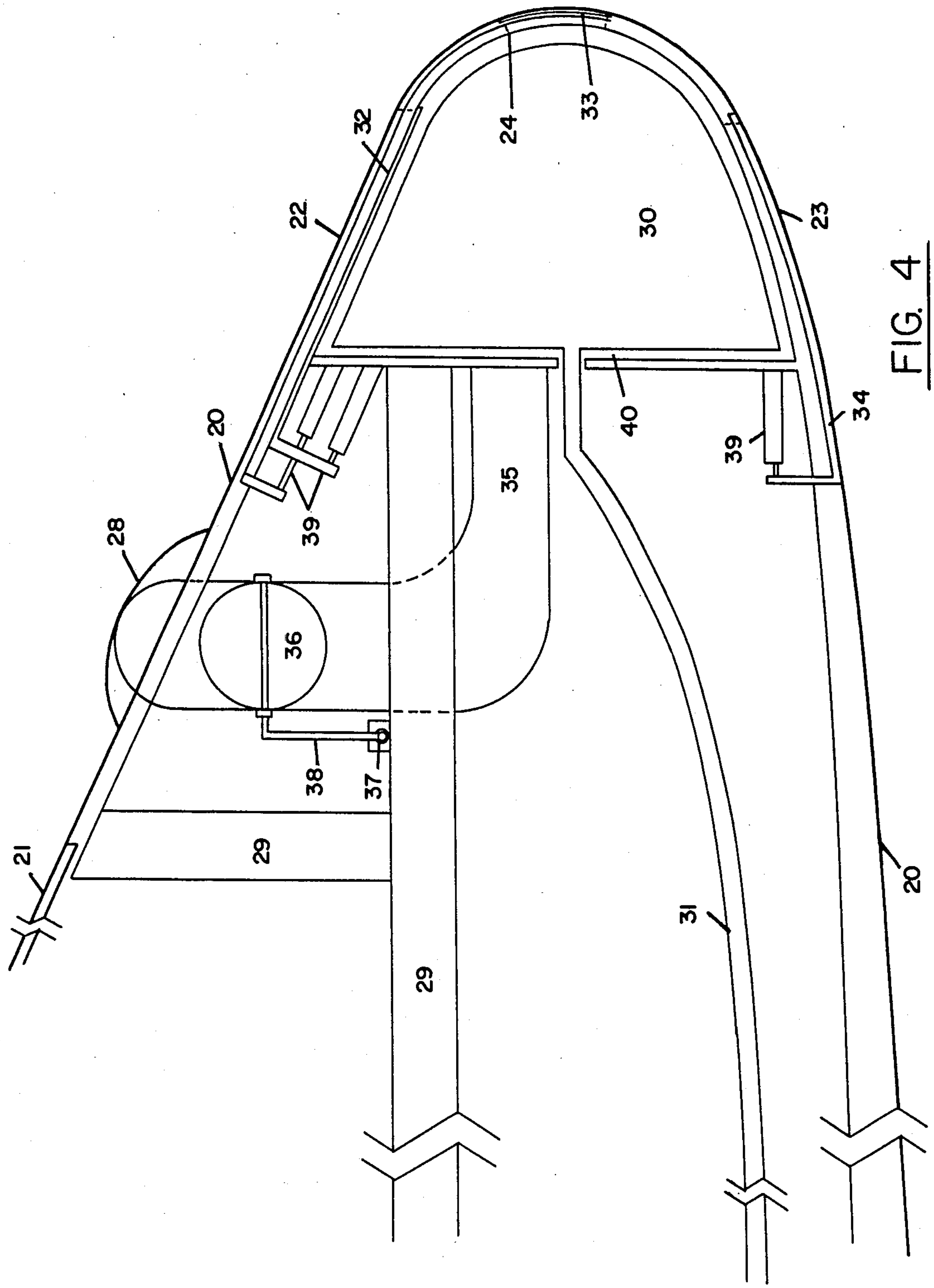


FIG. 4

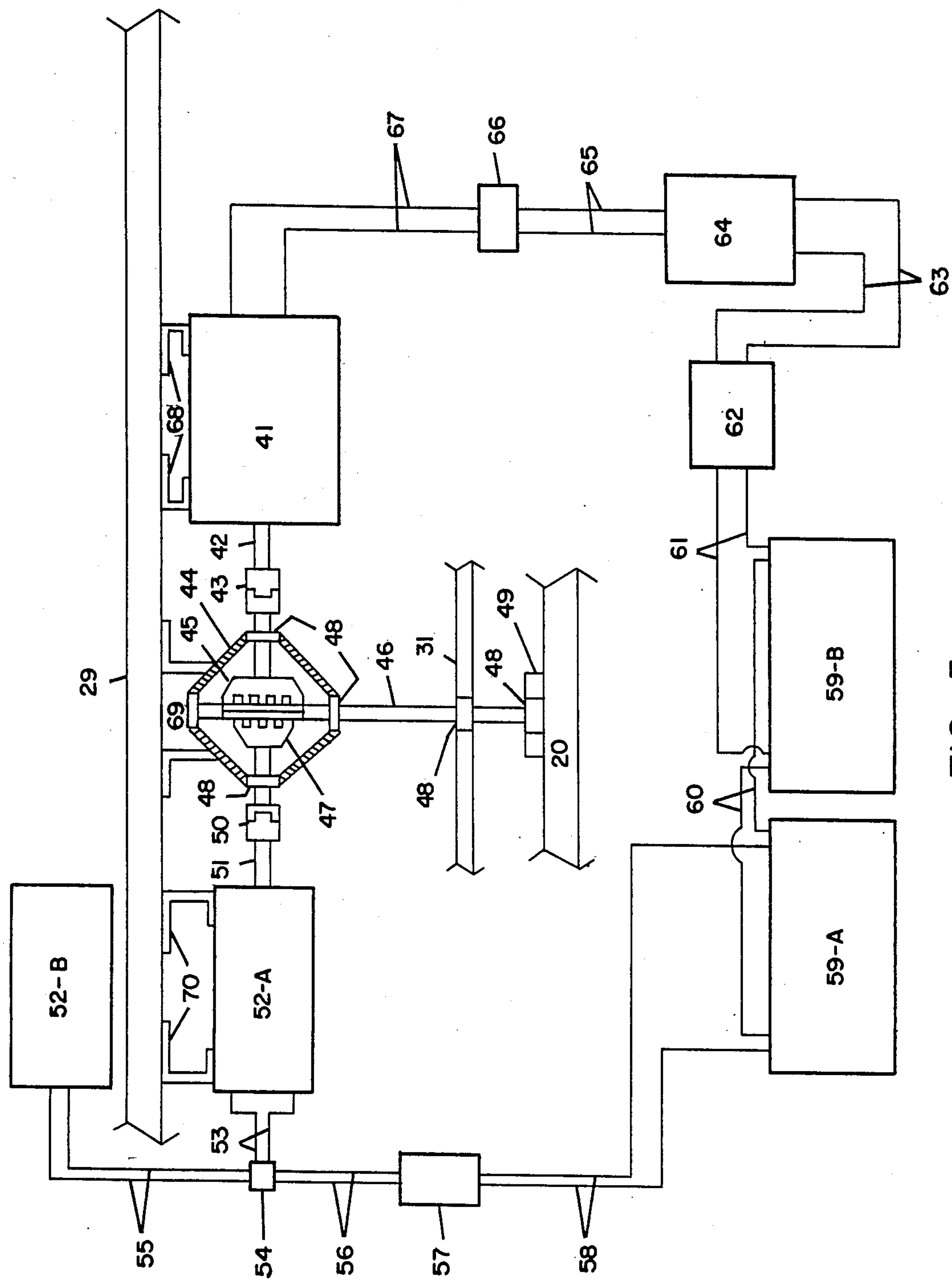

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FIG. 5

CIRCULAR AIRCRAFT

This invention relates to aircraft, and more particularly circular aircraft, which is a most desirable design for vertical take-off and landing, being one of several primary objects of this invention.

In considering the concept of ascent and descend aircraft, it must be realized the advantages of such aircraft over conventional type aircraft. One of the best advantages being safety. Conventional aircraft, in most areas, require the take-off and landing of the craft to cross over populated areas at a high rate of speed and relatively low altitudes for a considerable distance and if there occurs mechanical failure, the danger of loss to life and property are great. With the present invention, this is minimized due to its' ability to descend directly onto its' port at much slower speeds and very minimal noise. Because of its' ability to do this, it creates another advantage, being economical, in the sense that it requires less property for its' port, not needing runways.

Although other patents have been issued for aircraft of this particular type, they all appear to be very complicated and very costly to construct. Another object of the present invention is to provide a simply designed, cost efficient to construct, as well as operate, vertical ascent and descend aircraft.

Other objects of the present invention is to provide an aircraft basically circular in design and constructed in which lift is achieved by a circular designed, housed around the perimeter, housed impeller, designed to pull air in and force the air downward and outward. Said impeller to connect to a central power source through two or more arms. To provide an external framework of Rib-Type construction, spaced equally apart to form a circular shape. To provide an internal framework of pre-stressed truss design to house a passenger/cargo and control center and help support the present invention as a whole. To provide triangular spaced landing gear for the present invention to ascent from and descend onto. To provide a design that uses strategically placed intake and exhaust ports, being controlled by sliding panels, to control for forward, backward and sideway movement. To further provide an airduct extending from the housing of the power impeller, terminating at the outer perimeter of the craft. The exhaust of air being controlled by a damper, to counter the rotation of the craft caused by the directional rotation of the power impeller. Another feature added for control of the craft while in flight and for gliding purposes if there is a power failure, is external control flaps simular to those on the wings of conventional aircraft.

The above objects and advantages as well as other objects and advantages will become readily apparent to those skilled in the arts, when taken in conjunction with the following detailed description and accompanying drawings of the present invention.

In the drawings, which are to be regarded as merely illustrative:

FIG. 1: Is a front elevational view of the present preferred invention showing to advantage the side exhaust ports.

FIG. 2: Is a top plan view showing to advantage the cabin compartment, screened intake area and external top control flaps.

FIG. 3: Is a bottom plan view showing to advantage the screened vertical exhaust area, the bottom external control flaps and the landing gear.

FIG. 4: Is a cross sectional view showing to advantage parts of the airduct and controlled baffle, for counter rotation control, the exhaust port slide plates and control cylinders, the power impeller housing and an illustrative impeller blade and connecting arm.

FIG. 5: Is a illustrative schematic lay-out showing to advantage the power source to the power impeller, the generation system and re-generation system.

Referring now to the drawings in greater detail, there is shown in (FIG. 1), a front elevation view of a Aero-Dynamic Designed Circular Aircraft consisting of a main body generally designated **19** angling from the horizontal to a clear canopy **21** housing a passenger/-cargo area **72** and control center **71** (FIG. 2).

Four or more side exhaust ports **24** are placed around the circumference of the craft to provide forward, backward and lateral movement. Also provided for total control and all angles of movement of the craft, once in flight, are external control flaps **25** and **26** (FIGS. **1**, **2**, and **3**) placed in front, back and sides, top and bottom of the craft.

Lift is accomplished by the rotation of the power impeller **30** (FIG. **4**) located in housing **40** around the circumference of the present invention. Power impeller **30** will have a design so as to pull air in through top screened are **22** (FIGS. **1**, **2**, and **4**) to power impeller housing **40** (FIG. **4**) and force it downward, outward and rearward. The amount of air intake will be controlled by slide plates **32** (FIG. **4**) placed strategically around the top circumference of the craft **19** under screened area **22**. Slide plates **32** will be controlled by pneumatic cylinders **39** (FIG. **4**) or other means (not shown). As air is pulled in and forced downward, strategically placed slide plates **34** (FIG. **4**) around the bottom circumference, located under screened area **23**, are opened allowing air to be forced downward, thus forcing the present Invention **19** upward. Balance of the present Invention **19** on lift off is accomplished by the throttling of bottom slide plates **34** at the necessary points of the circumference.

When the desired altitude is achieved and forward movement is desired, slide plate **24** (FIG. **4**) in the aft locations of the present Invention **19**, is partially opened to provide forward thrust, while slide plates **34** are being closed, and a portion of slide plates **32** are closed, allowing air intake at the front of the present invention.

Once the present Invention **19** is in flight, attitude of the present Invention **19** is achieved through manipulation and coordination of exterior control flaps **25** and **26** (FIGS. **1**, **2**, and **3**) and slide port controls **32**, **33** and **34** (FIG. **4**). Coordination of attitude control can be achieved through a modern technological computer system (not shown).

To counter the rotation of the present Invention **19**, caused by the rotation of the power impeller **30** there is provided an airduct system **35** (FIG. **4**) extending from the impeller housing **40** to the exterior of the present Invention **19** exhausting to the atmosphere through a shroud **28** (FIGS. **2** and **4**). Control of air flow to the atmosphere is accomplished by providing a baffle in the duct system connected to a control arm **38**, connected to a control cylinder **37**.

(FIG. **5**) details the power source to the power impeller **30** of the present Invention **19**, beginning with one or more fully charged battery banks **59*a*** and **59*b*** there is shown connecting wires **60** between battery banks **59*a*** and **59*b***. Wires **61** from battery banks **59*a*** and **59*b*** enter a voltage converter **62**, from voltage converter wires **63** enter an electrical distribution panel **64**, from the electrical distribution panel **64**, wires **65** connect to a variable speed control switch **66**, from the variable speed control switch **66**, wires **67** are connected to an electric motor **41**, mounted to interior framework **29** by mounting brackets **68**. As the electric motor **41** turns, power is provided to shaft **42** which is connected through a bearing **48** to a drive gear **45** by means of a coupler **43**, drive gear **45** is connected to a geared drive shaft **46** that extends through gear housing **44** by means of a bearing **48** and connects to power impeller arms **31**. Geared drive shaft **46** terminates in a bearing **48**, housed in bearing housing **49** which is mounted to outer framework **20**.

To prolong the eventual depletion of power from the battery bank(s) **59***a* and **59***b*, there is provided a generation system **52** mounted to the interior frame **29** with bracket **70**. The generation system **52** is powered by a gear **47** connected to the geared driveshaft **46**, connected to the generation system **52***a* by a shaft **51**, passing through the differential housing **44** in a bearing **48** and interrupted by a coupler **50** as the generation system **52***a* turns, power is fed to a two-way switch **54** through wires **53**. From the two-way switch **54**, wires are connected to a high amperage battery charger, which in turn provides a fast high amperage charge, through wires **58**, to the battery bank(s) **59***a* and **59***b*.

Before this system depletes itself to the point of non-operation, there is provided an example of a back-up generation system **52***b*, that ties into the system through wires **55** to the two-way switch or other means (not shown) powered by an internal combustion engine (not shown). There could also be provided a solar power source (not shown).

My description in detail of the present preferred invention will suggest changes and substitutions from my disclosure.

What I claim is:

1. A circular aircraft comprising:

a. An outer and inner frame work designed to form a circumference of convexo-convex shape, a frame work to provide a power impeller housing around the circumference, a central frame work to provide, in the central region of the circumference, a canopied control, passenger and cargo section; a further frame work and bracket assembly to provide for any necessary appendage to the aircraft;

b. External control flaps, screened top air intake ports, screened bottom and side exhaust ports provided with strategically placed slide plates and operated from a central control center, providing a dual control system for the total control of movement of the aircraft;

c. An airduct system for control of counter rotation extending from the power impeller housing and exhausting to the atmosphere through a controlled damper;

d. A power impeller designed to provide vertical lift and horizontal thrust housed in the outer circumference of the aircraft;

e. A power source consisting of one or more battery bank(s), a voltage convertor, a variable speed control, an electric motor, a gear differential, a generator and back-up generator and a battery charger, connecting to the power impeller by connecting arms from a geared driveline extending from the gear differential;

f. An alternate power supply to the power impeller consisting of a internal combustion engine.

* * * * *

United States Patent [19]

Kim

[11] **Patent Number: 4,824,048**

[45] **Date of Patent: * Apr. 25, 1989**

[54] **INDUCTION LIFT FLYING SAUCER**

[76] Inventor: **Kyusik Kim,** 5026 Rhoads Ave., Santa Barbara, Calif. 93111

[*] Notice: The portion of the term of this patent subsequent to Mar. 24, 2004 has been disclaimed.

[21] Appl. No.: **27,174**

[22] Filed: **Mar. 16, 1987**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 849,116, Apr. 7, 1986, Pat. No. 4,651,953, which is a continuation of Ser. No. 701,856, Feb. 14, 1985, Pat. No. 4,667,900, which is a continuation of Ser. No. 240,615, Mar. 5, 1981, Pat. No. 4,429,775.

[51] **Int. Cl.**[4] **B64C 39/06**

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

[58] **Field of Search** .... 244/12.1, 12.2, 23 C, 244/23 R, 23 D, 12.5, 15, 12.6, 36, 207, 62, 53 R, 73 R, 74

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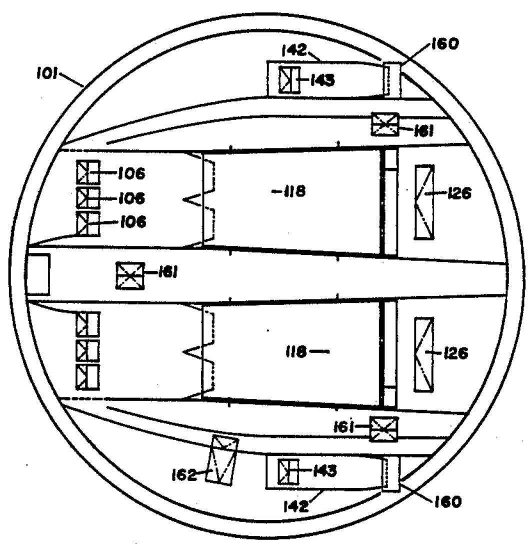
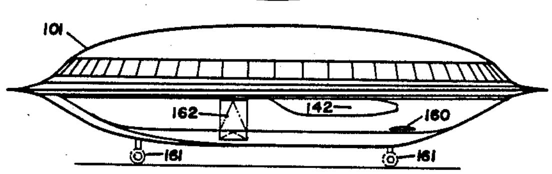
Primary Examiner—Galen Barefoot

[57] **ABSTRACT**

An induction lift flying saucer having a circular shaped air frame which houses a vacuum cell induction lift wing adapted to be used in an aerodynamic generating channel wherein the lift wing includes an airfoil having a leading edge and a trailing edge, a top panel and an acoustically treated hollow interior, and wherein the airfoil includes airtight partitions forming individual cells within the hollow interior and the airfoil has inclined slots extending from the top panel into each of the individual cells wherein the inclined slots extend at an angle from each of the individual cells toward the trailing edge of the airfoil and wherein the airfoil is adapted to be positioned within an aerodynamic generating channel with the top panel of the airfoil being adapted to form a lower boundary of the aerodynamic generating channel and to define a slip thereacross from an airstream passing through the aerodynamic generating channel, a bearing support operatively coupled to the airfoil adjacent the trailing edge to enable the airfoil to be rotated therearound to change the angle of incidence of the top panel to an airstream passing thereacross and a pivot support operatively couples to the airfoil adjacent the leading edge for moving the airfoil leading edge relative to an airstream by rotating the airfoil around the support member to change the angle on incidence of a top panel relative to an airstream enabling the airflow thereof to generate a vacuum within the individual cells is shown. A jet thrust peripheral flow recycling system and induction lift aerodynamic generating channel using the vacuum cell induction lift wing is also shown.

