

[54] AMPHIBIOUS HELICOPTER-TYPE AIRCRAFT

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[51] Int. Cl. B64c 29/00
[58] Field of Search 244/12 C, 23 C

[56] References Cited

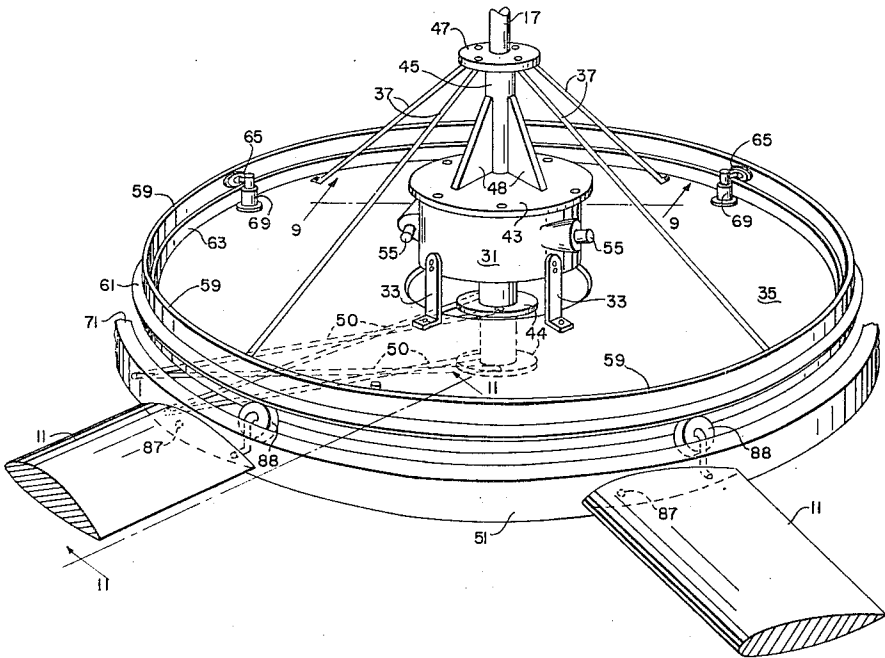
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[57] ABSTRACT

A fuselage is formed by an inner circular housing forming a dome which is spacedly surrounded by an annular housing which forms a toroid. Thus the two housings form an annular venturi-type duct tapering downwardly and inwardly. Across the duct extend variable pitch radially disposed rotor blades driven from a ring driven by a prime mover in the inner housing for inducing downwash of air in the form of a vortex through the duct with resulting lift. Cyclic pitches of the blades are variously controlled by a tiltable swash ring having various elevations in the inner housing and acting as a cam for followers on linkages connecting the ring with the blades as they rotate. The double purpose of rotor pitch changes is to vary lift force and to trim the craft to level or slanting attitudes in flight. Extending radially across the duct below the blades are adjustable counterrotation fins functioning in response to air downwash to prevent rotation of the fuselage. Extending tangentially across the duct below the counterrotation fins are adjustable navigating fins. These are grouped to form four banks of them in quadrature around the duct and are adjustable within their respective banks for directional navigation control. Pneumatic inflated retractable landing pads provide for soft landings of the craft and for flotation on water.