3 Claims, 10 Drawing Sheets





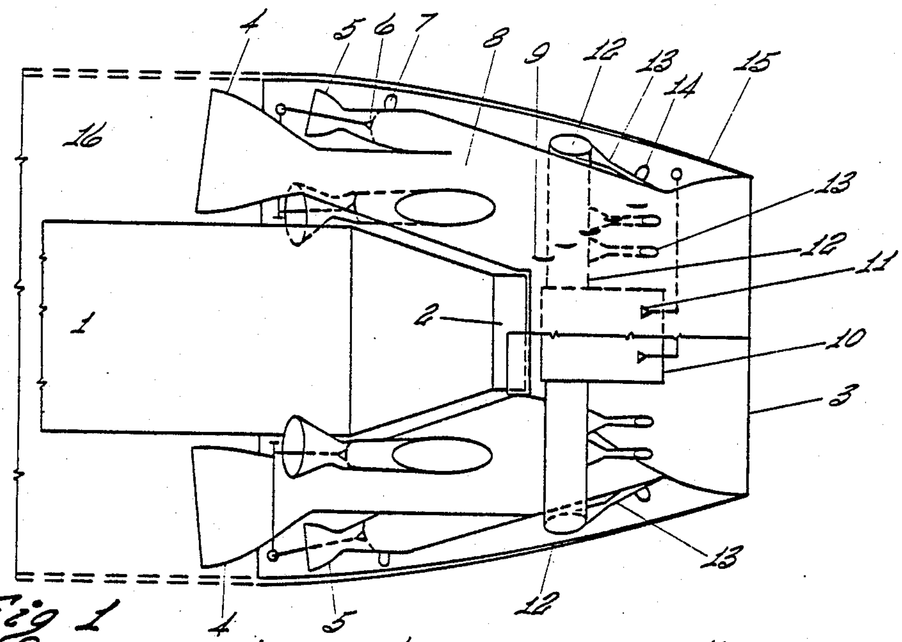


Fig 1

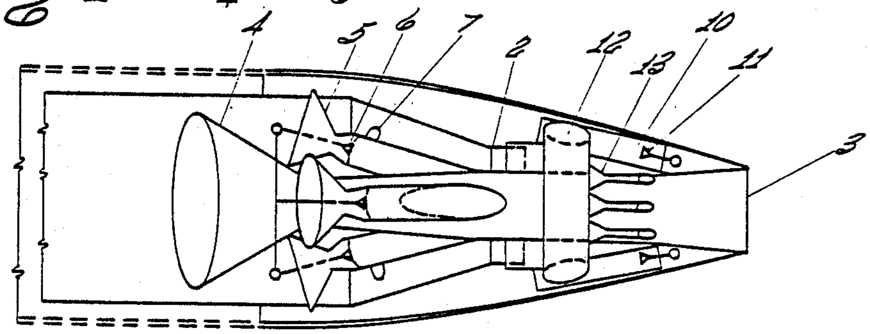
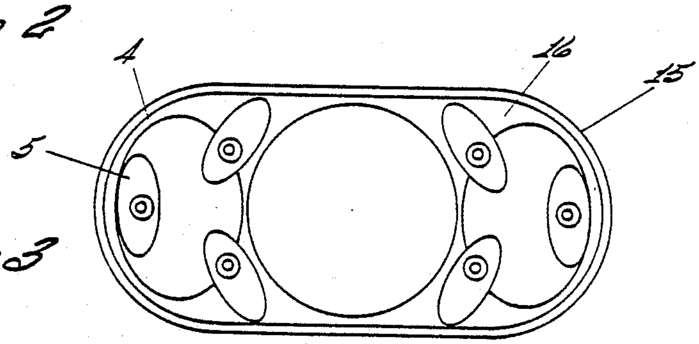


Fig 2



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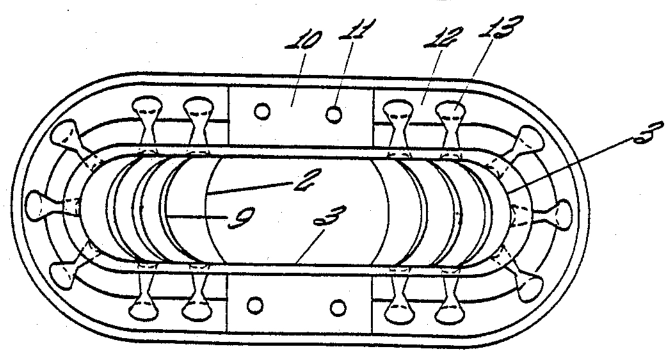

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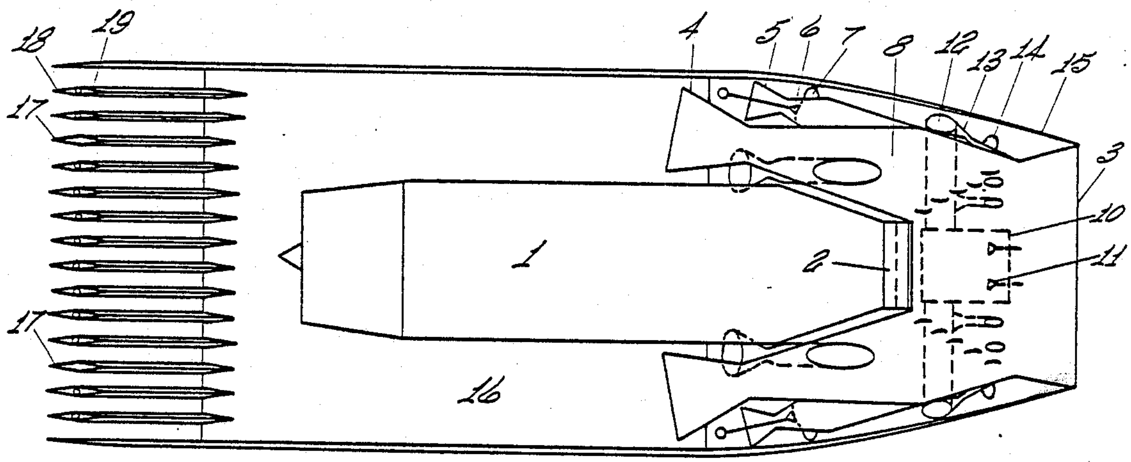
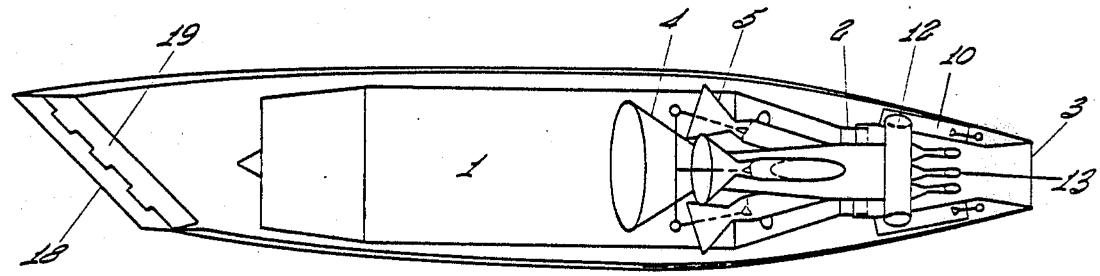


Fig 5



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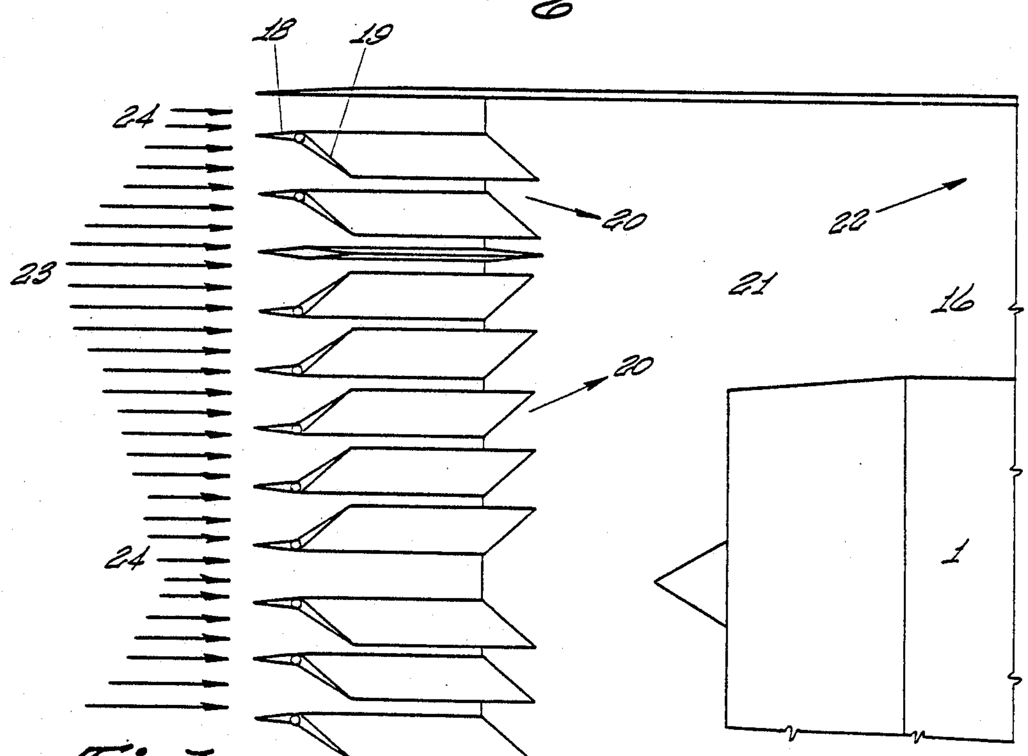

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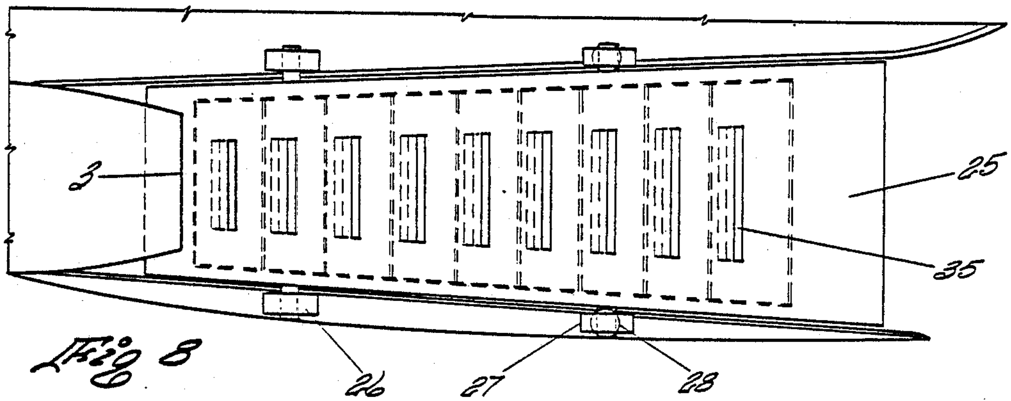

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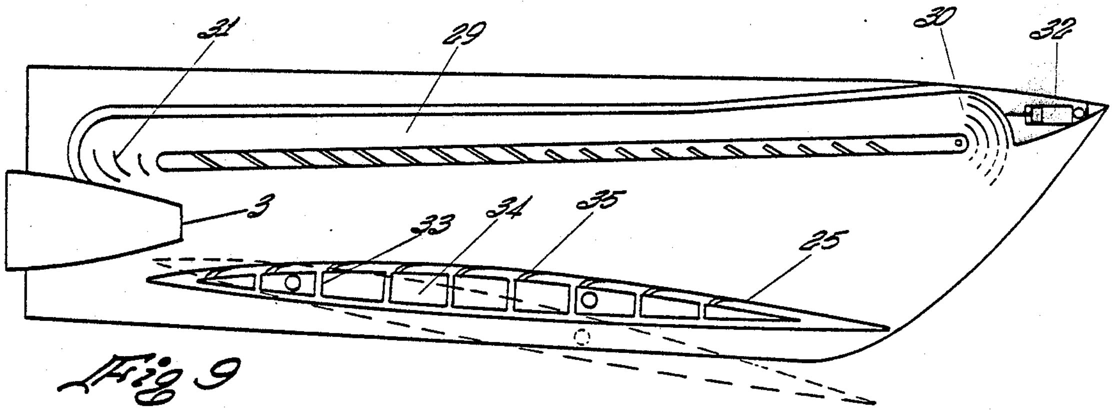

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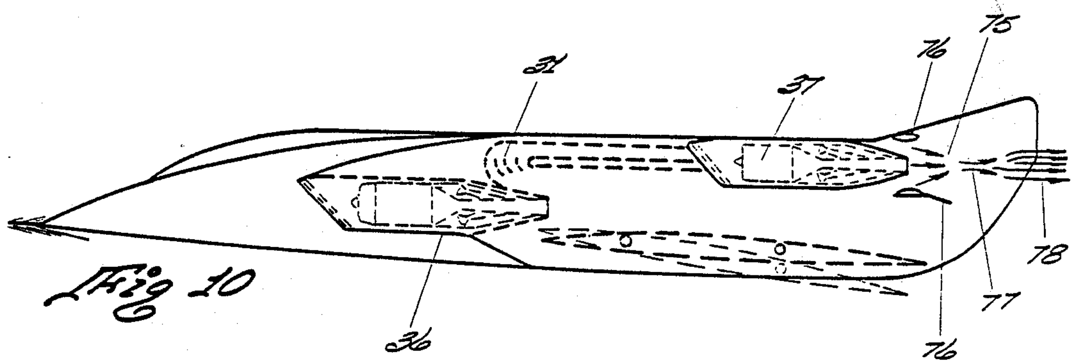

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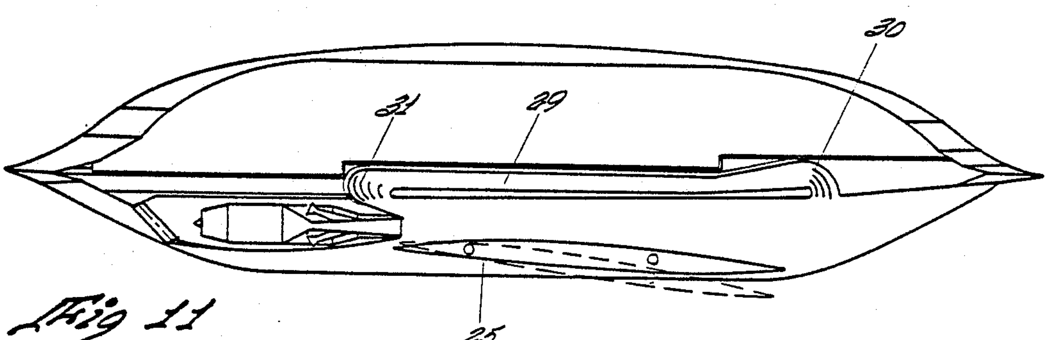

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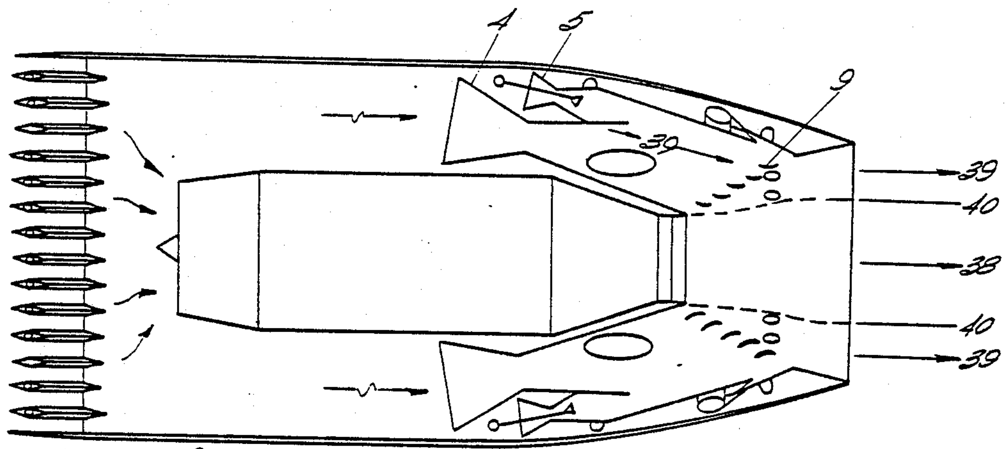

Fig 12

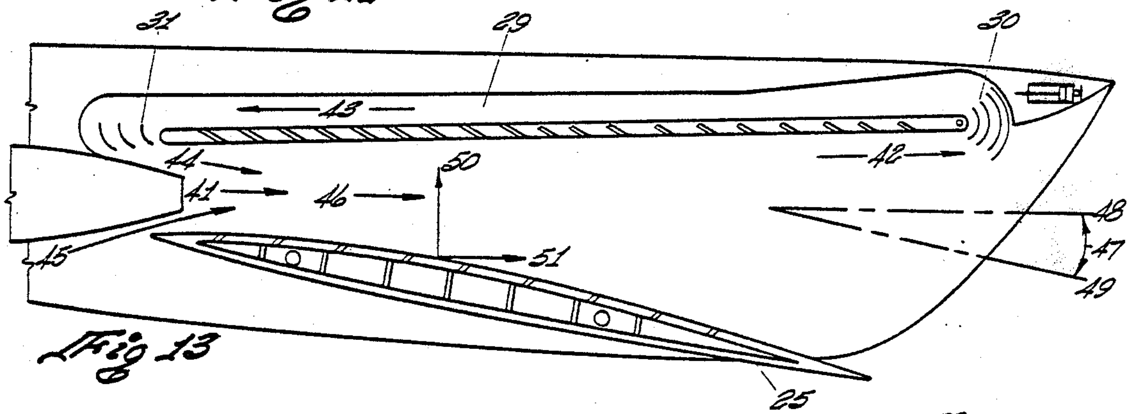

Fig 13

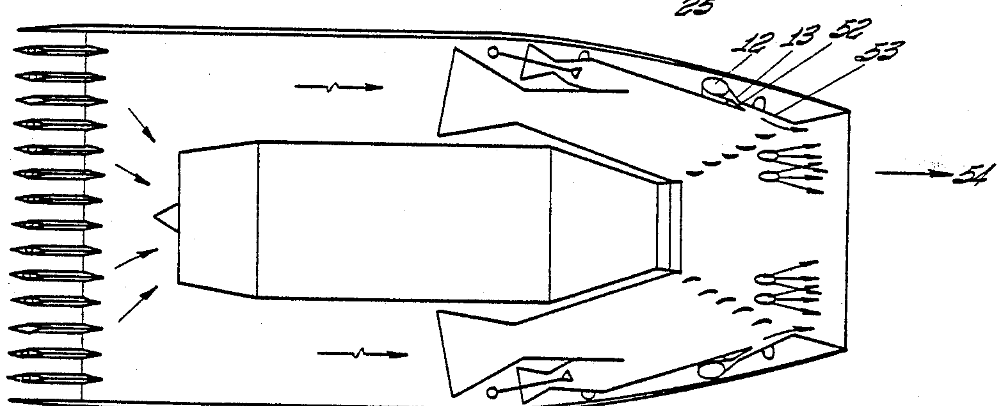

Fig 14

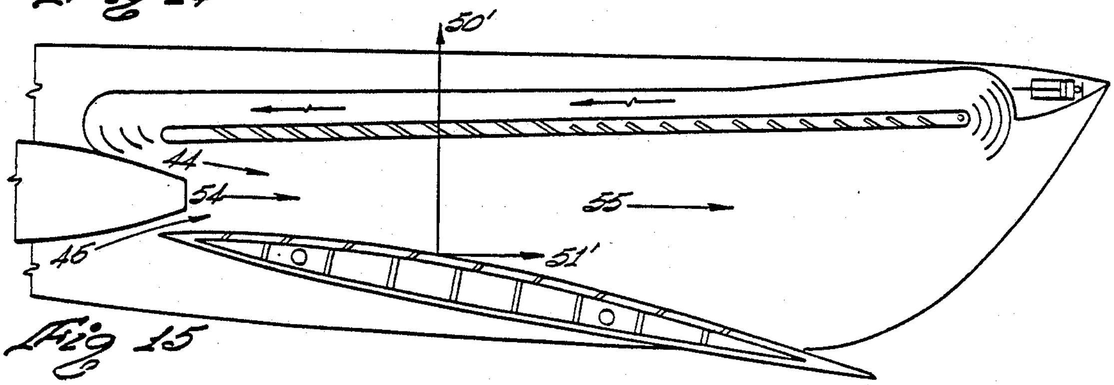

Fig 15

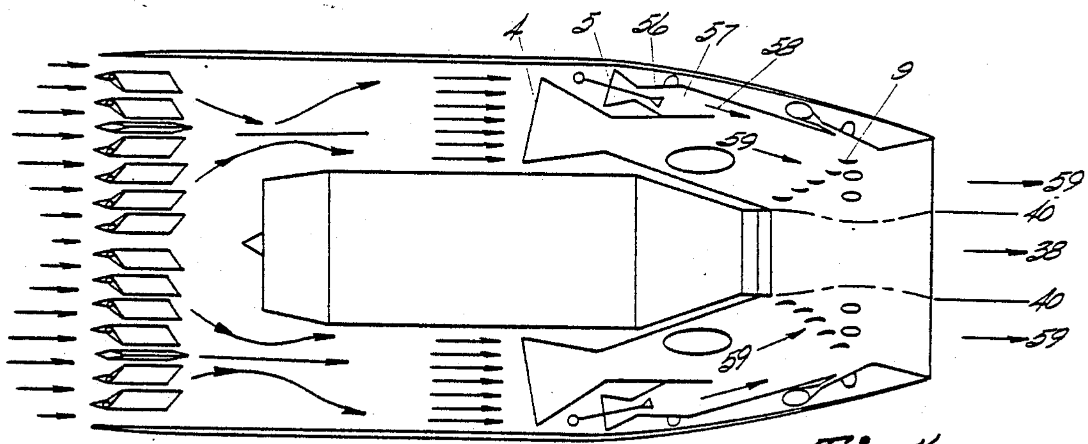

Fig 16

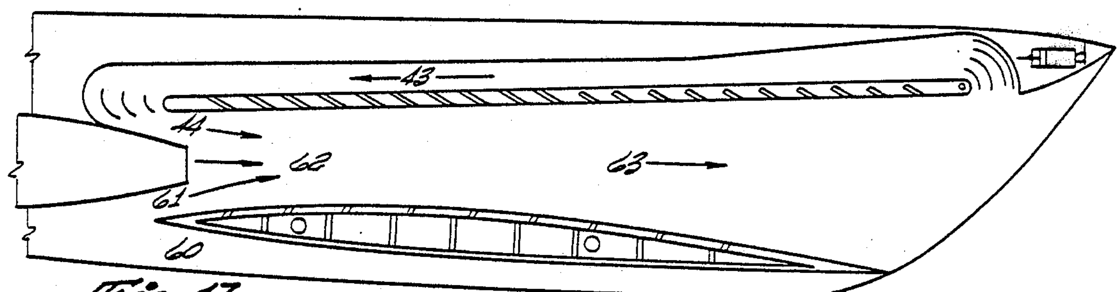

Fig 17

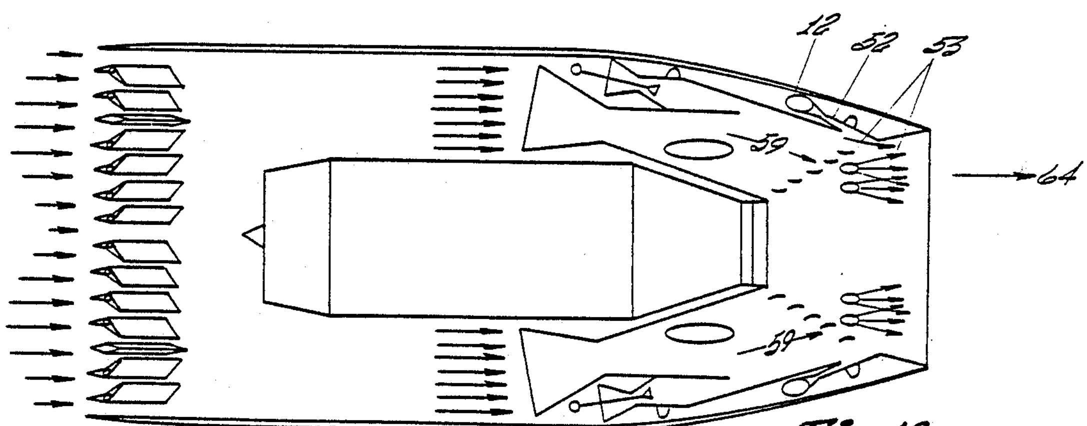

Fig 18

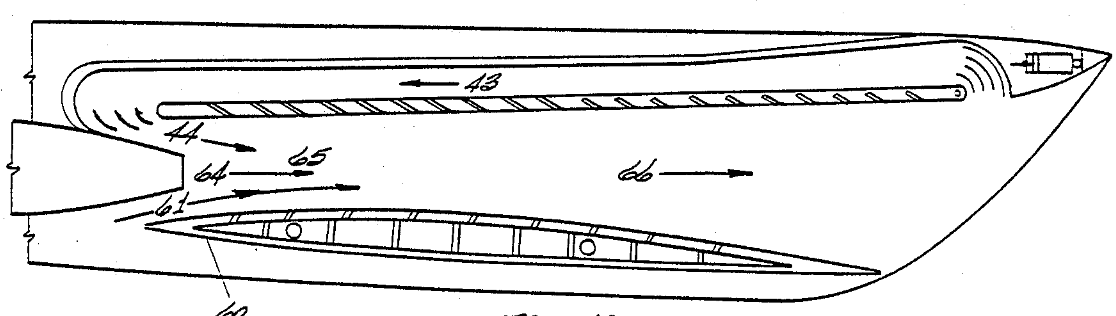

Fig 19

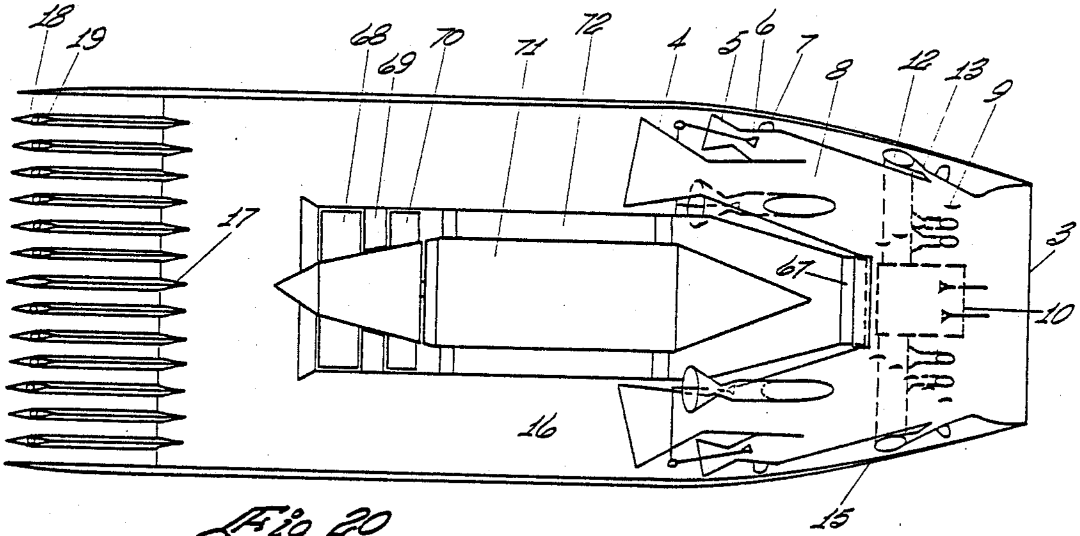

Fig 20

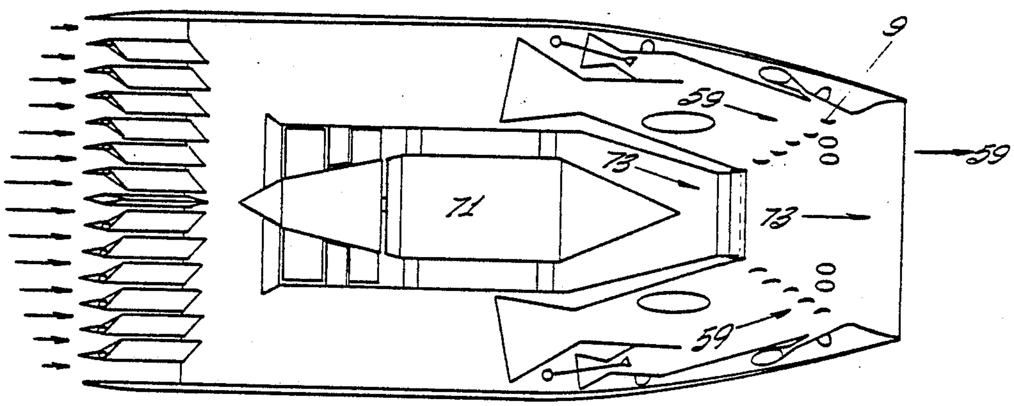

Fig 21

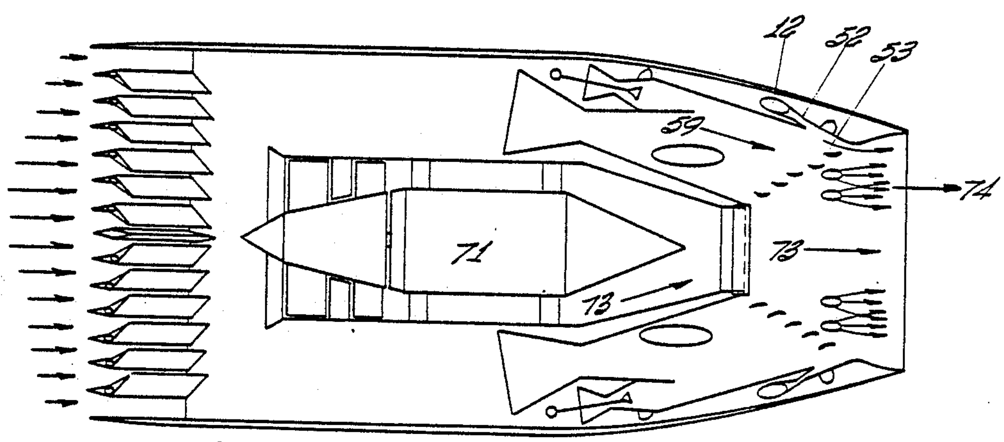

Fig 22

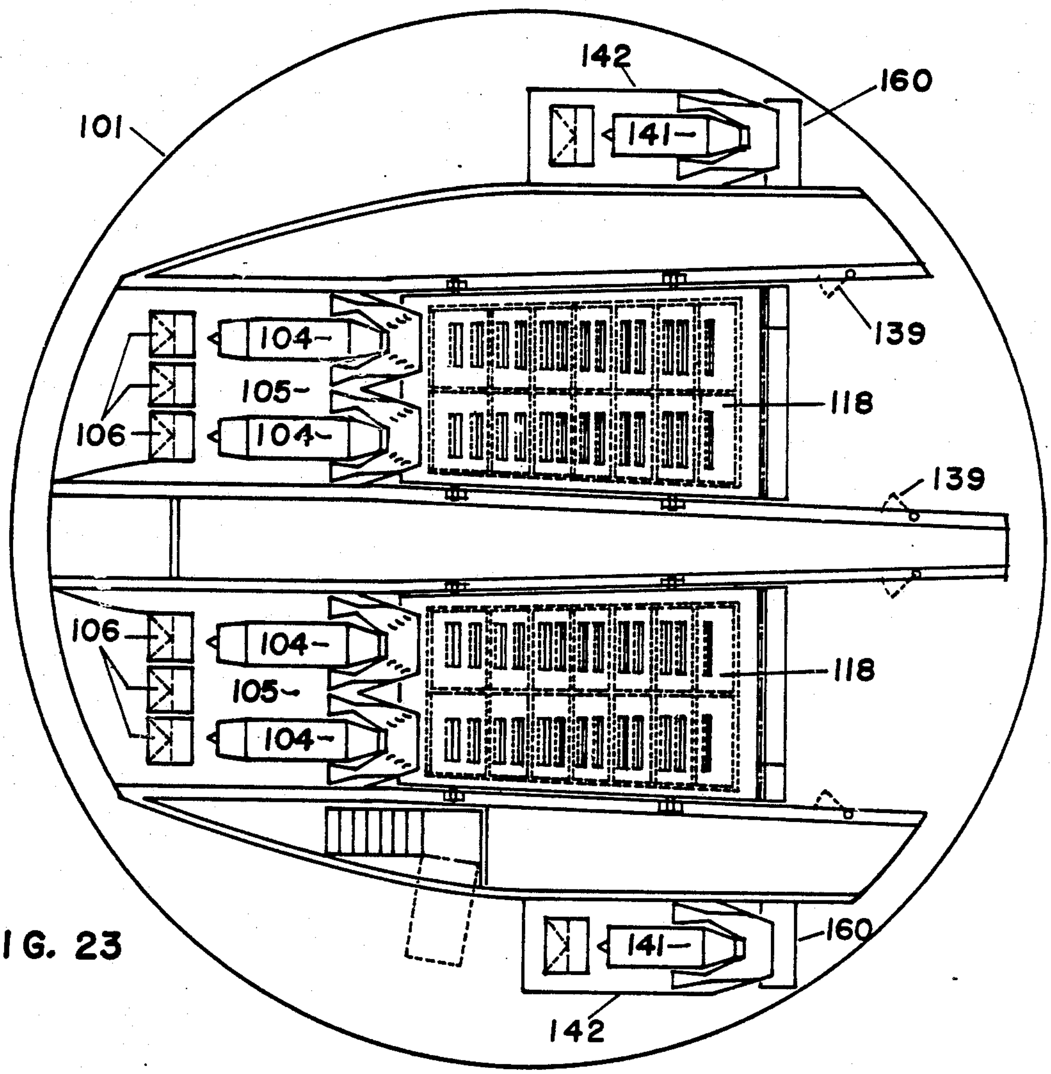

FIG. 23

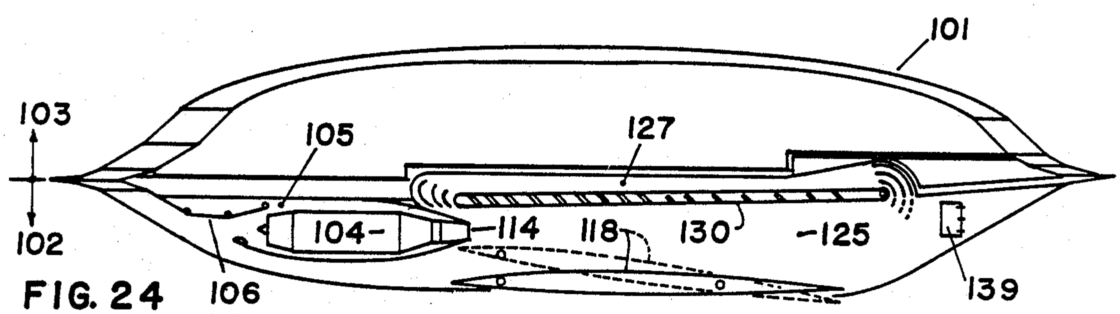

FIG. 24

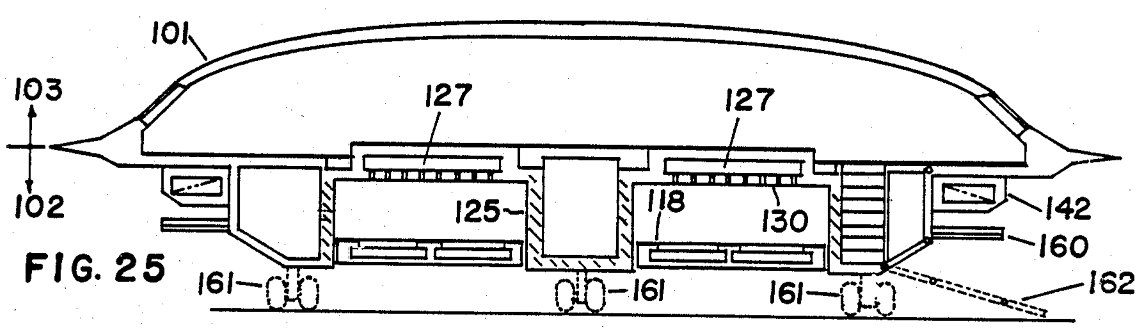

FIG. 25

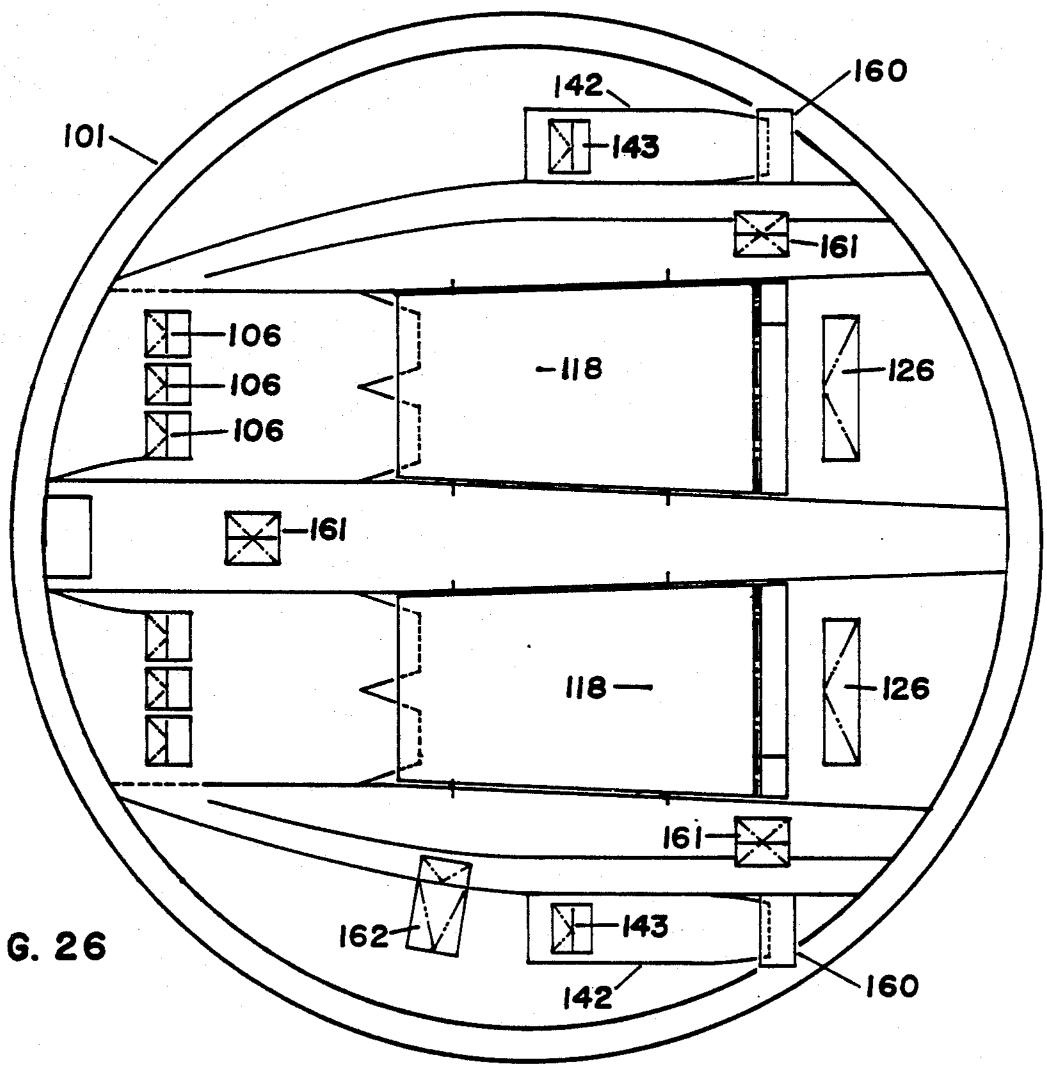

FIG. 26

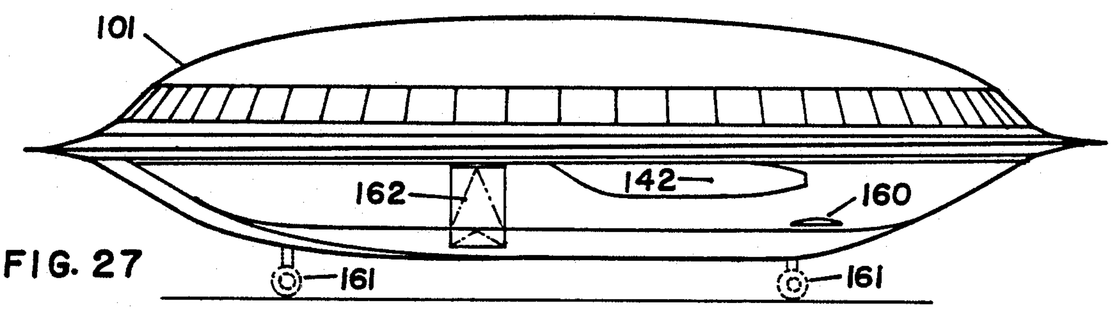

FIG. 27

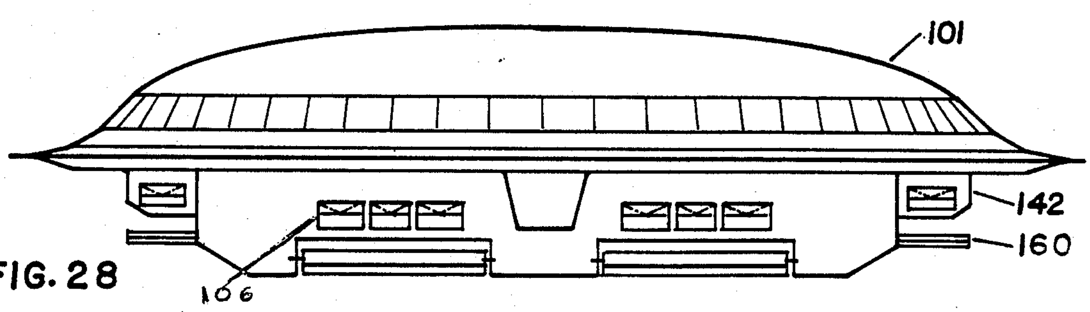

FIG. 28

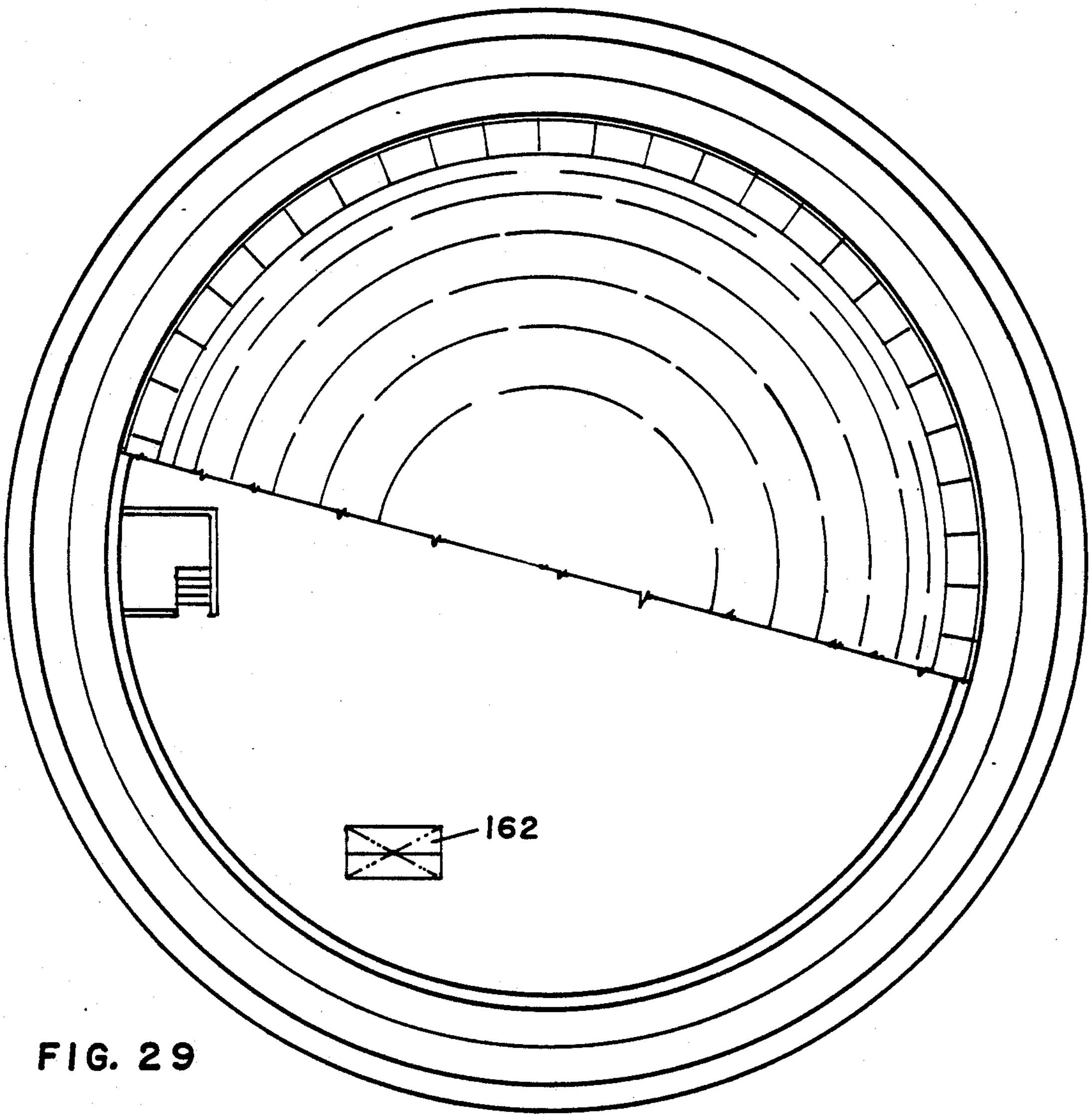

FIG. 29

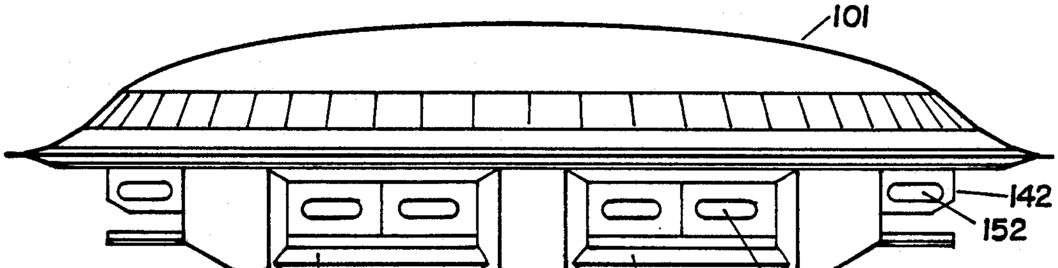

FIG. 30

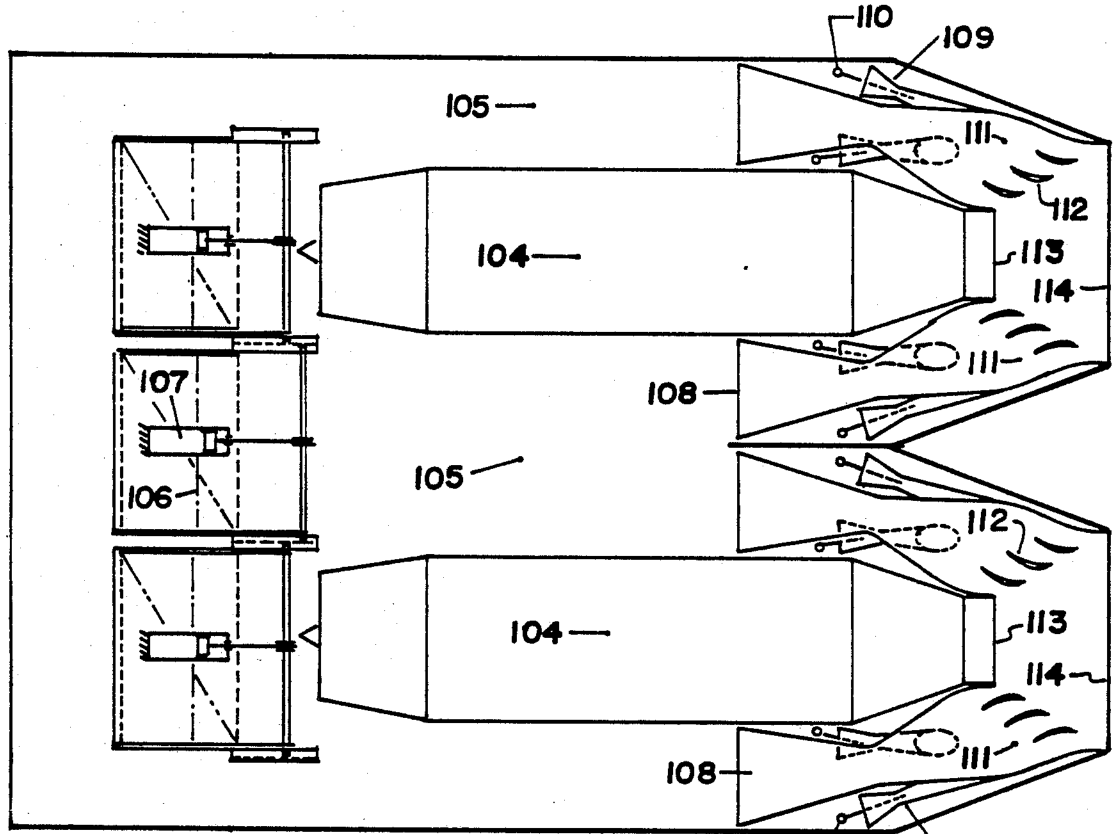

FIG. 31

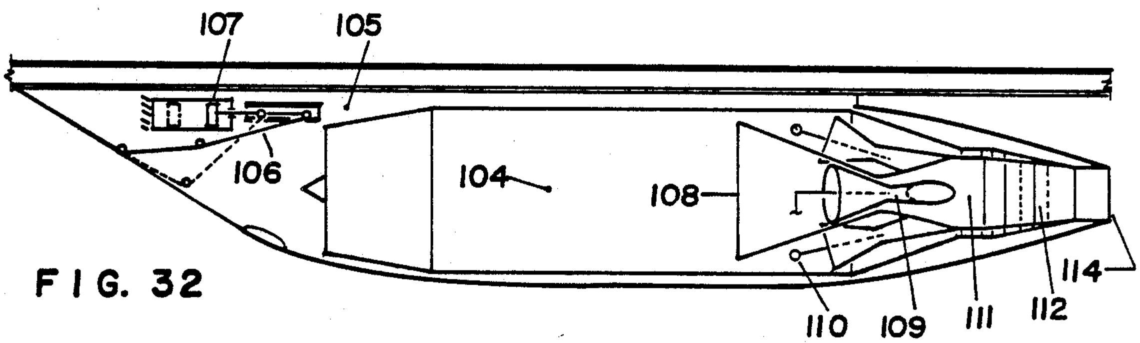

FIG. 32

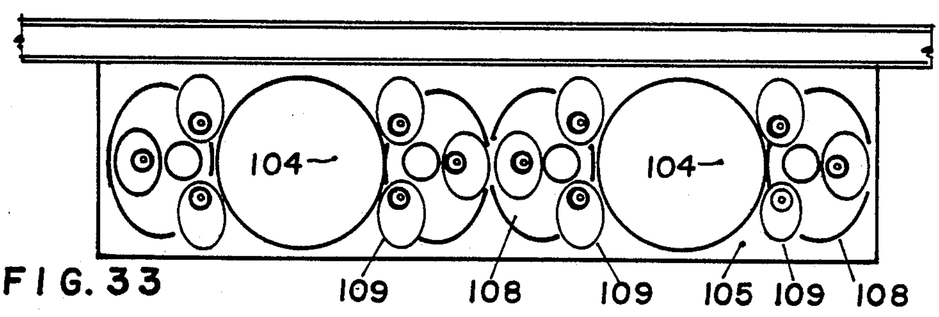

FIG. 33

INDUCTION LIFT FLYING SAUCER

This application is a continuation-in-part application based on U.S. patent application Ser. No. 06/849/116 filed Apr. 7, 1986, now U.S. Pat. No. 4,651,953; which is a continuation of Ser. No. 06/701/856 filed Feb. 14, 1985, now U.S. Pat. No. 4,667,900 which application, in turn, is a continuation of application Ser. No. 240,615 filed Mar. 5, 1981, now U.S. Pat. No. 4,429,775.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the propulsion system of an aircraft. It utilizes a liquid fuel prevaporization and back burning induction jet oval thrust nozzle which is fitted onto the exit nozzle of a conventional turbojet engine having a ram constriction air inlet plenum-engine pod located forward of the aerodynamic generating channel. The aerodynamic generating channel is located forward and above a vacuum cell induction lift wing and below recycling air inductor vanes

2. Description of the Prior Art

Tail pipes having round exit nozzles adapted to be affixed to the exit nozzle of conventional turbojet engines are known in the art.

SUMMARY OF THE PRESENT INVENTION

This invention relates to a round engine exit nozzle transition to a vertically converging and horizontally diverging oval thrust nozzle wherein the thrust nozzle has main airflow inducing nozzles, fuel injecting airflow inducing nozzles, combustion chambers, inductor vanes, liquid fuel prevaporization chambers, vaporized gas distributing manifolds with discharge nozzles, fuel injectors, ignitors and empty spaces adjacent the engine pod which forms a plenum. Air intake bellmouths of airflow inducing nozzles are installed inside the ram constriction air inlet plenums which are empty spaces in the engine pod on both sides of engine throat downstream of airflow inducing nozzles. The outlet of the airflow inducing nozzles are diverging and enter into the combustion chambers. The downstream ends of the combustion combustion chambers are parallel vertical equally spaced and downstreamwardly curved inductor vanes. Hollow spaces between the plenum wall and the flat span of transition walls comprise vaporization chambers fitted with fuel injecting sprays and vaporized gas distributing manifolds with discharge nozzles. The discharge nozzles are downstreamwardly inclined and connected on the minor axes span areas of the oval thrust nozzle. The openings of the inclined discharge nozzles are adequate for the slipflow of the thrust stream and the discharge nozzles are positioned slightly upstream from throat of the oval thrust nozzle for accommodation of ignition time span and to process the temperature reactants of back firing combustion downstream of the oval thrust nozzle. The dynamic pressure of the turbojet engine exhaust stream slipflows over the inductor vanes and induces induction air flow from the plenums through the airflow inducing nozzles. This results in increased airstream volume at the oval thrust nozzle. The turbo-induction jet air breathing is operative when the aircraft is on the ground with engine idling, during low speed operation of the aircraft or deceleration of the aircraft during flight.

When the the induction jet air breathing stream is injected with prevaporized liquid fuel to produce a combustable mixture which when ignited produces a flame thrust stream on downstream of the oval thrust nozzle. The expansion of the flame stream through the diverging contour of aerodynamic generating channel causes the flame thrust stream dynamic pressure to induce streams of air from surrounding air through the slot gap between the flat span of oval thrust nozzle and the leading edge of wing. This results in a recycled airstream at the forward upper portion of the aerodynamic generating channel which passes-through the reverse flow duct which is caused by the peripheral flow of rarefied thrust. These airstreams are merged with flame thrust which then produce the expanding combustion thrust stream in the diverging contour of the aerodynamic generating channel over the vacuum cell induction lift wing. The dynamic pressure of the expanding combustion thrust stream slipflows over the downstreamwardly inclined slot openings of vacuum cell wing. This stream action on the wing induces vacuum in internal cells of the wing which creates aerodynamic lift and drag forces on the wing. These forces correspond with the incidence angle of the wing which is the angle between the center-line of thrust stream and the wing chord line. The forces generated on the wing results in the drag force which counteracts the forward thrust of engine and stabilizies the horizontal moment of the airframe. The lift forces balance the weight of the aircraft during hovering of the aircraft Hovering capacity for the aircraft is accomplished by the turbo-inducting jet air breathing rocket thrust aerodynamic generating channel

Forward speed of the aircraft generates additional lift forces on the airfoil shaped airframe. These additional lift forces correspond to the reduction of the incident angle of the wing which reducts the drag forces on the vacuum cell wing. Forward acceleration is accomplished by the aircraft, from the aircraft hovering to the aircraft operating at hypersonic flight, by use of the liquid fuel prevaporization and backburning induction jet oval thrust nozzle.

The ram constriction air inlet plenums produce ram-static pressures when the aircraft is in high speed flight.

The ram airstream from the plenum pass through the airflow inducing nozzles and flow into the oval thrust nozzle. When fuel injectors are turned on downstream of the throat of the fuel injecting airflow inducing nozzles, a combustable mixture is produced. The combustion mixture is ignited and produces a flame stream which flows downstream of the main airflow inducing nozzles and enter the combustion chamber. The expanded combustion streams product ramjets through the diverging contours of the combustion chambers. The expanding ramjet airstream are combined with the turbojet stream at oval thrust nozzle. The oval thrust nozzle handles the turbojet stream and the ramjet streams creating a turbo-ram induction jet air breathing engine The turbo-ram induction jet air breathing engine operates on the principle of free stream air intake, which are tangential oblique stream flows, interacting with a throat constriction to achieve a critical pressure The free stream throat, located inside the low velocity air plenums, results in first a constraining of the ram airflow and then the expanding of the ram-airstream which controls the ram pressure on air intake bellmouths of the ram-airflow inducing nozzles which are ramjet components of the induction jet oval thrust nozzle. The turbo-ram induction jet air breathing oval thrust stream is operated when the aircraft is in supersonic flight.

When the turbo-ram induction jet air breathing oval thrust stream receives an injection of prevaporized liquid fuel prevaporization a combustable mixture is produced. The combustable mixture is ignited and produces a flame thrust stream downstream of the oval thrust nozzle in the forward section of aerodynamic generating channel. The dynamic pressure of back burning oval thrust stream induces a recycled peripheral thrust airstream which diverts the stream into the forward and upper portion of channel through the reverse flow duct and recycling inductor vanes. The leading edge of wing on airstream which interacts with the flame stream of a turbo-ram induction jet air breathing rocket thrust. The streams are tangentially constricted to develop a critical pressure and form a high velocity free stream throat in the forward section of channel. These streams are merged with the expanding ignited combustion mixture downstream of the free stream throat and the expansion of thrust stream in the diverging contours of channel results in a hypersonic velocity which is accomplished by the turbo-ram induction jet air breathing rocket thrust aerodynamic generating channel.

The liquid fuel prevaporization and back burning induction jet oval thrust nozzle which is fitted on the round exit pipe of conventional ram-axialflow turbine having a ram constriction air inlet plenum which is installed in the ram-stream zone of airframe. The ram-axialflow turbine is operated during high speed flight and the fuel injectors in the ram-airflow inducing nozzles are activated to ignite the combustible mixture to produce, downstream of the airflow inducing nozzles, the ramjet streams in the combustion chambers. The expanding ramjet streams slipflow over the exit pipe of axialflow turbine and induce a negative pressure region downstream of the turbine which, result in an increased pressure differential on the turbine inlet and outlet. This enhances the power of the ram-axialflow turbine and operates an electric generator. The ramjet-induction axialflow turbine operation is obtsined by the liquid fuel prevaporization and back burning induction jet oval thrust nozzle fitted onto the conventional axialflow turbine. When the ramjet induction axialflow turbine thrust stream is mixed with the prevaporized liquid fuel at the throat of ramjet induction oval thrust nozzle and the combustible mixture is ignited, hypersonic flame thrust is produced which provides the capacity of hypersonic flight and the ability to generate a high capacity electrical power source for future developments.