11 Claims, 13 Drawing Figures



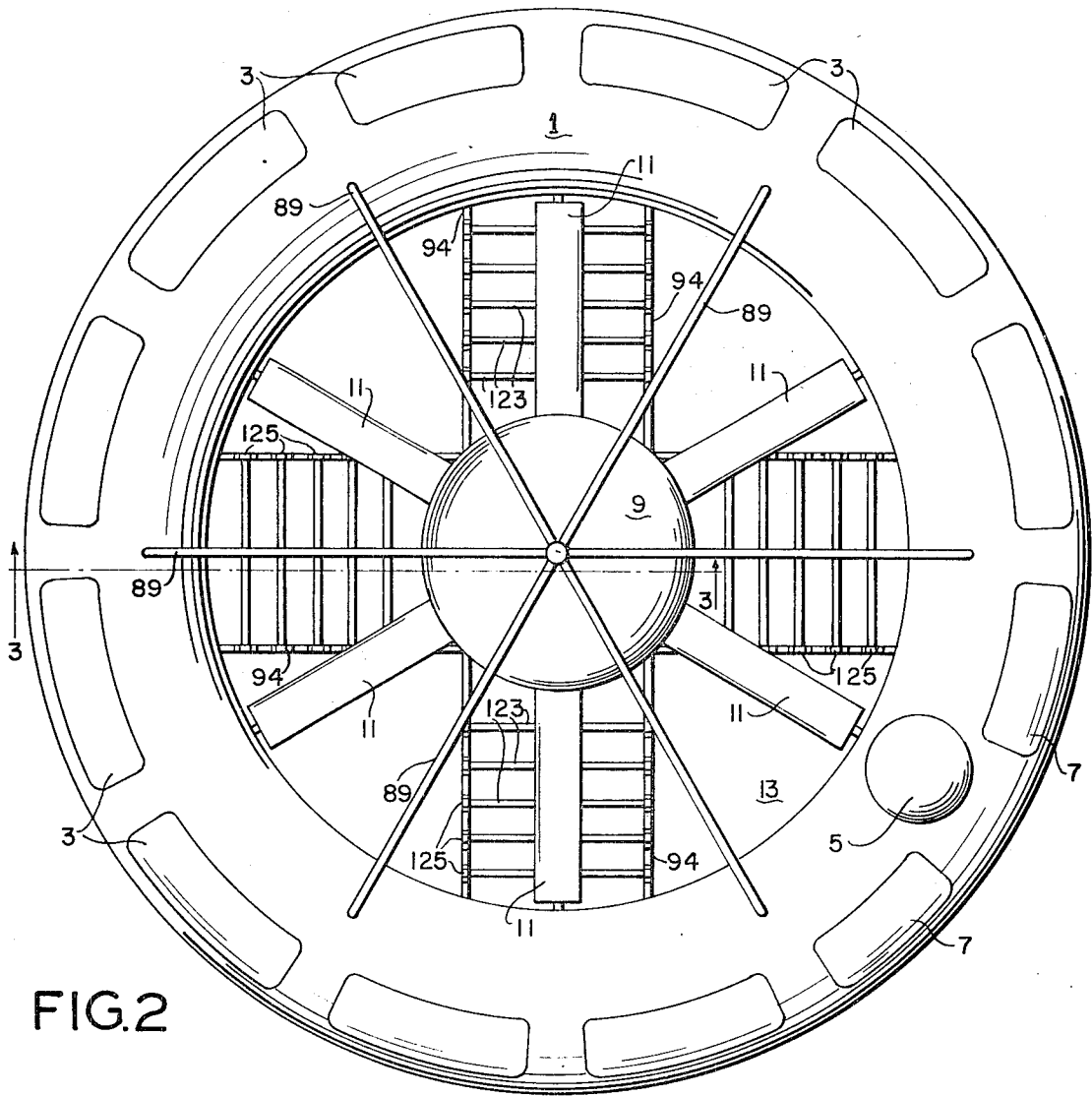


FIG. 2

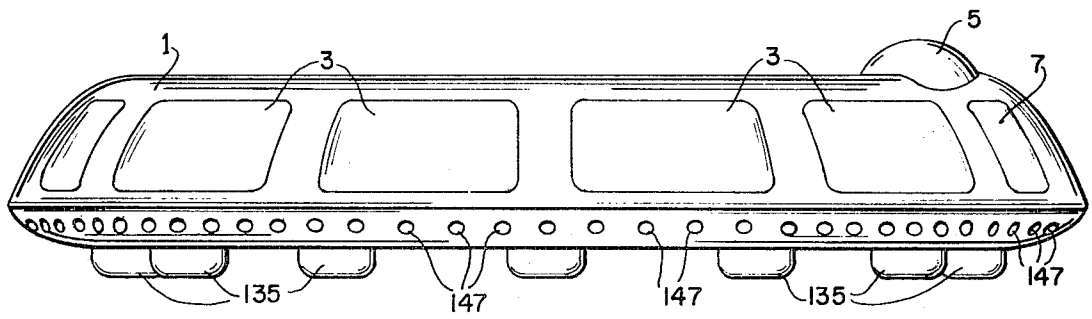


FIG. 1