The liquid fuel prevaporization and back burning induction jet oval thrust nozzle is technically feasibile for use with conventional air breathing engine to convert the same to a multi-stage power plant using an induction jet air breathing engine. The multi-stage power plant can be used in an induction lift aircraft. The multi-stage power plant using the air breathing jet engine is based on the principal of management of fuel injection, as described above, and on the principals of induction and free stream constriction where the induction is based on the freedom balancing beyond-dynamic pressure of thermal thrust stream interacting on the diverging contours of the transition tail pipe and aerodynamic generating channel. A free stream formed of tangentially flowing oblique stream intersects with and is shaped by a throat constriction to develop a critical pressure in a constricted free stream flow and the constricted free air stream flow is then expanded on the air intake zone of the low velocity air plenums and in the aerodynamic generating channel The power plant stages are summarized below:

Stage 1: Turbo-induction jet air breathing engine;

Stage 2: Turbo-induction jet air breathing rocket engine;

Stage 3: Turbo-ram induction jet air breathing engine; and

Stage 4: Turbo-ram induction jet air breathing rocket engine.

DESCRIPTION OF THE DRAWINGS

This invention is described in accompanying drawings which are:

FIG. **1** is a plan view of a liquid fuel prevaporization induction jet oval thrust nozzle which is adapted to be attached to a conventional turbojet engine;

FIG. **2** is a side view of FIG. **1** showing the round engine exit nozzle;

FIG. **3** is a cross section of FIGS. **1** and **2** showing the throat of the airflow inducing nozzles;

FIG. **4** is a cross section at the throat of the oval thrust nozzle;

FIG. **5** is a plan view of the induction jet air breathing power plant having a conventional turbojet engine and the liquid fuel prevaporization and back burning induction jet oval thrust nozzle which includes a plenum containing an inclined air intake opening fitted with rigidly fixed straight vanes and deflectable tailing sectin of vanes;

FIG. **6** is a side view of FIG. **5** showing inclined air intake of the plenum showing the fixed and deflectable vanes;

FIG. **7** is a partial paln view of the ram constriction air inlet plenum;

FIG. **8** is a plan view of the aerodynamic generating channel;

FIG. **9** is a longitudinal section of the aerodynamic generating channel having an a vacuum cell induction lift wing with an acoustically treated hollow interior wherein the airfoil has airtight partitions containing downstream inclined slot openings;

FIG. **10** is a side elevation cf the induction lift aircraft;

FIG. **11** is a longitudinal sectional view of an induction lift flying saucer;

FIG. **12** is a schematic view of a turbo induction jet aircraft when the aircraft is operated in a neutral position, low speed flight or deceleration of flight;

FIG. **13** is a schematic showing the air distribution of turbo-induction jet air breathing thrust stream in the aerodynamic generating channel when the aircraft is operated in a neutral position, low speed flight or deceleration of flight;

FIG. **14** is a schematic diagram of a turbo induction jet air breathing engine when the aircraft is operated in VTOL;

FIG. **15** is a schematic diagram showing the distribution of turbo-induction jet rocket air breathing thrust stream in the aerodynamic generating channel when the aircraft is operated in maximum hovering capacity with extreme incidence of angle of wing;

FIG. **16** is a schematic diagram of turbo-induction jet air breathing thrust stream when the aircraft is operated in supersonic flight;

FIG. **17** is a schematic diagram showing the distribution of turbo-ram induction jet air breathing thrust stream in the aerodynamic generating channel when the aircraft is operated in supersonic flight;

FIG. 18 is a schematic diagram of turbo-ram induction jet rocket air breathing thrust stream when the aircraft is operated in hypersonic flight;

FIG. 19 is a schematic diagram showing the distribution of turbo-ram induction jet air breathing rocket thrust stream in the aerodynamic generating channel when the aircraft is operated in hypersonic flight;

FIG. 20 is a plan view of the liquid fuel prevaporization and back burning induction jet oval thrust nozzle attached to the round exit pipe of an air breathing jet engine;

FIG. 21 is a schematic diagram showing the air distribution of the ramjet induction axialflow turbine when the aircraft is in supersonic flight;

FIG. 22 is a schematic diagram showing the air breathing of the ramjet induction axial flow turbine ehaust stream which receives the prevaporized liquid fuel to produce the flame thrust stream during hypersonic flight;

FIG. 23 is a bottom plan view of the central power plant section of the induction lift flying saucer showing the vacuum lifting wing airfoils;

FIG. 24 is a pictorial representation showing the relationship of a jet engine, aerodynamic generating channel and vacuum lift wing of the induction lift flying saucer;

FIG. 25 is a rear elevational plan view of the central power plant section of the induction lift flying saucer;

FIG. 26 is a pictorial representation showing that portion of the central power plant section of the induction lift flying saucer which supports the air intakes and acoustic ceiling of the/aerodynamic generating channel;

FIG. 27 is a right side plan view of the induction lift flying saucer;

FIG. 28 is a front elevational plan view of the induction lift flying saucer;

FIG. 29 is a partial sectional and top elevational plan view of the circular outer surface of the induction lift flying saucer;

FIG. 30 is a rear elevational plan view showing the output of the jet thrust stream generating means used as an input to the aerodynamic generating channels;

FIG. 31 is a pictorial representation of the bottom of air breathing jet engines of FIG. 23 together with the air intake control;

FIG. 32 is a side elevational view of the pictorial representation of the air breathing jet engines and air intake controls of FIG. 32; and

FIG. 33 is a front elevational view of the bell mouth air intakes for the jet thrust stream generating means.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As illustrated in FIGS. 1 through 4, the outside of the power plant has a shape which defines a low velocity air plenum-engine pod. Multiple vanes are fitted on the inclined air intake opening at the forward section of the plenum. The induction jet oval thrust transition tail pipe is fitted on the rear end of the plenum. The conventional turbojet engine is installed inside of and on the center-line of the plenum.

The air inlet of the ram constriction system is illustrated in FIGS. 5, 6 and 7. Multiple inflective vertical vanes assemblies are fitted on the inclined opening at the forward portion of the low-velocity air plenum-engine pod. The vanes are fabricated with rigidly fixed straight vanes **17** and are positioned in the center-zones of the low velocity air plenums **16** located in the empty spaces on both sides of engine **1**.

Deflectable trailing section of vanes **19** are hinged with rigidly fixed forward section of vanes **18** and are equally spaced from the rigidly fixed straight vanes **17**. The deflectable trailing section of vanes **19** are linked with conventional hydraulic actuators for adjusting the position of vanes such as in the closed or open position. Deflectable vanes **19** are positioned straightly and parallel with the rigidly fixed straight vanes **17** when the air intake is wide open as illustrated in FIGS. **12** and **14**. The postion of the vanes illustrated in FIGS. **12** and **14** applies when the aircraft is in stationary or low speed and deceleration of flight.

FIGS. **16** and **18** illustrate the positon of the vanes when actuated by the hydrauic actuators to deflect the trailing sections thereof toward the straight vanes **17**. This position applies when the aircraft is in high speed flight. The sahping action of the ram-stream inside the low velocity air plenums are illustrated in FIG. **7**. This occurs when the deflected trailing sections of vanes **19** are bent toward the rigidly fixed straight vanes **17** positioned on the center-line of the low velocity air plenums, which occurs during supersonic flight

The ram-stream impacts on the rigidly fixed forward section of the vanes **18**. The ram-stream is restricted and deflected by the trailing section of vanes **19**. The stream flow directions are inflected by the vanes **19** to produce the oblique streams **20**. These streams are tangentally constrained towards the center-line zone of the low velocity air plenums **16** The shaping action of the ram-constriction causes the ram-stream to reach the critical pressure to form the free stream throat **21** and controls the stream pressure which is achieved by the ram-stream and controls the ram-air volume and ram-pressure inside the low velocity plenums **16**. This results in a reduction of the dynamic drag force on the engine section diffuser during high speed flight. The ram drag is reduced on the front of the air intake opening. This is caused by the variable ram back pressure gradient downstream of the vanes where the center zones of ram constriction portion has more pressure drag force **23** on the front of the vanes and less pressure drag force **24** on the front of the engine suction and on both sides the air separation zones downstream of the vanes. The ram drag force on the front of the vanes, which is ram pressure, exceeds the critical pressure downstream of the vanes. This results in the pressure drag dynamic slip-down on the inclined face of the air intake which is a reduction of the ram drag force on the front of the air intake opening. Ram stream constrictions enhance the ram static pressure inside the low velocity air plenums which enhance the efficiency of ramjets on the ram-axialflow inducing nozzles **4** and **5** of turbo-induction jet air breathing engine.

The ram-stream constriction air intake system for ramjets induction axialflow is illustrated in FIGS. **20**, **21** and **22**. Rigidly fixed straignt vane **17** is positioned on the center-line of the axial flow turbine. Deflectable trailing section of vanes **18** and **19** are equally spaced and located on both sides of the rigidly fixed straight vans and deflect the trailing section of vanes **19** which are bent towards the rigidly fixed straignt vane **17**. A stream shaping action occurs downstream of the vanes at the front of the axialflow turbine during supersonic flight. The streams are constrained and control the stream properties and the conversation of ram dynamic pressure to static pressure at the stream critical pressure on the front of the axialflow turbine to enhance the power of the axialflow turbine.

The power plant of an aircraft utilizing the liquid fuel prevaporization induction jet oval thrust nozzle is illustrated in FIGS. **1**, **2**, **3** and **4**. The engine has a round engine exit nozzle **2** and the fuel prevaporization induction jet oval thrust nozzle has an oval thrust nozzle **3** and the interior of the thrust nozzle provides the transition from the round exit nozzle **2** to the oval thrust nozzle **3**. The thrust nozzle is fabricated with main airflow inducing nozzles **4**, fuel injecting airflow inducing nozzles **5** fitted with conventional fuel injectors **6** and ignitors **7**, combustion chambers **8**, inductors vanes **9**, liquid fuel prevaporization chambers **10** fitted with fuel injecting sprays **11** and pressurized vapor gas distributing manifolds **12** having discharge nozzles **13** fitted with ignitors **14**. Airflow inducing nozzles **4** and **5** having bellmouths, which enable the air to enter the nozzles, are installed inside of the ram-constriction air inlet plenums **16** which are empty spaces in the engine pod on both sides of the engine.

The downstream throat of the airflow inducing nozzle are diverging throats and direct the airflow into the combustion chamber **8**. The combustion chamber **8** has major axes span which extend from the round exit nozzle to the oval transition tail pipe and encloses the parallel, verically, equally spaced curved inductor blades which curve in the direction of the downstream flow. The hollow spaces between the envelope of the plenum **15** and flat span of the major axes transition wall comprise the open pressure vessel for vaporization boiling chambers **10** fitted with liquid fuel injecting sprays **11**. The chambers are connected with prevaporization and pressurized gas distributing manifolds **12** with discharge nozzles **13**. The discharge nozzles **13** are inclined in a downstream direction and are connected to the minor axes areas of the oval thrust nozzle. The discharge nozzles **13** are fitted with ignitors **14** which are located at the vaporized gas air mixing point The openings of the discharge nozzles **13** are adequate for slip flows of thrust stream and are positioned slightly upstream from the throat of the oval thrust nozzle for accommodation of ignition time span and to process the temperature reactants of the after/back burning combustions at downstream throat of the oval thrust nozzles. The vaporization boiling chambers are installed in the center portion of the diverging major axes exhaust stream zones of the oval thrust nozzles. This results in the boiling chambers **10** inner walls increasing in temperature due to heat transmitted from the engine exhaust stream.

The pressure inside the vaporization boiling chambers fluctuates in response to the injecting rates of the liquid fuel sprays. When the fuel injection is turned off, the boiling chambers are maintained at a high temperature and a negative pressure. Cavitation is caused by the dynamic pressure of the oval thrust stream as it slipflows over the downstreamwardly inclined openings and induces the negative pressure inside the hollow chamber through the throats of the inclined suck nozzles **13** and the distributing manifolds **12**. When this occurs, the boiling chambers are maintained at a high temperature and negative pressure. The means that the air mass inside the boiling chambers is maintained at a minimum for preventing explosion when the fuel injection is started and continuous combustion cannot occur in inside the vaporization boiling chambers

In order to turn-on the liquid fuel prevaporization and back burning, liquid fuel spray is injected into the high temperature-negative pressure of the boiling chambers. The liquid fuel is vaporized which expands its volume and builds up the local pressure inside the boiling chambers. The thermal energy of the engine exhaust is converted into dynamic pressure inside the boiling chambers. The temperature of the engine jet stream after the engine exit nozzle and before the throat of the oval thrust nozzle is reduced which increases the nozle efficiency and enhances the random velocity of the thrust stream at downstream of the oval thrust nozzle. The vaporized and pressurized gases expand and are discharges through the convergent-divergent inclined nozzles **13**.

The liquid fuel prevaporization and pressurization afterburners result prevaporization and pressurization of liquid fuel before mixing of the same in the airstream and to reduce the time required for vaporization and expansion of the gas in the airstream. The expansion/-combustion in the short span of the airstream and the explosion in the downstream throat of the oval thrust nozzle increases the thermal head/dynamic pressure of the oval thrust rarefied stream. Any excess of the flamable vaporized gas flow resulting from the fuel injection flows into the throat of the oval thrust nozzle. As a result, continuous combustion will occur downstream of the nozzle exit and preceeding the back-fire on the surrounding airstream interaction which is an oblique shock stream induced from the forward speeding edge of the wing. The actuation of the oval thrust nozzle produces a real high temperature thrust stream from the rocket nozzle. As a result, a liquid fuel prevaporization and backburning induction jet oval thrust nozzle is achieved. This is power source operates on the induction principal and is the aerodynamic system of the aircraft.

The induction jet power plant as illustrated in FIGS. **5** and **6** is a prefabricated liquid fuel prevaporization and back round exit nozzle **2** of the conventional air breathing engine **1** which is enveloped with ram constriction air inlets plenums **15**, **16**, **17**, **18** and **19**.

Installation of the power plant is illustrated in FIGS. **8**, **9**, **10** and **11** and the power plant is installed forward of the aerodynamic generating channel located forward of and above the vacuum cell induction lift wing **25** and below the recycling air inductor vanes **31**. The transition tail pipe of the oval thrust nozzle is designed such that their major axes are horizontal and their minor axes are vertical. The engine jet stream passes through the engine exit nozzle **2**, then through the transition tail pipe where the stream is constrained vertically. The converging jet stream is converted into an adverse pressure in the direction of flow and this adverse pressure reconverts into a velocity head in the direction of flowing in the diverging region of the oval thrust transition tail pipe.

The converging of the stream with the diverging transition tail pipe functions to shape the stream and to reduce turbulence in the round vorticity engine exhaust stream. The stream is constrained in the converging zones. The stream geometric contours are subject to stream separation at the horizontal divergent region. Thus, the stream underexpands in the direction of flow and the conversion into a velocity in the diverging zones is achieved through adverse pressure from the converging portion of the tail pipe. Conversion into a velocity is achieved by the thermal head effect occuring on the diverging contours of the transition tail pipe. The conversion velocity effect is proportional to the contours of nozzle and to the thermal head.

The stream shaping action inside the transition tail pipe develops the momentum equilibrium-freedom balancing of the stream dynamic pressure developed by the induction airflow inducing nozzles and inductor vanes.

The stream shaping action results in a vertically constrained, laminated stream which gains adverse pressure in the direction of flow in the converging zones and which underexpands in the direction of flow on the diverging zones. This action stimulates random velocity flow in the diverging zones of the oval thrust transition tail pipe.

The random velocity of underexpanding airstream contours will slipflow over the downstreamwardly curved inductor blades **9** and generate a cavitation at the intermediate area of the inductor vanes. This cumulative cavitation is equal to the pulling force which occurs beyond the thermal stream dynamic pressure in the diverging stream contours. The pulling force of the stream dynamics induces the induction airflow from the low velocity air plenums through the airflow inducing nozzles. This results in the induction airflow balancing the pulling pressure of the thermal stream dynamics. The balancing occurs because of the freedom balancing of stream shaping action with the momentum equilibrium of the stream dynamic pressure of the induction jet oval thrust transition tail pipe.

The inductor vanes **9** are so positioned near the boundary layers which surround the underexpanded region of the engine exhaust stream inside the diverging area of the oval transition tail pipe. FIGS. **12** and **16** show the boundary layers **40** and **40'** which exists at the interface of the turbojet stream **38** and the induction airstream **39** or ram jets **59**

The position of boundary layers will shift in response to changes in the speed of flight FIG. **12** shows the boundary layers **40**, which are located near the inductor vanes **9**, when the aircraft is stationary or during low speed flight of the aircraft. FIG. **16** shows the boundary layers **40'**, which shift toward the center-line of the engine jetstream **38**, when the aircraft is in supersonic flight

The processing of the thrust stream inside the induction jet oval thrust transition tail pipe's result in a cylindrical vortex engine jet stream passing first through the round section of the engine nozzle **2** and then through the transiton tail pipe. The strong random velocity of the engine exhaust stream will be constained by the adverse pressure gradient at the vertical convergence zone. The stream will be underexpanded in the direction of flow in the region of horizontal divergence. The diverging contours are subject to stream separation illustrated in FIG. **12**. The underexpanding generates the induction airstreams **39** through the airflow inducing nozzles **4** and **5**. This results in an induction airflow having a reduction in separation of engine exhaust stream at the diverging contours of the tail pipe and an increase in the volume cf the oval thrust stream. A drastic reduction of stream separation occurs at the horizontal divergent due to the vertical constriction of stream-strain action resulting in a vertical converging, airstream shaping action taking over which nearly dies-out the stream rotation vorticity distribution and fully develops the stream flow into a nearly uniform profile, which means a laminated high volume thrust stream is achieved in the oval thrust nozzle. The above can be achieved by an induction jet oval thrust nozzle being fitted onto a conventional air breathing engine.

The prime force behind the induction air flowing is that a turbojet stream is achieved by means of the turbo-induction jet air breathing engine wherein the thrust stream is processed by the principle of induction which is freedom balancing beyond the dynamic pressure of thermal thrust stream on the diverging contours of transition tail pipe. A laminary high volume rarefied flow results which is used for the produciton of aerodynamic forces.

These streams shaping actions are processed by the local component of the induction jet oval thrust tail pipe before the stream passes through the exit nozzle of the oval thrust nozzle. This results in reduced vorticity turbulences of engine exhaust stream and the lamination of the stream by the transition tail pipe's convergance combining with the diverging shaping action of the induction airflow. The induction jet oval thrust transition tail pipe induces a high volume air breathing effect while reducing turbulance in the rarefied jet thrust which flows through the aerodynamic generating channel over the vacuum cell induction lift wing. The vacuum cell induction lift wing has an acoustically treated hollow interior and the airfoil has airtight partitions which contain downstream inclined slot openings and the jet thrust stream flows over the slots.

The turbo-induction jet air breathing oval thrust stream in the aerodynamic generating channel is illustrated in FIG. **13**. The dynamic pressure of the oval thrust stream **41** is an induced airstream which recycles and surrounds the aerodynamic generating channel. The airstream **44** is recycled as the thrust peripheral flow diverts the stream flow into the forward upper portion of channel as a diverting flow **42** turning vanes **30** and as a reversed flow **43** through duct **29** and recycling air inductor vanes **31**. The surrounding airstream **45** is induced at the forward portion of the channel through the slot gap between the flat span of the oval thrust nozzle and leading edge of wing. These airstreams increase in volume at the forward section of the aerodynamic generating channel and are merged with the induction jet thrust stream. This increases the airstream **46** flowing through the aerodynamic generating channel over the vacuum cell induction lift wing and generates the aerodynamic lift **50** and drag **52** forces. The drag force on the wing counter balances the forward thrust of engine idling operation when the aircraft is stationary.

The operation of a turbo-jet air breathing rocket oval thrust stream is illustrated in FIG. **14**. During hovering operation or forward acceleration, which occurs with turned on fuel injecting sprays in the vaporization chambers, a prevaporized and pressurized gas stream **52** flows into the induction air stream zones **39** of the oval thrust nozzles **13**. As a result, the turbo-jet air breathing oval thrust stream receives the prevaporized liquid fuel. Ignition of the combustible air mixture **53** produces a flame thrust stream **54** downstream of the oval thrust nozzle. This results in a high thermal rocket thrust stream which creats a turbo-induction jet air breathing rocket thrust engine. This is accomplished by the liquid fuel prevaporization and back burning induction jet oval thrust nozzle which fits onto the convention air breathing engine.

The hovering capacity is generated by the turbo-induction jet air breathing engine rocket oval thrust channel as illustrated in FIG. **15**. In FIG. **15**, the dynamic pressure of the oval thrust flame stream induces recycling and surrounding air streams. The recycling airstream **44** is the thrust peripheral flow which is diverted into the forward and upper portions of the channel through the turning vanes **30**, through the reversed flow duct **29**, and through the recycling air inductor vanes **31**. The surrounding airstream **45** is located at the forward and lower portion of channel, and passes through the slot gap between the flat span of the oval thrust nozzle and the leading edge of wing. These streams increase the volume of airstream in the channel and are merged with flame of the turbo-induction jet air breathing rocket thrust. The merging of these streams produces the expanding combustion thrust stream and flow through the diverging contours of the aerodynamic generating channel over the vacuum cell induction lift wing.

The dynamic pressure of the expanding combustion thrust stream **55** slipflows over the downstreamwardly inclined slot openings of vacuum cell wing. This stream action on the wing induces a vacuum in the internal cells of the wing which creates aerodynamic lift and drag forces on the wing. These forces correspond with the incidence angle **47** of the wing. The incidence angle **47** is the angle between the center-line of thrust stream and chord line of wing. The forces generated on the wing result in the drag force counteracting the foreward thrust of engine and stablizing the horizontal moment of the airframe. The lift force balances the weight of the aircraft. Hovering is produced by the turbo-induction jet air breathing rocket thrust aerodynamic generating channel. Aircraft VTOL hovering manoeuvers are achieved by the turbo-induction jet air breathing rocket thrust aerodynamic generating channel.

The operation of a turbo-ram induction jet air breathing oval thrust stream, during supersonic flight, is illustrated in FIG. **16**. FIG. **16** shows that the ram constriction air inlet plenums **16** gain in ram-static pressure and that the ramstream flows through the airflow inducing nozzles **4** and **5** past turned on fuel injectors **56** located downstream of the fuel injection airflow inducing nozzles **5**. The combustion mixture **57** is ignited and produces a flame stream **58** which flows into and combines, downstream of the main airflow inducing nozzle **4**, with the airstream as the flame stream enters the combustion chamber. The expanding combustion streams produce ramjet streams through the diverging contours of the combustion chamber and the expansion of the ramjets streams **59** which combine with turbojet stream **38** at oval thrust nozzle. The oval thrust nozzle handles the turbojet air stream and the ramjets streams to create a turbo-ram induction jet air breathing engine. The air intake free stream is a tangentially flowing, oblique-stream which interacts with the throat constriction inside the low velocity air plenums to producing critical pressures in the ram-airstream resulting first in the constraining and then the expansion of the ram-airstream which controls the ram pressure on air intake bell-mouths of airflow inducing nozzles which function as the ramjet components of the induction jet oval thrust nozzle.

The turbo-ram induction jet air breathing rocket oval thrust stream, during hypersonic flight, is illustrated in FIG. **18**. As illustrated in FIG. **18**, the fuel injecting sprays are turned on in the vaporization chambers to produce the prevaporized and pressurized gas stream **52** which is discharged into the ramjet stream zones located at the oval thrust nozzle. The prevaporized and pressurized gas stream **52** passes through the distributing manifolds and inclined discharge nozzles into the ramjet stream. The turbo-ram induction jet air breathing stream receives the prevaporized liquid fuel and when the mixture is ignited, the combustible mixture **53** produces flame thrust stream **64** downstream of the oval thrust nozzle The ignited mixture products a high thermal stream, such as a rocket thrust stream, creating the turbo-ram induction air breathing rocket thrust engine.

As illustrated in FIG. **19**, hypersonic flight is generated with the turbo-ram induction jet air breathing rocket oval thrust stream flow through the diverging contours of aerodynamic generating channel The dynamic pressure of the back burning oval thrust stream induces the recycled airstream **44** which is the thrust peripheral flow diverted into the forward and upper portion of the channel and through the reverse flow duct **43** and the recycling air inductor vanes **31**.

The forward leading edge **60** of wing at the airspeed of the aircraft induces the oblique shock airstream **61** to interact with the flame stream **64** of the turbo-ram induction jet air breathing rocket thrust. These streams are tangentially constriction to develop the critical pressure and to form the high velocity free stream in throat **65** located in the forward section of the channel. These streams are merged which produces the expanding combustion downstream of the free stream throat and expanded to produce the hypersonic velocity of thrust stream **66** in the diverging contours of channel thus creating a turbo-ram induction jet air breathing rocket aerodynamic thrust channel.

The ramjet induction axialflow turbine is achieved by the liquid fuel prevaporization and back burning induction jet oval thrust nozzle, illustrated in FIGS. **20**, **21** and **22**, during high speed flight. The liquid fuel prevaporization and back burning induction jet oval thrust nozzle slip fits on the exit pipe **67** of a conventional axialflow turbine (rotators **68**, **70** and stators **69**). An electric generator is installed inside the exhaust pipe **72** of the axialflow turbine which has a ram constriction air inlet plenum.

Ram constriction assembly having multiple vanes **17**, **18** and **19** is fitted on the inclined ram-air intake opening forward of the plenum pod located on the front of the axial flow turbine inlet diffuser. The forward speed of aircraft generates a ram-stream which passes through the deflectable multiple vanes **18** and **19** of the air intake and then flows into the plenum pod. The trailing sections of multiple vanes **19** are deflected towards the rigidly fixed straight vane **17** at the center-line of the axialflow turbine. The ram-stream passing through the multiple vanes is inflected in the flow direction and is tangentially constrained to produce a critical pressure on front of the axialflow turbine inlet diffuser. The critical ram pressure flow impinges on the axialflow turbine blades **68** and **70** rotating the turbine wheels.

The expanding ramjet thrust streams **59** flow through the inductor vanes **9** and induce a negative pressure differential on the turbine inlet and outlet. This enhances the power of the ram-axialflow turbine and operates the electric generator. The ramjet-induction axialflow turbine operation is obtained by the liquid fuel prevaporization and back burning induction jet oval thrust nozzle fitted onto the conventional axialflow turbine having a ram constriction air inlet plenum located in ram stream zone of airframe.

The liquid fuel prevaporization and backburning induction jet oval thrust nozzle of this invention is used for an induction lift aircraft.

In FIGS. **23** and **24**, the circular airframe **101** of the inductive lift flying saucer houses the central power plant section of the induction lift flying saucer. The air breathing jet engines **104** have air intake controls **106** to control the air flow into the jet engines **105** and through channel **105** to the jet thrust means generating means located rearward of and behind the jet engines. This is shown in greater detail in FIGS. **31** and **32**. The vacuum lift wing airfoils **118** are located rearward of the jet thrust stream generating means. Air Brakes **139** are provided. Additional jet engines **141** and air pods **142** are provided adjacent the main power section.

FIG. **24** shows the oval shaped thrust nozzle **114** from the jet stream thrust producing means. The circular airframe **101** has a sharp outer peripheral edge defined by the upper section **103** and a lower section **102**. The aerodynamic thrust generating channel is shown as **125** and the acoustical channel **130** is shown to form the reverse channel **127**.

FIG. **25** the shape of the outlet of the aerodynamic channel, the location of the reverse channels **127** and the location of the vacuum lift wings **118**. Wheels **161** are shown which support the aircraft for takeoff and landing.

The additional jet engines **141** likewise have outlets for the jet thrust stream generating means shown as **160**. A ramp **162** is provided for ingress into the spacecraft **101**.

FIGS. **26** and **27** include the same elements described above in connection with FIGS. **23** through **25** with the addition of outlets **126** positioned rearward of the aerodynamic generating channels.

FIG. **28** shows the the air controls **106** at the front of the spacecraft.

FIG. **29** show the entry **162** for providing access to the interior of the induction lift flying saucer.

FIG. **30** shows the outlets **114** of the jet thrust stream generating means used as the inputs to the aerodynamic generating channel, the bottom of which is enclosed by the vacuum lift wing.

FIGS. **31** and **32** show the details of the air controls having deflectable member **106** controlled by actuator **107** which determines the volume of air being passed to the air breathing jet engine **104** and the air passing through channel **105** which is used as the input to the jet thrust stream generating means.

The air passing through channel **105** is passed through a bell mouth intakes **108**, **109** and **110**. The air is compressed and injected with fuel to produce the jet thrust stream in the chamber **111** which is passed through chamber **112** to compress the same as it passes out of the exit nozzle **114**.

FIG. **33** shows the relationship of the bell mouth air intakes **108** and **109**, and the position of the same relative to the jet engine **104** and the air path **105**.

What is claimed is:

1. An inductive lift flying saucer comprising:

a circular airframe having an aerodynamic outer surface and a central power plant housing section;

an aerodynamic generating channel having an elongated main generating channel located in the central power plant housing section and defined by an inlet adjacent a jet engine which communicates with the main generating channel, an upper portion defining a reverse flow channel and wherein the lower portion and outlet of the main generating channel is opened and is part of said main generating channel;

a vacuum cell induction lift wing airfoil including a leading edge and a trailing edge and having a top panel and an acoustically treated hollow interior, said airfoil including airtight partitions forming individual cells within said hollow interior and having inclined slots which extend from the top panel of said airfoil into each of said individual cells, said inclined slots extending at an angle from each of said individual cells toward the trailing edge of said airfoil, said airfoil being adapted to be positioned within an aerodynamic generating channel in the lower portion thereof and spaced from the upper portion forming said elongated channel with the top panel of the airfoil being adapted to form a lower boundary of a said aerodynamic generating and forming an outlet for the main generating generating channel between the trailing edge of the airfoil and the rearward section of the upper portion forming the reverse flow channel and being adapted to define a slipflow thereacross from an airstream passing through a said aerodynamic generating channel;

support means operatively coupled to said airfoil adjacent the trailing edge for enabling said airfoil to be rotated therearound to change the angle of incidence of the top panel to a said airstream passing thereacross; and

pivoting means actuators operatively coupled to said airfoil adjacent the leading edge for moving said airfoil leading edge relative to a said airstream by rotating said airfoil around said support means to change the angle of incidence of said top panel relative a said airstream enabling a said airflow to generate a vacuum within said individual cells having a pressure which is determined by the angle of incidence of the top panel of the airfoil to the said airstream and by the shearing stress of a said airstream passing over said inclined slots in the top panel of said airfoil.