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FIG.12

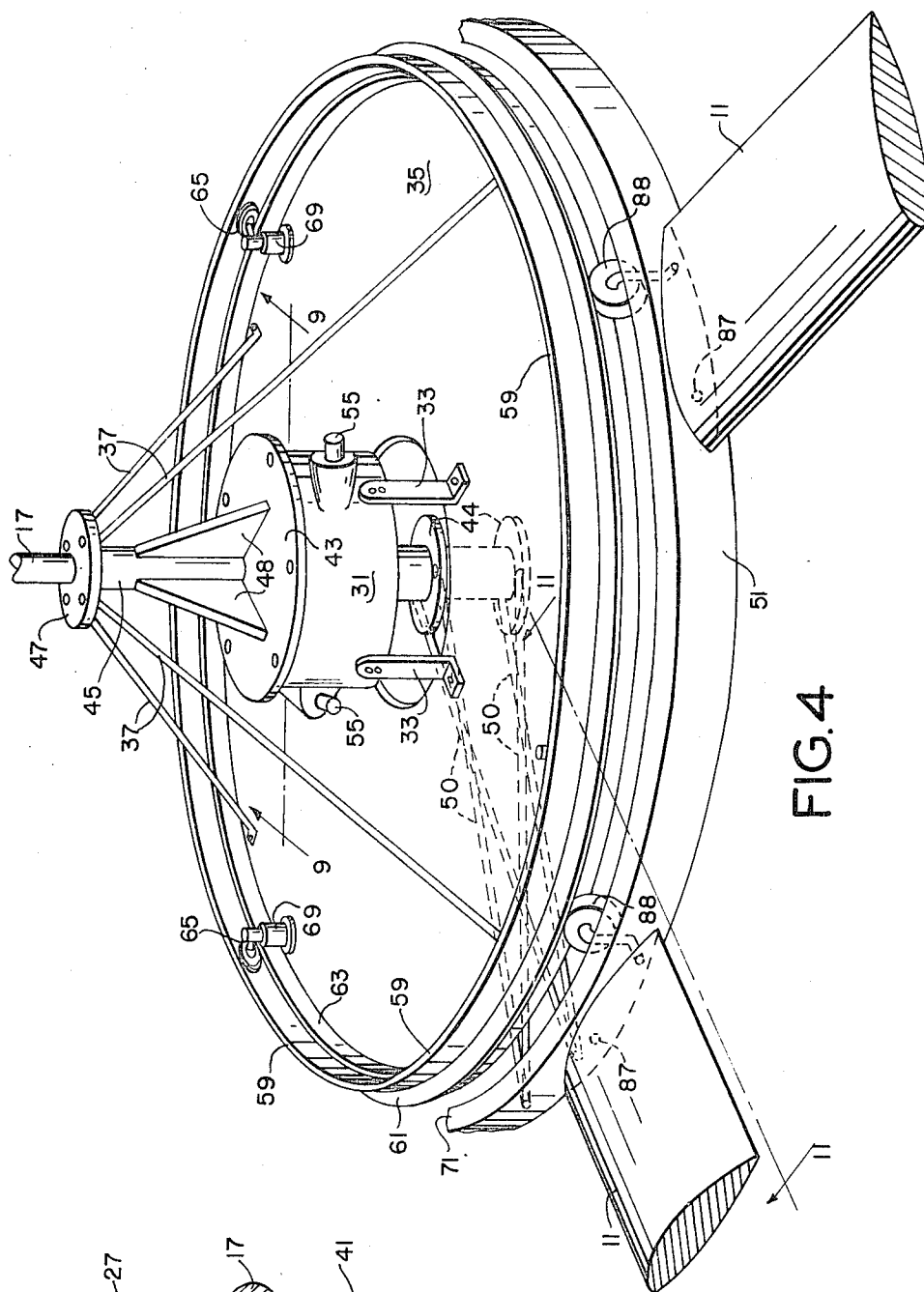
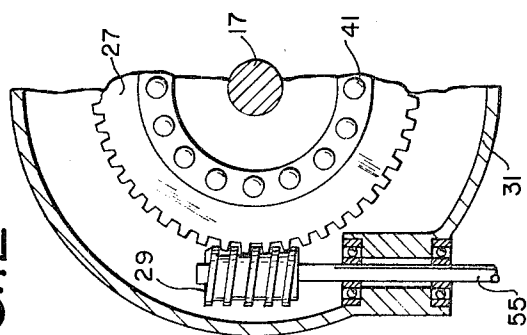