2. An inductive lift flying saucer comprising:

a circular airframe having an aerodynamic outer surface and a central power plant housing section;

a jet engine producing a jet thrust stream having a thrust nozzle located in the central power plant section;

a jet thrust peripheral flow recycling system located rearward of and adjacent to the thrust nozzle, said jet thrust peripheral flow recycling system comprising:

a housing defining an aerodynamic generating channel adapted to pass a jet thrust stream from the thrust nozzle of said jet engine therethrough, said housing including a main generating channel having an inlet and an outlet and a reverse flow channel located in the upper portion of the main generating channel channel and separated from the main generating channel by an acoustically treated panel having inclined orifices which are directed towards this outlet, said reverse flow channel having an inlet opening located at the outlet of the main generating channel and an outlet opening located adjacent the inlet of the main generating channel, said inclined orifices being operative to provide a slipflow for a said jet thrust stream passing through the main channel;

a vacuum induction lift wing airfoil including a leading edge and a trailing edge and having a top panel and an acoustically treated hollow interior, said airfoil including airtight partitions forming individual cells within said hollow interior and having inclined slots which extend from the top panel of said airfoil into each of said individual cells, said inclined slots extending at an angle from each of said individual cells toward the trailing edge of said airfoil, said airfoil being positioned within an aerodynamic generating channel with the top panel of the airfoil being adapted to form a lower boundary of a said aerodynamic generating channel and being adapted to define a slipflow thereacross from an airstream passing through a said aerodynamic generating channel;

support means operatively coupled to said airfoil adjacent the trailing edge for enabling said airfoil to be rotated therearound to change the angle of incidence of the top panel to a said airstream passing thereacross; and

pivoting means actuators operatively coupled to said airfoil adjacent the leading edge for moving said airfoil leading edge relative to a said airstream by rotating said airfoil around said support means to change the angle of incidence of said top panel relative a said airstream enabling a said airflow to generate a vacuum within said individual cells having a pressure which is determined by the angle of incidence of the top panel of the airfoil to the said airstream and by the shearing stress of a said airstream passing over said inclined slots in the top panel of said airfoil;

reverse flow turning vanes located in the inlet of the reverse flow channel and being adapted to divert a portion of a said jet thrust stream passing through said reverse flow channel back into the main generating channel; and

actuators operatively coupled to said reverse flow vanes for controlling the position of the reverse flow turning vanes relative to a said jet thrust stream passing through the main generating channel to regulate the volume of a said jet thrust stream being diverted into and passing through said reverse flow channel.

3. An inductive lift flying saucer comprising:

a circular airframe having an aerodynamic outer surface and a central power plant housing section;

a jet engine producing a jet thrust stream having a thrust nozzle located in the central power plant section;

an induction aerodynamic lift generating appararus located rearward of and adjacent to the thrust nozzle of the jet engine producing a jet thrust stream comprising:

a housing defining an aerodynamic generating channel having an elongated main generating channel defined by an inlet adjacent a jet engine which communicates with the main generating channel, an upper portion defining a reverse flow channel and wherein the lower portion and outlet of the main generating channel is opened and is part of said main generating channel adapted to pass a jet thrust stream through including said main generating channel having said inlet and an outlet and said reverse flow channel located in the upper portion of the main generating channel channel and separated from the main generating channel by a panel, said reverse flow channel having an inlet opening located at the outlet of the main generating channel and an outlet opening located adjacent the inlet of the main generating channel;

an airfoil including a leading edge and a trailing edge and having a top panel and an acoustically treated hollow interior, said airfoil including airtight partitions forming individual cells within said hollow interior and having inclined slots which extend from the top panel of said airfoil into each of said individual cells, said inclined slots extending at an angle from each of said individual cells toward the trailing edge of said airfoil, said airfoil being adapted to be positioned within said aerodynamic generating channel in the lower portion thereof and spaced from the upper portion forming said elongated channel with the top panel of the airfoil being adapted to form a lower boundary of a said aerodynamic generating and forming an outlet for the main generating generating channel between the trailing edge of the airfoil and the rearward section of the upper portion forming the reverse flow channel and being adapted to define a slipflow thereacross from a jet thrust stream passing through a said aerodynamic generating channel;

support means operatively coupled to said airfoil adjacent the trailing edge for enabling said airfoil to be rotated therearound to change the angle of incidence of the top panel to a said jet thrust stream passing thereacross; and

pivoting means actuators operatively coupled to said airfoil adjacent the leading edge for moving said airfoil leading edge relative to a said jet thrust stream by rotating said airfoil around said support means to change the angle of incidence of said top panel relative a said jet thrust stream causing a said airflow to generate a vacuum within said individual cells having a pressure which is determined by the angle of incidence of the top panel of the airfoil to the said jet thrust stream and by the shearing stress of a said jet thrust stream passing over said inclined slots in the top panel of said airfoil, said jet thrust stream being adapted to pass through the aerodynamic generating channel and over the top surface of the vacuum cell induction lift wing for producing thermal aerodynamic lift and drag forces which are determined by the angle of incidence of said vacuum cell induction lift wing and that portion of said jet thrust stream being diverted into and passing through said jet thrust stream being diverted into and passing through the reverse flow channel and back into the main generating channel.

* * * * *

United States Patent [19]

von Kozierowski

[11] **Patent Number: 4,976,395**

[45] **Date of Patent: Dec. 11, 1990**

[54] **HEAVIER-THAN-AIR DISK-TYPE AIRCRAFT**

[76] Inventor: **Joachim von Kozierowski,** Zum Darloh 5, D-5982 Neuenrade 4, Fed. Rep. of Germany

[21] Appl. No.: **235,592**

[22] Filed: **Aug. 24, 1988**

[30] **Foreign Application Priority Data**

Aug. 24, 1987 [DE] Fed. Rep. of Germany 3728153

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

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

[58] **Field of Search** .... 244/12.2, 23 C, 23 A, 244/23 R; 60/39.34, 39.35, 39.43, 39.75; 416/175, 182, 179, 183

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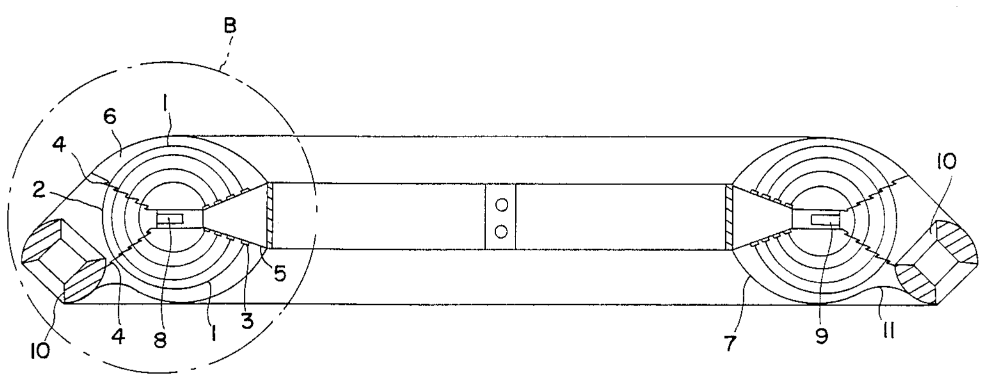
Primary Examiner—Galen Barefoot
Attorney, Agent, or Firm—Pollock, Vande Sande & Priddy

[57] **ABSTRACT**

Vertically starting and landing centrifugal toric ring shape, transport capsules for movement in any desired medium. The capsules consist of circular ring shells, arranged above or inside each other, and rotating concentrically at a distance around a central axis. Each circular ring shell consists of compressor blades (1) and turbine blades (2), arranged side-by-side on a circular ring and connected to each other by means of separator rings (4) and bearing rings, and which have one or several energy aggregates which drive the circular ring shells, so that the surrounding medium is taken up by the circular ring shells, accelerated and again expelled through nozzles (10), whereby the centrifugal ring itself is held rotationally stable with respect to the center axis by an electronically controlled braking device (14) on the counter-running shells or by means of nozzles or through a projecting torque support.

4 Claims, 5 Drawing Sheets



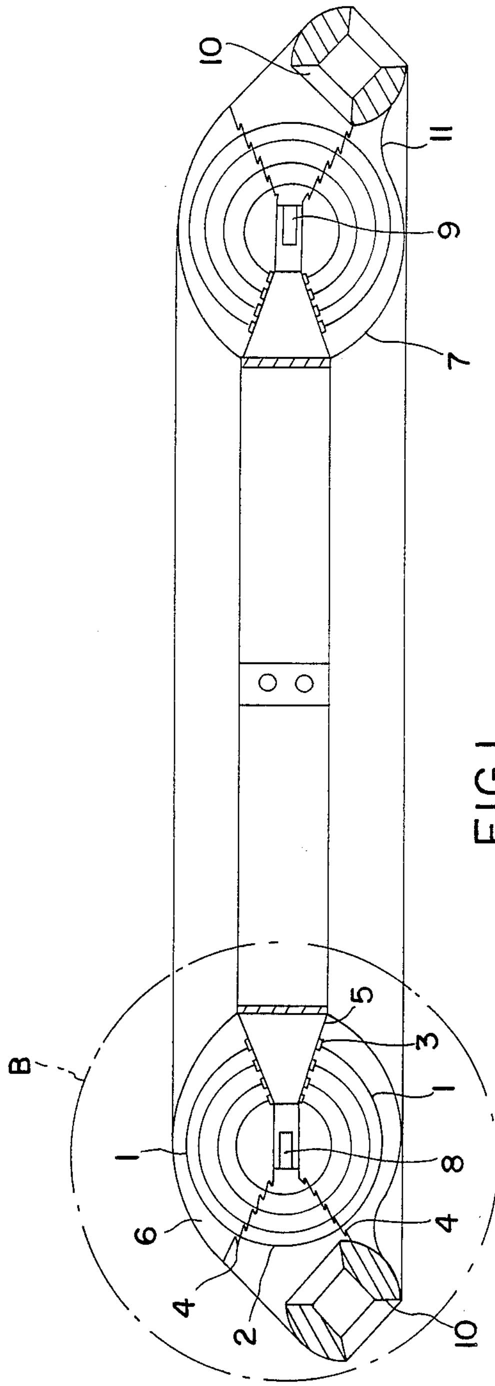


FIG. 1

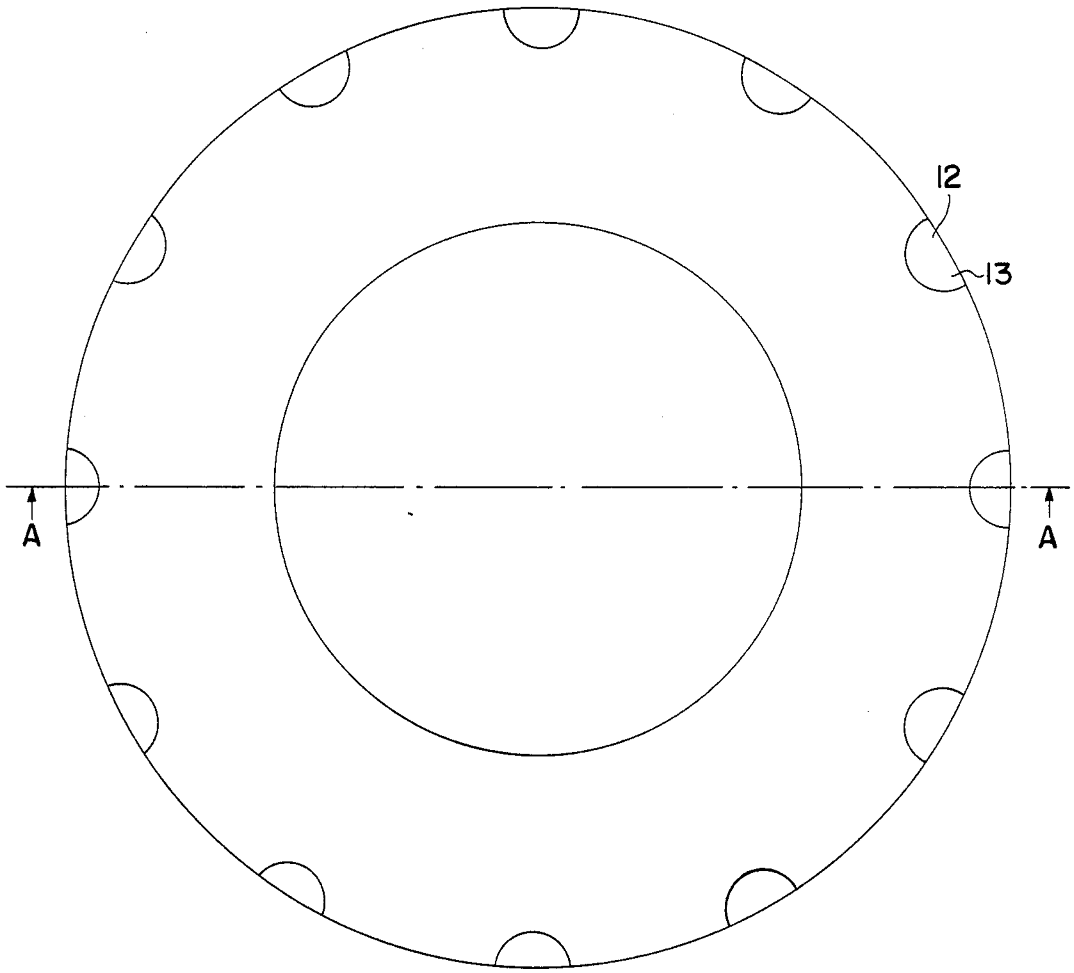


FIG.2

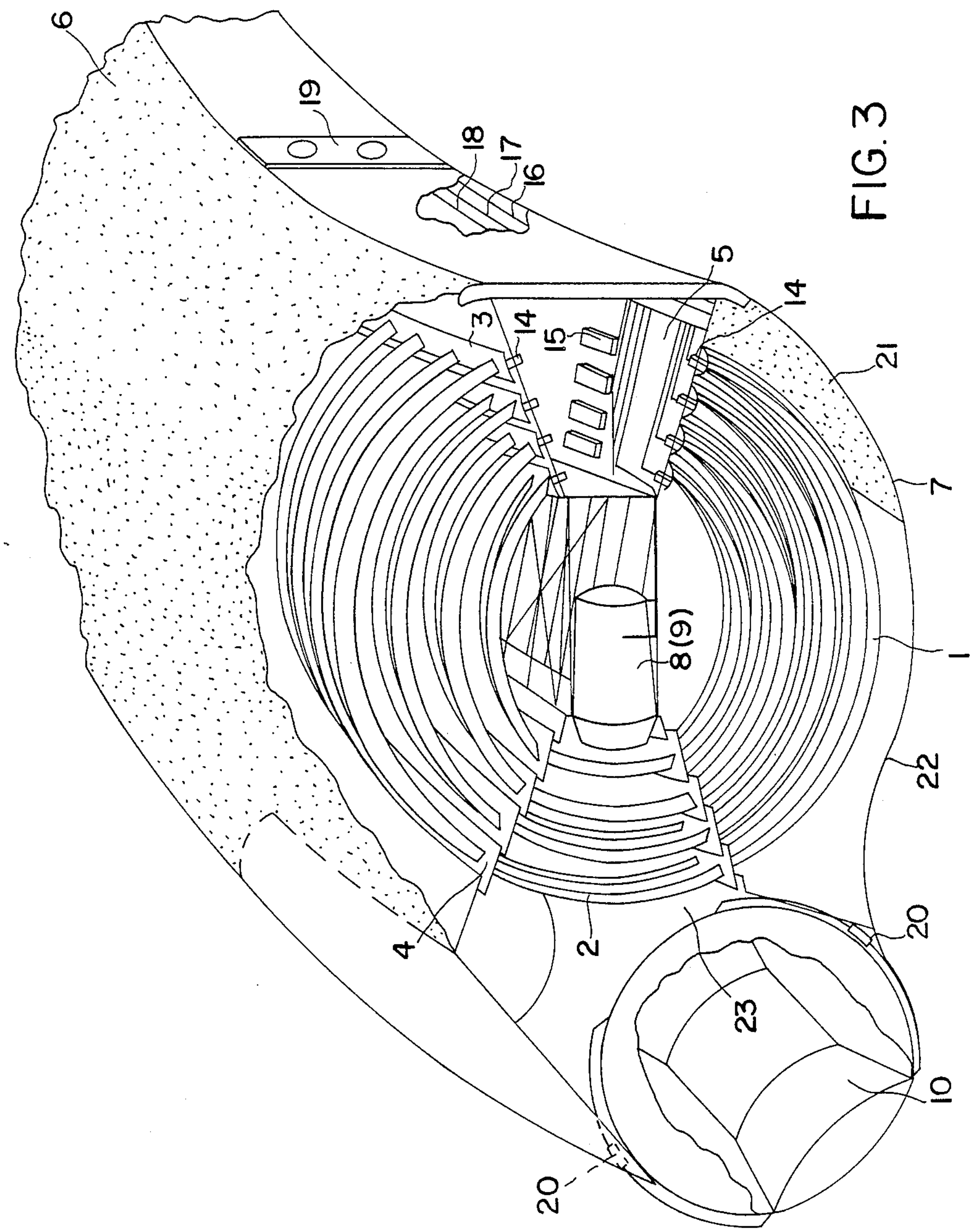


FIG. 3

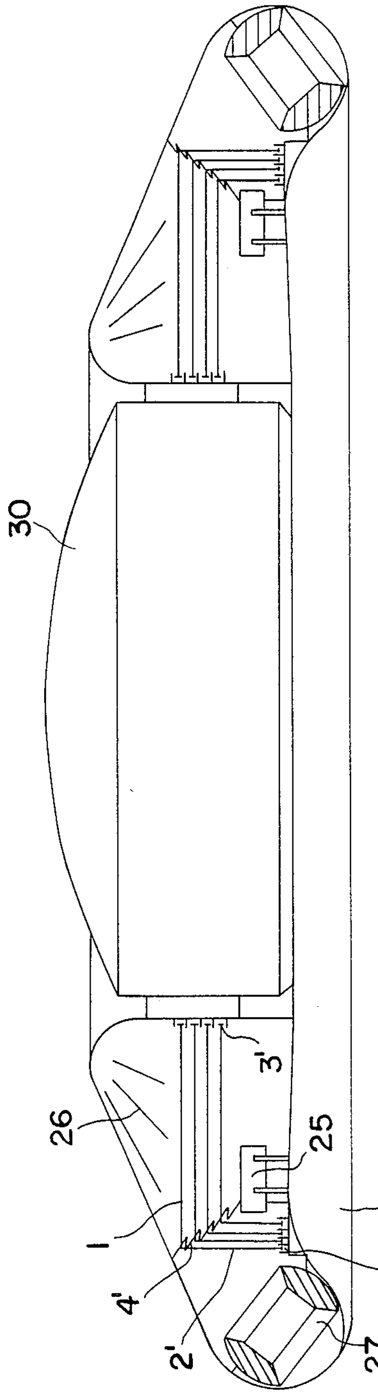


FIG. 4

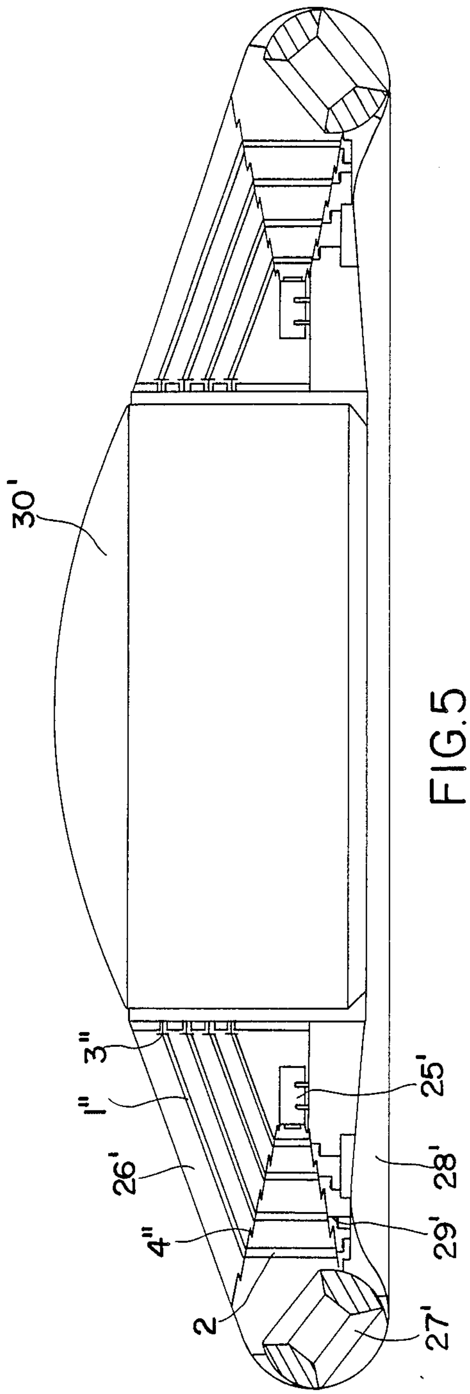


FIG.5

HEAVIER-THAN-AIR DISK-TYPE AIRCRAFT

FIELD OF THE INVENTION

The invention relates to a heavier-than-air disk-type aircraft, which is substantially symmetrical about a vertical axis and which can take off and land vertically.

BACKGROUND OF THE INVENTION

Such an aircraft is known per se, and normally consists of a structure which embodies rotating turbines, as disclosed, for example, in U.S. Pat. Nos. 3,024,966 and 4,193,568, or of a disk-type structure which contains a centrifugal blower driven by a central shaft and which moves air from an intake slot toward a discharge slot, as disclosed in U.S. Pat. No. 3,123,320.

The prior art disk-type aircraft have compressor blades arranged annularly and mounted radially, so that the air inlet is close to the center of the aircraft, where the air is led downwards through the relatively small inlet. Due to this technique it is hardly possible to make an economic modular design of a disk-like aircraft.