FIG.4

FIG. 5

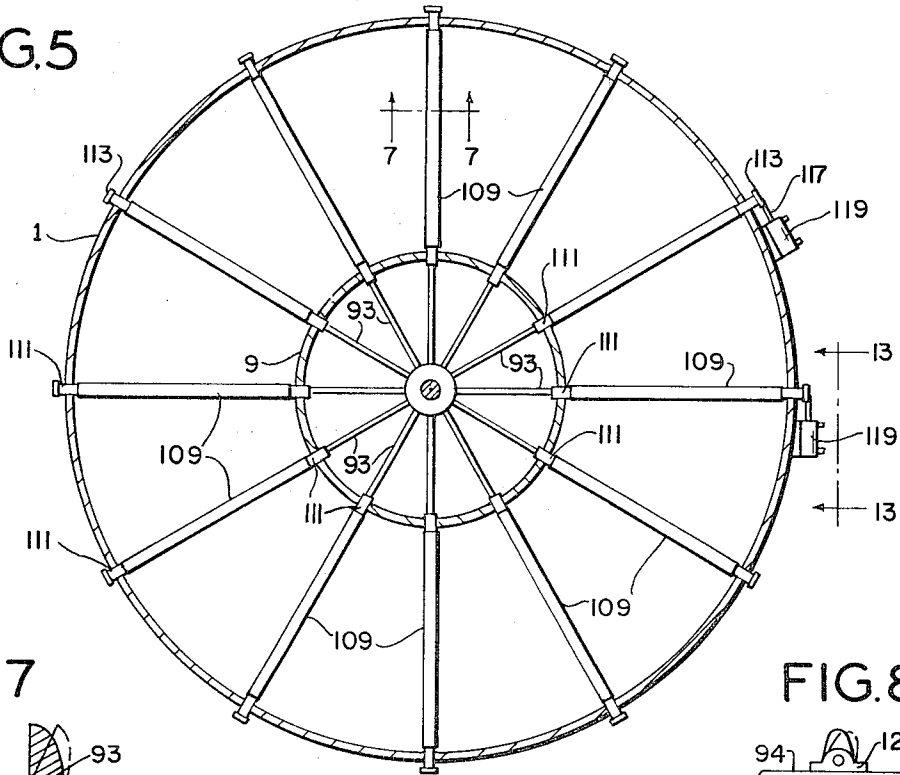


FIG. 7

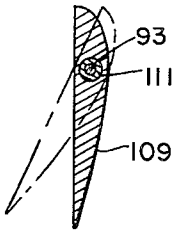


FIG. 8

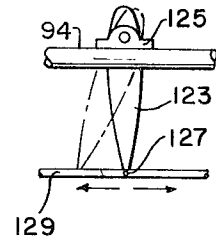
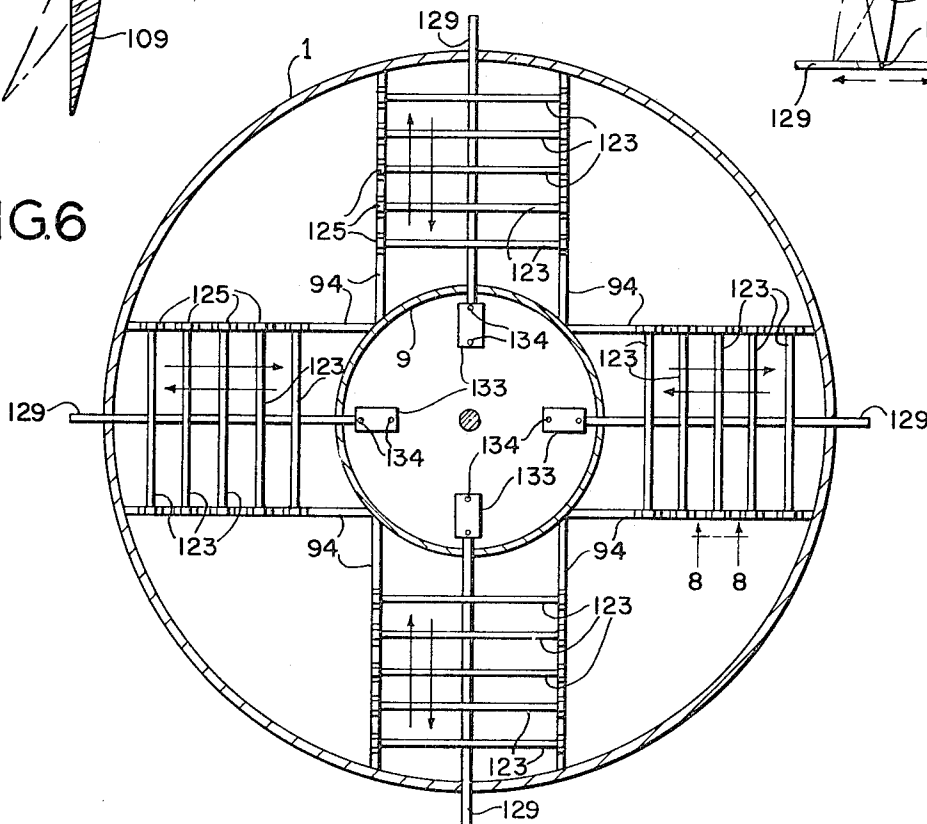


FIG. 6



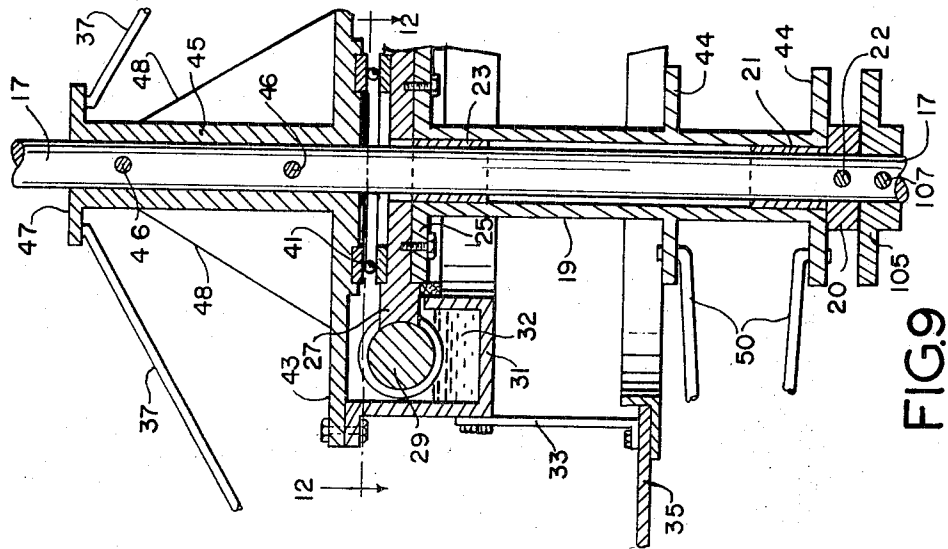


FIG. 9

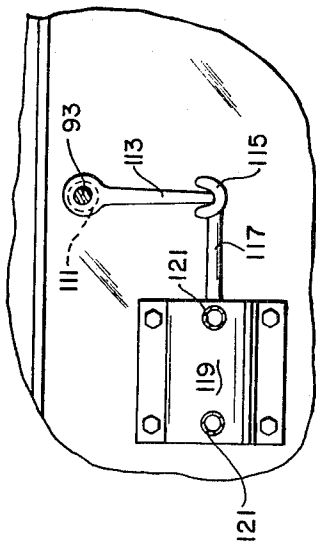


FIG. 13

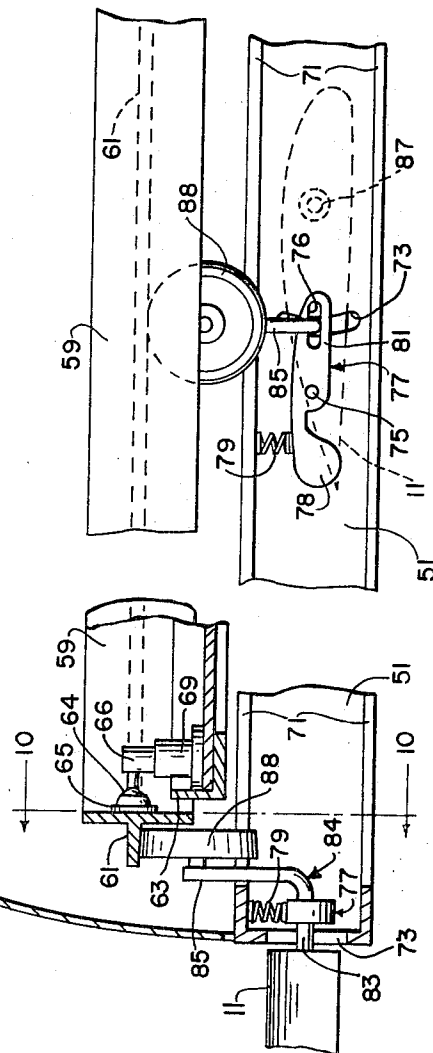


FIG. 10

FIG. 11

AMPHIBIOUS HELICOPTER-TYPE AIRCRAFT

BACKGROUND OF THE INVENTION

The field of my invention is that of vertical takeoff aircraft. There are at present known two general types of these: (1) the conventional helicopter which for counterrotation employs oppositely turning lift blades or a tail propeller driven from the power plant which also drives the lift blades; and (2) wing-type craft having sidewise pivoted wing-and-propulsion means which may be angled for vertical lift thrust and forward navigating thrust.

SUMMARY OF THE INVENTION

An annular exteriorly streamlined toroidal housing surrounds a central dome-shaped circular housing to form an annular vortex space of downwardly converging venturi shape through which a vortex of air is drawn by variable pitch rotor blades extending radially across said vortex space. The venturi contour adds to the speed of the downwash of air induced by the blades. And the venturi effect adds lift to the toroidal and dome surface. The tips of the blades are surrounded by the toroidal housing and are thus protected against undesirable horizontal flow of air across them such as would otherwise occur by transverse movement of the craft when cruising. By use of the swash ring, trim of the craft is easily maintained. These features provide