SUMMARY OF THE INVENTION

The object of the invention is a disk-type aircraft consisting of a controlled non-rotatable, permeable, driving centrifugal ring into the center of which transport or passenger cabins are interchangeably hooked.

For the solution of this problem, the invention provides that, on a circular ring related to a center axis, blades which are straight or bent along their longitudinal axes are arranged at intervals next to each other, thus forming a circular ring shell. Other circular ring shells are arranged concentrically to each other, without touching, above each other or inside each other. These shells are rotatably driven by one or several energy aggregates, and thus take in the surrounding medium which, depending on its type, is compressed and/or accelerated and expelled. One or several stabilizers hold the permeable housing rotationally stable with respect to the center axis, and thus form a torus-like body, freely moving through a medium, into the center of which transport or passenger cabins are exchangeably hooked.

This has the effect, compared to the closest state of the art, that through the annular arrangement of the blade shells a stabilizing centrifugal force and a large amount of accelerated medium is provided, which medium, led over adjustment nozzles or control panels, puts the centrifugal ring into motion and stabilizes it.

The ring itself is rotationally stable with respect to its center axis, since it is held by means of an electronically controlled braking device on the counter-rotating shells or through nozzles or through a projecting torque support.

It is thus possible to locate interchangeable passenger cabins in the center of the centrifugal ring.

Due to the relatively great thrust forces attained by the centrifugal ring based on the large air flow through its permeable outer skin, and due to the stabilizing centrifugal force from the rotation of the shells as well as the arrangement of the adjustment nozzles, vertical take-off, landing, and holding in position in the air is possible.

On the basis of the air absorption over the greatest part of the outer skin, and of the relatively flat construction, there is a favorable air resistance value for flight in a radial direction.

The large surfaces across which air is absorbed favor flight at a high altitude in thin air.

When flying in axial direction and during vertical landing the air resistance value produced by the large circular ring surface helps to reduce speed. This effect is enhanced by the hooked in center capsule.

Through the electronic control the passenger capsule can always be positioned during flight in such a manner that the passengers are pressed into their seats during acceleration and decelerations.

The concept of the invention is also applicable to use of the centrifugal ring in water, where it can serve for the transport of bathyspheres.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the invention may be more clearly understood, it will now be described with reference to the accompanying drawings, wherein several embodiments of the invention are described for purposes of illustration and wherein:

FIG. **1** is a cross section through a front elevation view of a first embodiment of the centrifugal ring along line A—A of FIG. **2**, with two compressors sides;

FIG. **2** is a top plan view of the first embodiment of the centrifugal ring;

FIG. **3** is a perspective section view of the centrifugal ring along line B of FIG. **1**;

FIG. **4** is a cross section through a front elevation view of a second embodiment of the centrifugal ring, with angled shells consisting of straight compressor and turbine blades and only one compressor side; and

FIG. **5** is a cross section through a front view of a third embodiment of the centrifugal ring, with straight shells, consisting of compressor blades placed behind each other in a straight line, and turbine blades with only one compressor side.

DESCRIPTION OF PREFERRED EMBODIMENTS

On the periphery related to the center line of the centrifugal ring, upper and lower compressor blades **1**, arranged next to each other, form with turbine blades **2** a torus-like shell above bearing rings **3** and separator rings **4** arranged concentrically around the center of the centrifugal ring.

The shells, rotating on runway **5** around the center axis of the centrifugal ring, compress with their compressor blades **1** the air air entering through the outer skin areas **6**, **7** (shown schematically in FIG. **3**), which are permeable to the medium so as to provide sufficient flow to the turbines, yet act as a barrier to the entry of undesirable matter. This air is accelerated by combustion chambers **8** and gas turbines **9** arranged along the circumference. The hot gas drives the shell via the turbine blades **2**.

The medium guided across the turbine blades **2** of the centrifugal ring is expelled through downstream adjustment nozzles **10**, which may be equipped with afterburners, so that the centrifugal ring is propelled in the selected direction by reverse thrust. The outer skin area **11** is also permeable to the medium.

In FIG. **2**, positions **12**, **13** represent sliding separations which automatically open and close the apertures of the propulsion nozzles.

In FIG. **3**, the counter-running shells each consist of compressor blades **1** and turbine blades **2**, arranged behind each other and attached at intervals next to each other on two concentric bearing rings **3** and connected to each other by two separator rings **4**, and being driven by the accelerated medium of the combustion chambers **8** and/or gas turbines **9** arranged on the periphery.

The electronically controlled adjustment nozzles **10**, mounted downstream of the combustion chambers **8** and/or gas turbines **9**, which can be equipped with afterburners, produce the reverse thrust power needed for the motion and control of the centrifugal ring.

The counter-rotating, air cushion supported shells have contact and guidance with the electronically controlled braking wheels **14**, mounted on the periphery, by means of which the rotation stability is attained in cooperation with the adjustment nozzles **10**.

The air pressure between bearing ring **3** and runway **5** is regulated by means of electronically controlled pneumatic valves **15** which receive the compressed air from the compressor.

Data transmissions and fuel supply pass through lines **16** and **17**. The compressed air distribution proceeds through line **18**. All three lines **16, 17, 18** are connected through couplings in the docking column **19** to the transport capsule hooked into the center.

The electronically controlled servomotors **20** bring the peripherally mounted nozzles **10** into the desired position.

The air intake by the lower blades proceeds through bypass next to the chambers **23** and throught the permeable sheet metal housing **21**.

The sheet metal **22** is selectively air-permeable or air impermeable.

In FIG. **4**, the compressor blades **1**, arranged at right angles to the centerline of the centrifugal ring, arranged on the circle circumference, relative to the center line of the centrifugal ring, form, together with the turbine blades **2′** arranged parallel to the center line on the periphery and the joint separator ring **4′**, a circular ring shell with bearing rings **3′**, **29**. The radially inner portions of blades **2′** are supported in upper bearing rings **3′**, while the lower portions of blades **2′** are supported in lower bearing rings **29**. This arrangement provides additional rigidity to the structure.

Other shells of scaled down size are concentrically arranged above each other without contact and are driven in opposite direction by the energy aggregate **25** through the turbine blades of the circular ring shells. The compressor blades of the circular ring shells take up the surrounding medium through openings in the outer skin **26**.

The medium guided across the turbine blades of the centrifugal ring is expelled through the downstream adjustment nozzles **27**, which may be equipped with afterburners, so that the centrifugal ring with the centrally hooked in, interchangeable capsule **30** is pushed by reverse thrust into the desired direction.

The lower housing side of the centrifugal ring **28** is impermeable to the medium.

In FIG. **5**, the compressor blades **1″** and turbine blades **2″**, arranged side-by-side at intervals, inclined toward the centerline and connected to each other by the separator ring **4″**, arranged on the circle circumference, relative to the center line of the centrifugal ring, form a circular ring shell with bearing rings **3″**, **29′**.

Other shells of scaled down size are concentrically arranged above each other without contact and are driven in opposite directions by the energy aggregate **25′** through the turbine blades of the circular ring shells, whereby the compressor blades of the circular ring shells take in the surrounding medium through openings **26′** in the outer skin.

The medium guided across the turbine blades of the centrifugal ring is expelled through the adjustment nozzles **27′**, mounted downstream, which may be equipped with afterburners, so that the centrifugal ring with the centrally hooked in, interchangeable capsule **30′** is pushed by reverse thrust into the desired direction.

The lower housing side of the centrifugal ring **28′** is impermeable to the medium.

What is claimed is:

1. Circular centrifugal transport ring comprising spaced blades located side-by-side relative to a center axis of said ring, each of said blades comprising a plurality of compressor blades **(1)** and a turbine blade **(2)**, said blades being connected to each other through at least one separator ring **(4)** to form a circular ring shell with bearing rings, other circular ring shells being arranged concentrically with adjacent circular ring shells without contact, above each other or inside each other, an energy aggregate being housed in an innermost one of said circular ring shells, said energy aggregate inducing a relatively or absolutely opposite rotation of the circular ring shells, so that the surrounding medium is taken in by the circular ring shells, accelerated and expelled through guide means, whereby the housing of the centrifugal ring itself is held rotationally stable with respect to the center axis and a torus-like body is formed for receiving in a center thereof interchangeable transport cabins hooked thereinto.

2. Centrifugal ring according to claim **1**, wherein the adjustment nozzles are pivotably attached at the diameter of the centrifugal ring, and the centrifugal ring obtains vertical lift by adjustment in axial direction and can take off and land vertically.

3. Centrifugal ring according to claim **1**, wherein the outer housing and the at least one capsule centrally and interchangeably docked thereto is rotatable and positionable as desired relative to the center axis.

4. Centrifugal ring according to claim **2**, wherein the outer housing and the at least one capsule centrally and interchangeably docked thereto is rotatable and positionable as desired relative to the center axis.

* * * * *

United States Patent [19]

Valverde

[11] **Patent Number: 5,039,031**

[45] **Date of Patent: Aug. 13, 1991**

[54] **TURBOCRAFT**

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

[21] Appl. No.: **504,853**

[22] Filed: **Apr. 5, 1990**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 355,414, May 23, 1989, abandoned.

[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** .... 244/23 C, 23 B, 12.2, 244/12.3, 23 R, 12.1, 53 R, 60, 62, 52, 36, 17.19

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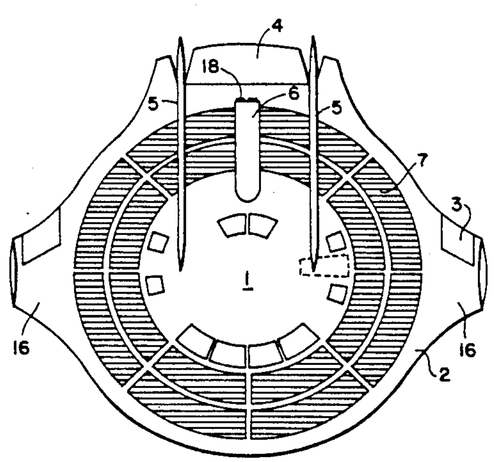
Primary Examiner—Galen Barefoot
Attorney, Agent, or Firm—Oltman and Flynn

[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.

18 Claims, 8 Drawing Sheets



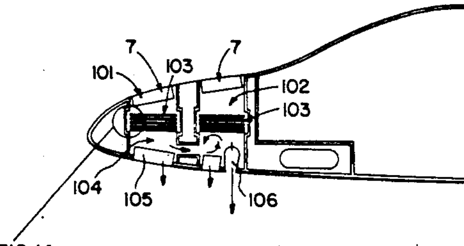


FIG. 14

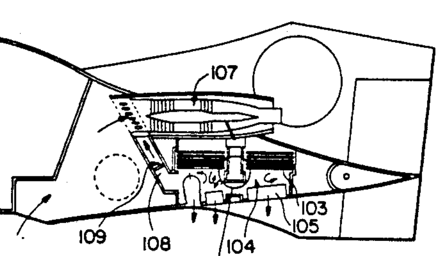


FIG. 16

FIG. 1

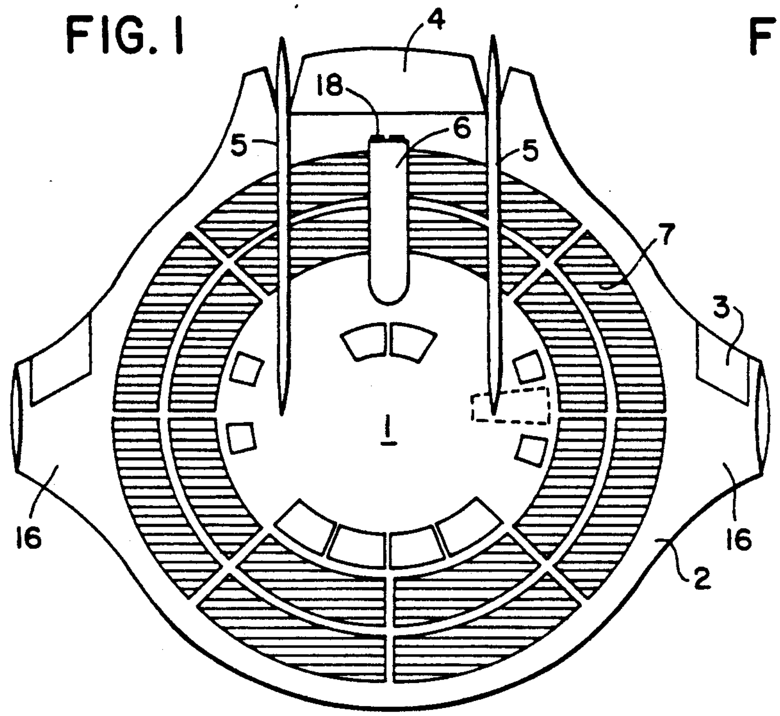


FIG. 2

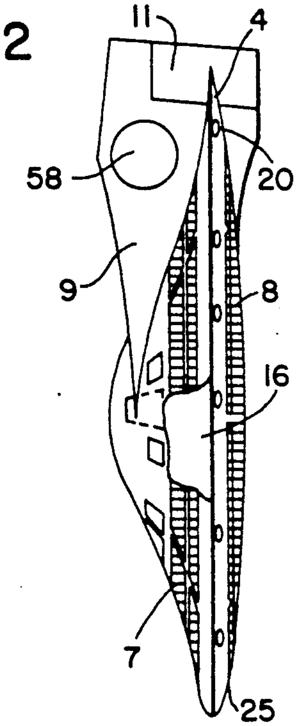


FIG. 3

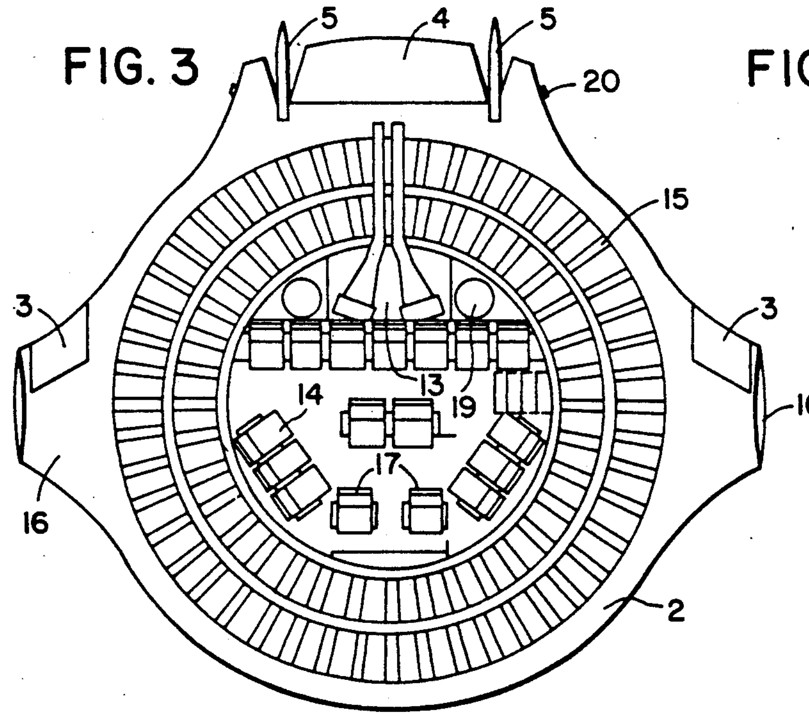


FIG. 4

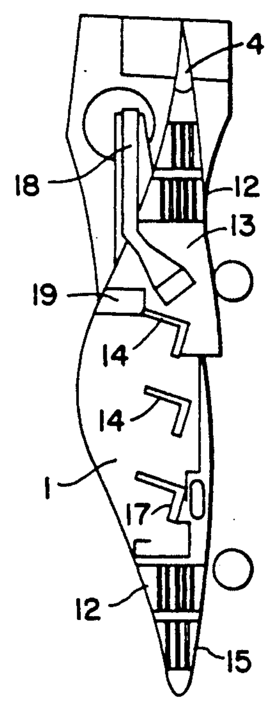


FIG. 5

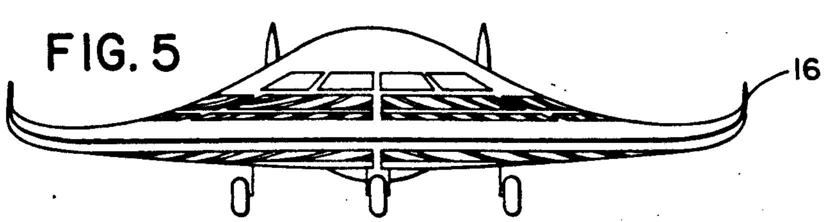
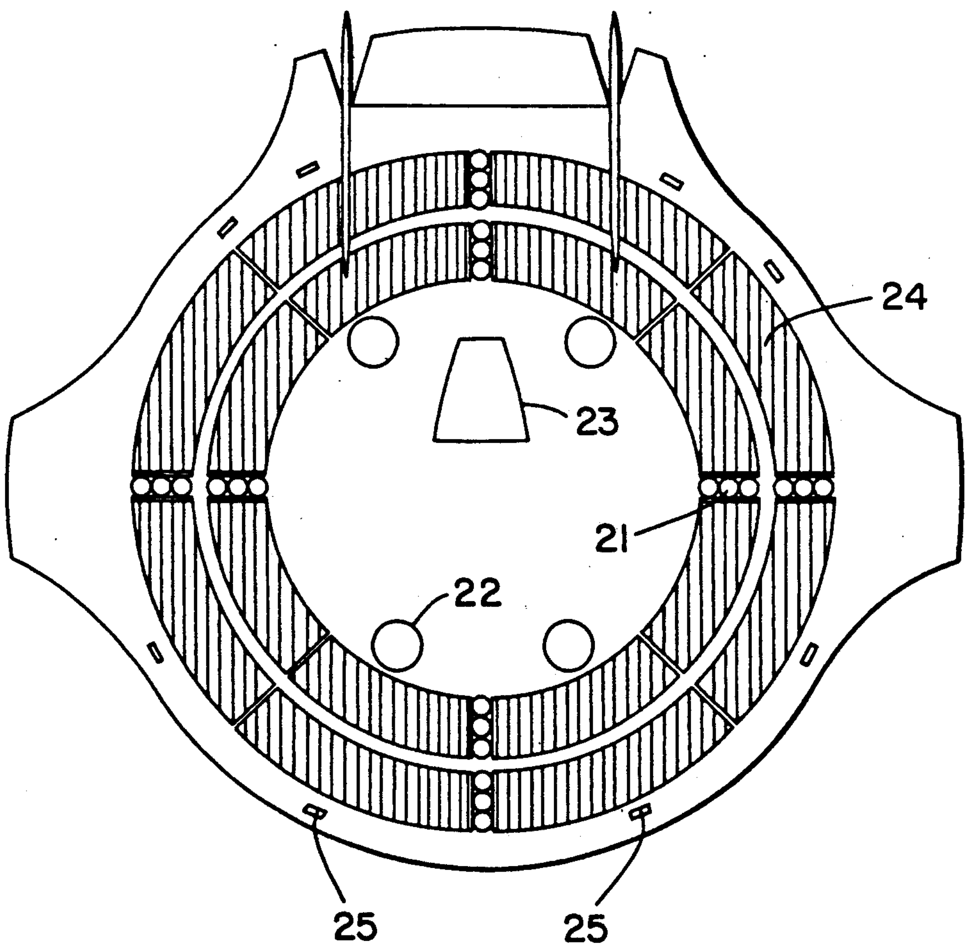


FIG. 6



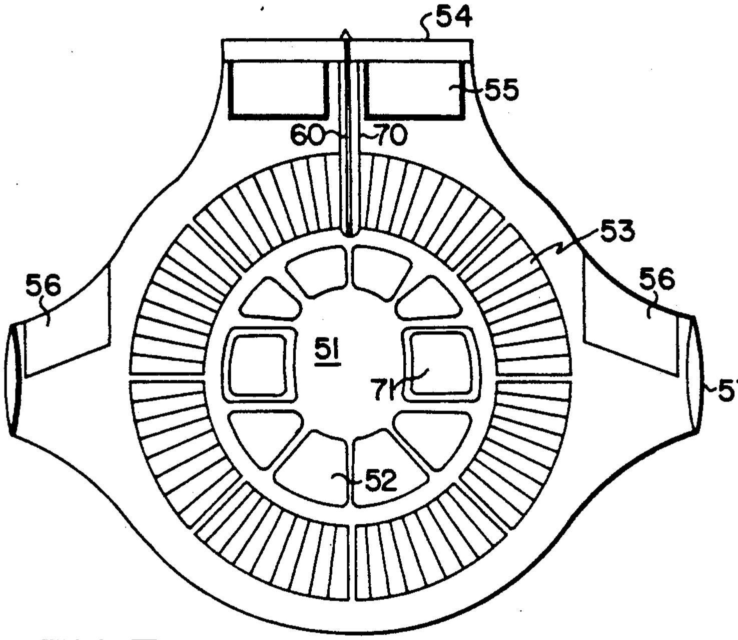


FIG.7

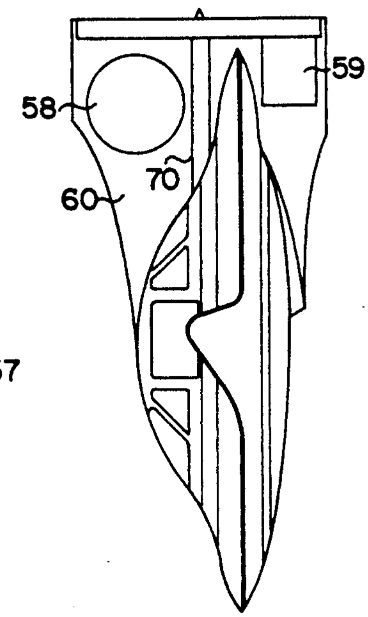


FIG.8

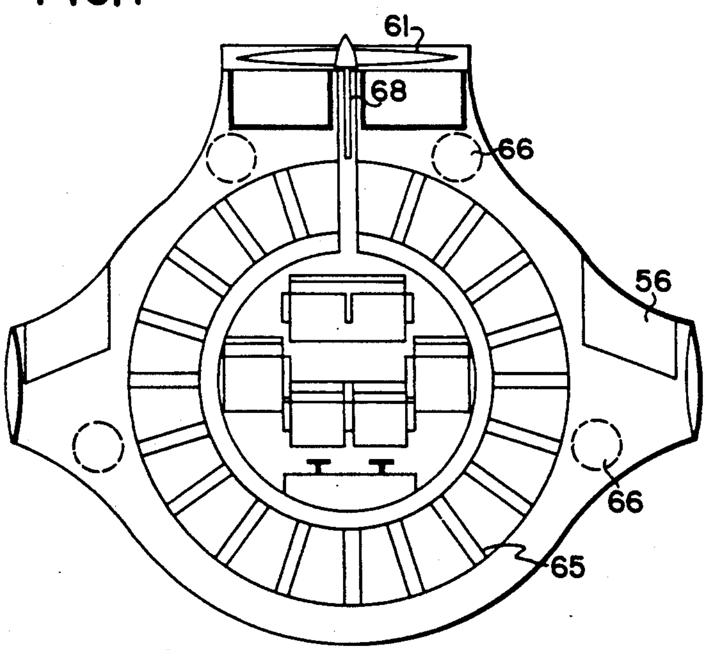


FIG.9

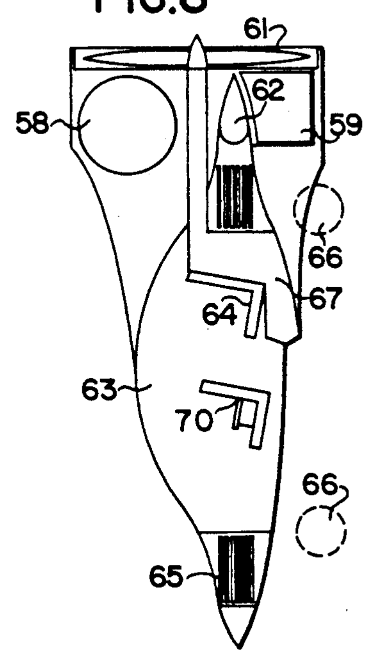


FIG.10

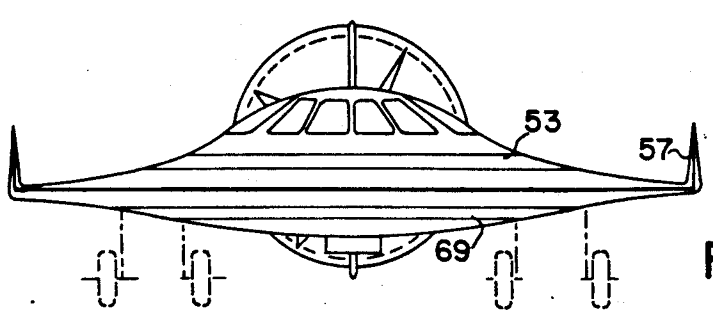


FIG.11

FIG. 12

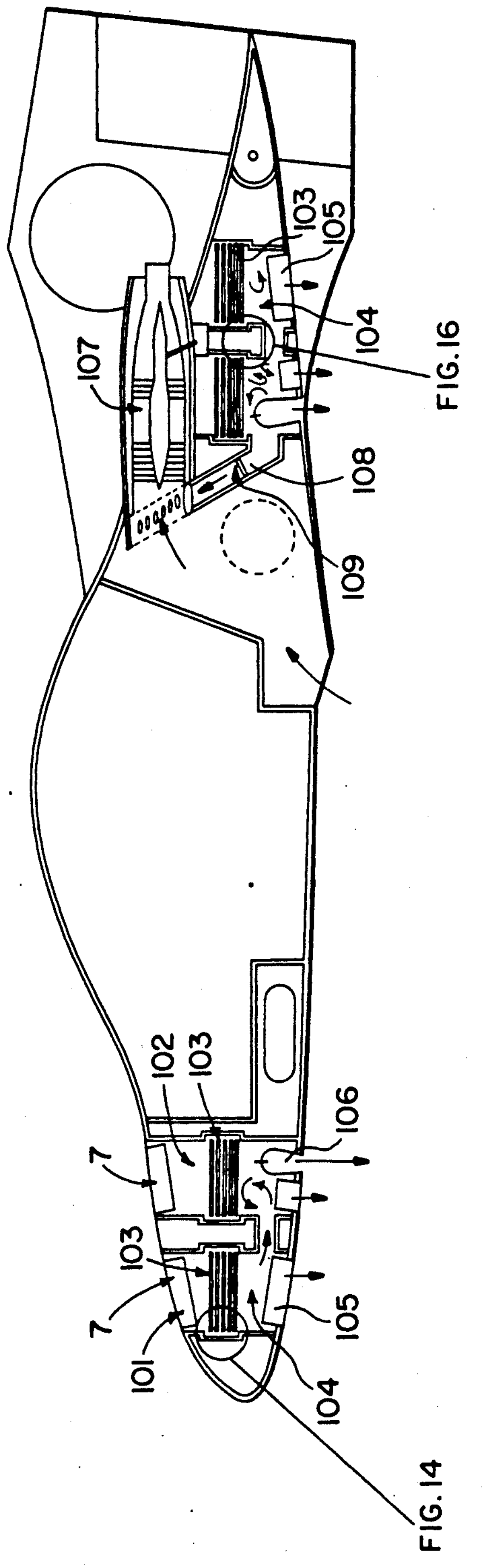

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FIG.16
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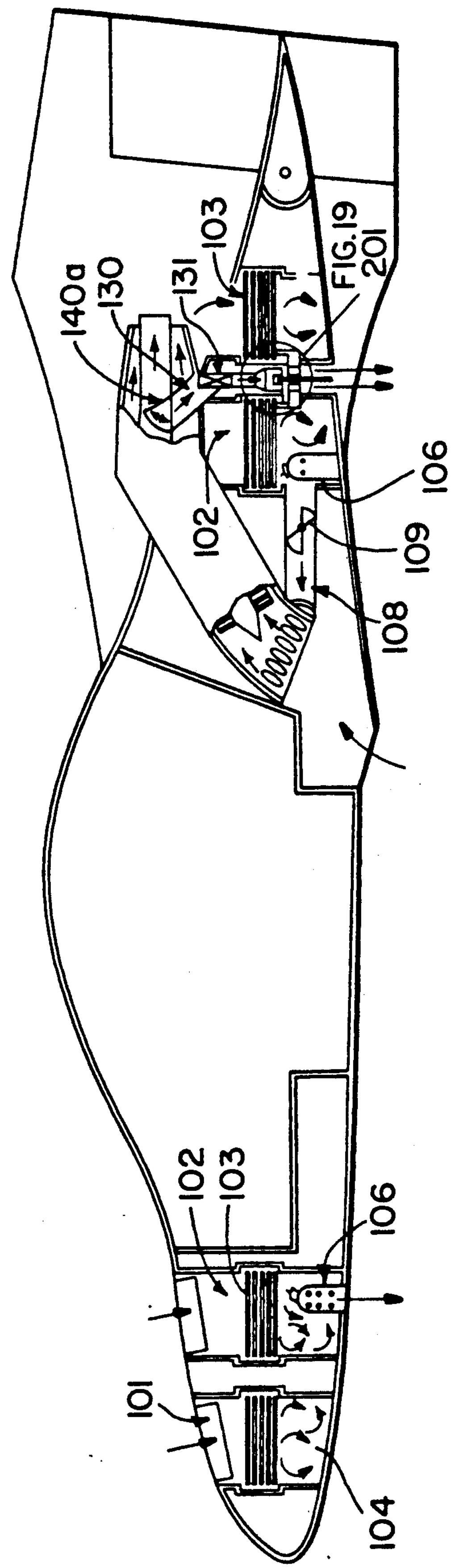
FIG.14

FIG. 13



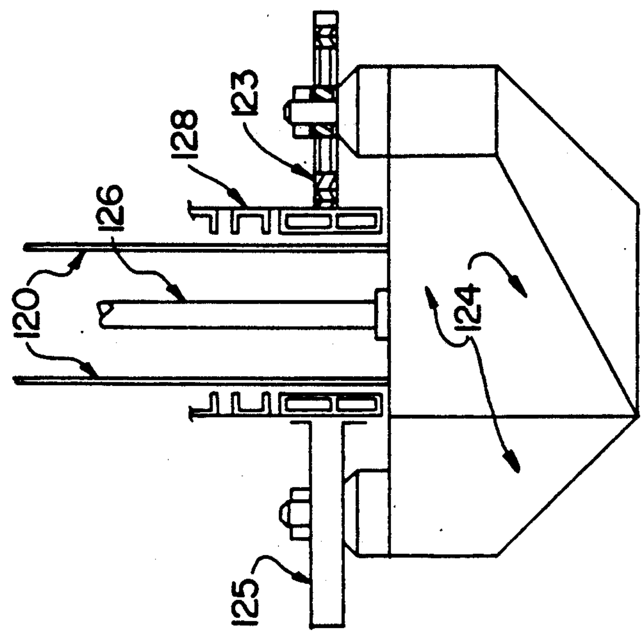


FIG. 16

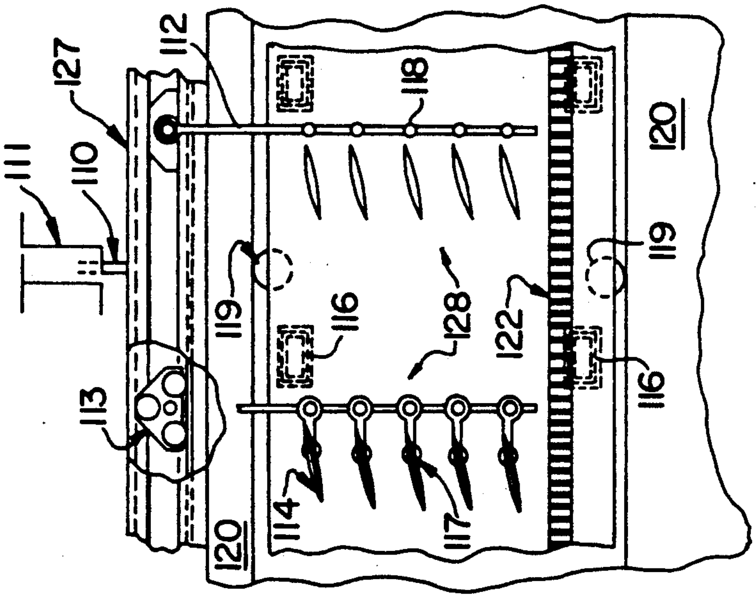


FIG. 15

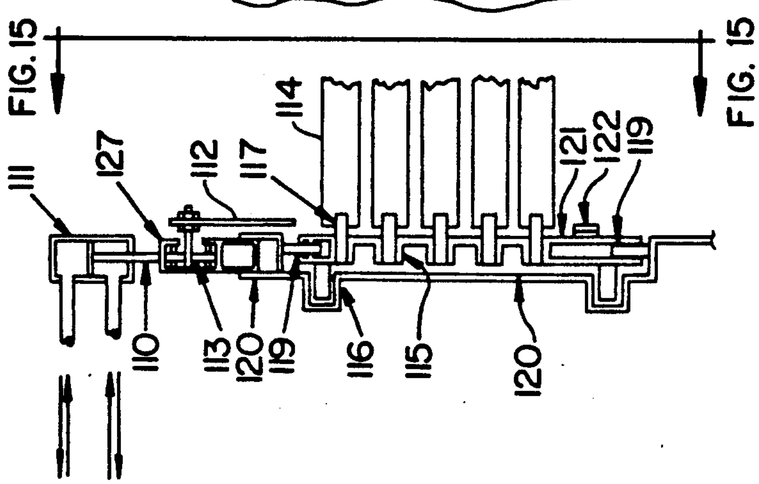


FIG. 14

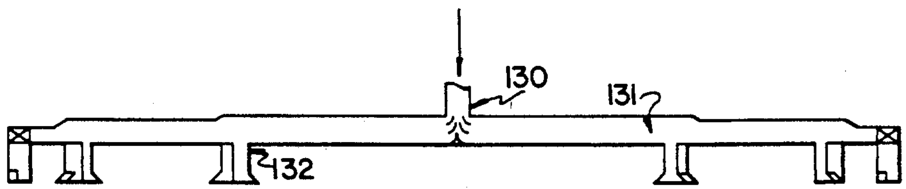


FIG. 18

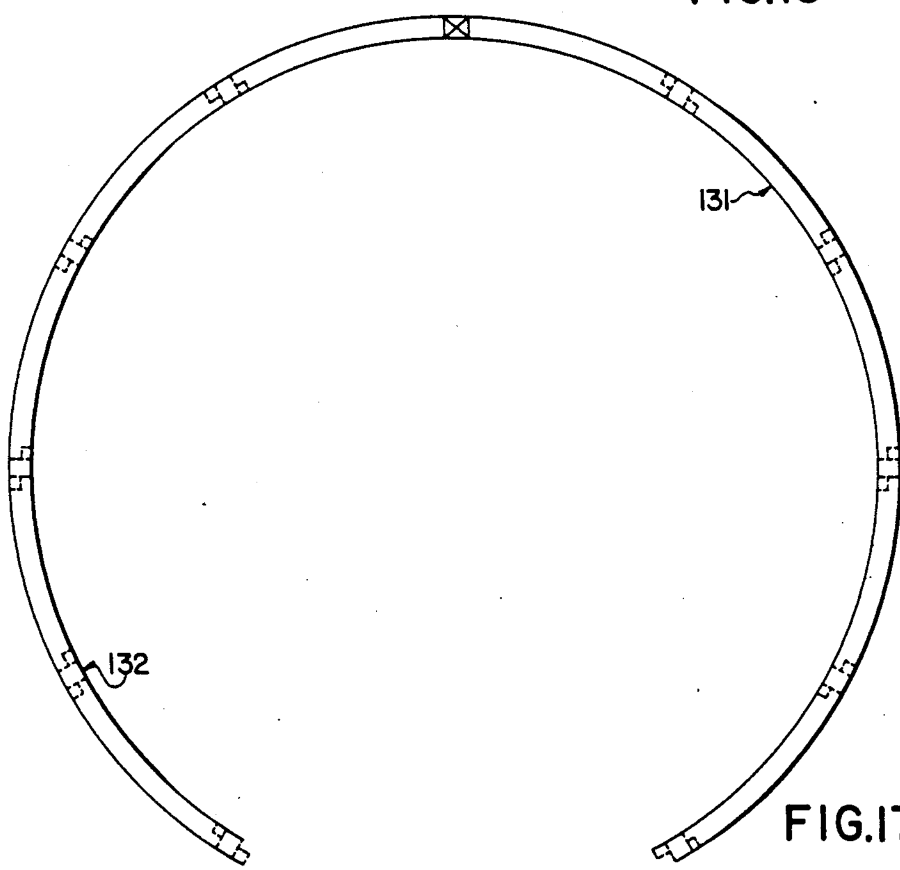


FIG. 17

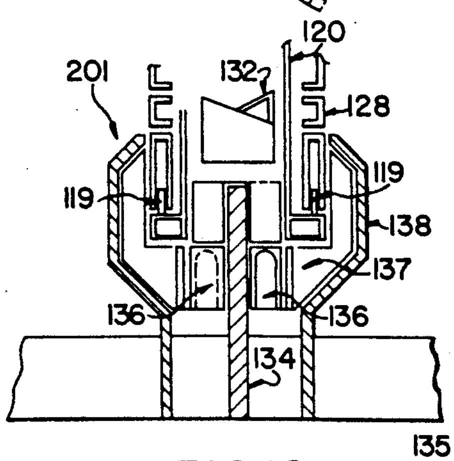


FIG. 19

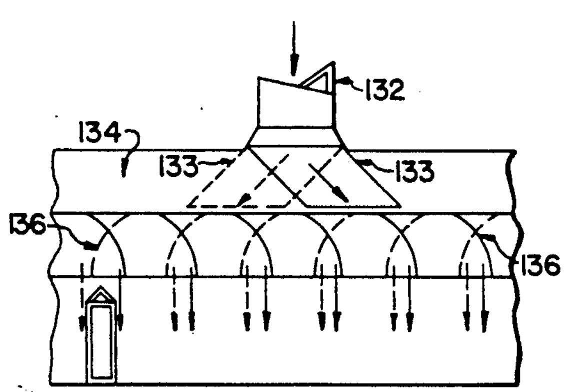


FIG. 20

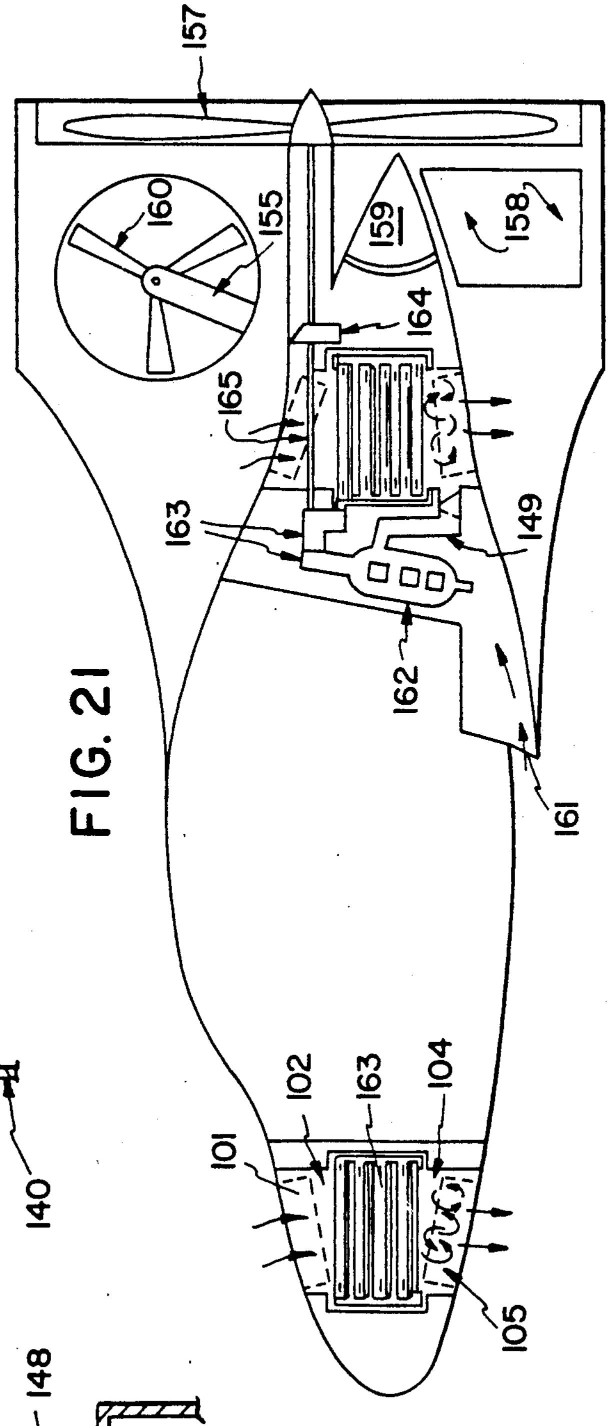

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FIG. 21

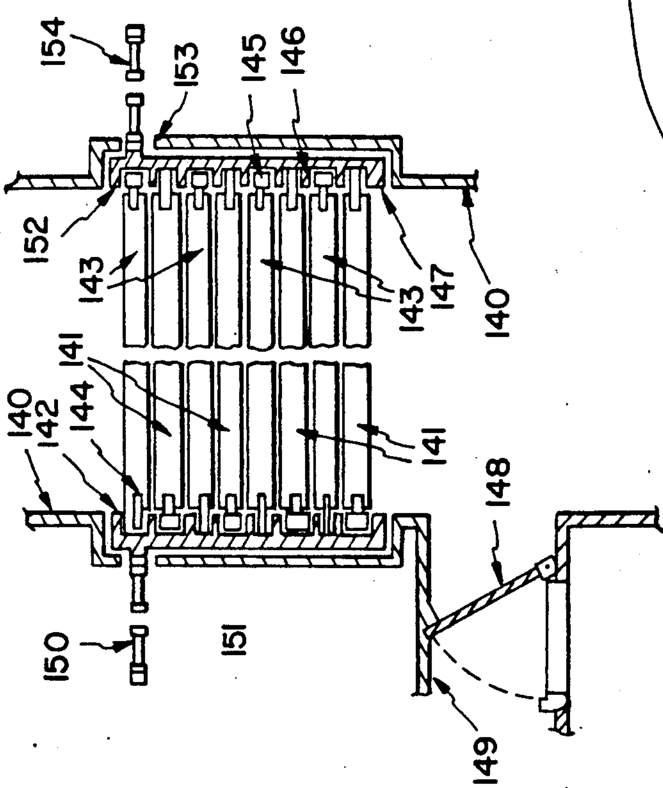
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FIG. 22

TURBOCRAFT

This is a continuation-in-part of application Ser. No. 07/355,414 filed 05/23/89, now abandoned.

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 increase ia 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 (turbo-blades) 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 wing 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.

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 aid 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 turbo-blade compressor in the tandem configuration.

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 it 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 is 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 air plane, air gas must flow uninterruptedly along the upper and lower surface of the wind.

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 yew 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

Heretofore, the aircraft of the instant invention has been shown to be capable of climbing, hovering, flying forward, turning 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 yaw 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 precompressed air (and consequently oxygen) to the turbofan 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 ia 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 with 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 would 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 eaters the compressed air plenum 104. Depending of 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 feed 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 108 with gate valve 109 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. They 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 **111** 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 retro-boosting 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 toward 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 invention.

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 Figure. 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 **43** 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 counter 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 **142**, and, similarly transmission gear and clutch assembly **164** transfer rotation 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 of 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.

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.

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-rotation turbo-blade assemblies disposed within said body for effecting a vertical lifting air stream through said assemblies, power generating means, 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 below said turbo-blade assemblies for boosting said vertical lifting airstream, a compressed air plenum disposed below said turbo-blade assemblies 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 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 of 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 of 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 claims 10 and 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 wings, 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 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.

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