not only simple means for navigation and trimming, but also efficient lift thrust by eliminating reaction thereto such as is caused by downwash of air against the fuselage of the craft in the case of conventional helicopters. The form of the craft also substantially isolates noise and vibration of the prime mover apparatus in the central housing from passengers in the toroidal housing spaced therefrom. The use of inflated retractible landing pads makes the craft amphibious without causing unwanted drag when airborne. Air drag is reduced by providing for flow of air through a lower part of the toroidal housing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation of my new craft;

FIG. 2 is a top plan view;

FIG. 3 is a partial vertical section taken on line 3—3 of FIG. 2;

FIG. 4 is a fragmentary three-dimensional view of certain driving and control parts;

FIG. 5 is a horizontal section taken on line 5—5 of FIG. 3;

FIG. 6 is a horizontal section taken on line 6—6 of FIG. 3, the section being extended;

FIG. 7 is an enlarged detail section taken on line 7—7 of FIG. 5;

FIG. 8 is an enlarged detail section taken on line 8—8 of FIG. 6;

FIG. 9 is a vertical section taken on line 9—9 of FIG. 4;

FIG. 10 is a vertical section taken on line 10—10 of FIG. 11;

FIG. 11 is a vertical section taken on line 11—11 of FIG. 4;

FIG. 12 is a cross section taken on line 12—12 of FIG. 9; and

FIG. 13 is a fragmentary view across line 13—13 of FIG. 5.

Similar reference characters indicate corresponding parts throughout the several views of the drawings. The drawings are chiefly diagrammatic and are to various scales so as most clearly to illustrate the principles upon which the invention is operative. Details of electrical, hydraulic and pneumatic control circuitry are omitted as being within the skill of the art.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now more particularly to FIGS. 1—3, there is shown at numeral 1 an annular housing of toroidal form which provides space for passengers or other payload on a circular floor or platform 2 therein. The platform divides the toroid into upper and lower compartments 1A and 1B, the former being for payload and the latter to form an air duct, as will appear. Numeral 3 indicates windows in the upper compartment

1A of housing 1, and 5 a transparent canopy type of window for the pilot who sits at a suitable instrument control panel beneath it but not shown. Doors are indicated at 7.

Centered within and spacedly surrounded by the toroidal housing 1 is a central circular housing 9 in the form of a dome. The combination of the toroidal housing 1 and the central dome 9 forms a downwardly converging annular venturi-shaped space 13 for acceleration of any downwash of air brought about by rotation of six cantilever rotor blades 11 which extend radially from a ring 51, the latter forming part of the apparatus in the dome 9 to be described. The blades have cross sections forming airfoils (see FIG. 4). Other numbers of them may be used.

The central housing 9 has a bottom 15 (FIG. 3) to which is centrally affixed a vertical support in the form of a post 17 (see FIG. 9) which extends up through the top of the dome 9 as shown at 18. A rotatable hub 19 is carried by bearings 21 and 23 on post 17. A collar 20 affixed to post 17 by a pin 22 supports the hub 19. Fastened to an upper flange 25 of hub 19 is a worm wheel 27, driven by several worms, one of which is shown at 29 in FIG. 9. The resulting worm-and-wheel drive (27,29) is not limited to a single one, for as illustrated in FIG. 4 there may be several (three in the present example) driving worms 29 around the rim of the worm wheel 27. FIG. 4 illustrates three worm-and-wheel drives, one being hidden. Other numbers of such drives (27,29) may be used. Each worm 29 lies within an annular gearbox 31 wherein it meshes with its respective worm wheel 27. The box 31 forms an annular oil sump for oil 32. A thrust bearing 41 is provided between the gear 27 and an upper cover 43 of the box 31.

The gearbox 31 is supported by suitable means such as standards 33 fastened to a floor plate 35. Plate 35 is marginally supported by struts 37. A sleeve 45 extends upward from the gearbox cover 43 and is fastened to the post 17 (see cross pins 46). It terminates in a flange 47 to which the upper ends of the struts 37 are fastened so that the floor plate is marginally supported (see FIGS. 4 and 9). Webs 48 stiffen the cover and sleeve assembly (43,45). Thus the housing 9, post 17, gearbox 31, floor plate 35 and struts 37 form a rigid assembly.

At the lower end of the hub 19 are two flanges 44 from which extend angled spokes 50. These are in the form of crossed rods extending outward to connections with a rim 51 to which the blades 11 are pivoted. In FIG. 4 in order to avoid unduly complicating the drawing, there is indicated only a single complete set of four of a greater number of sets of such spokes. As many are employed as may be necessary to provide an adequate support for, and driving connection with, the rotor rim 51 and the blades 11 attached thereto.

A suitable engine 53 supported by the fixed plate 35 is connected to each worm-and-wheel drive (27,29). Such connections are numbered 55 (FIG. 3). Each engine 53 exhausts products of combustion from housing 9 through an exhaust pipe as shown at 57, for example. Thus the engines through the gear trains (29,27) drive the hub 19 which through spokes 50 drive the ring 51 and pivoted blades 11 around space 13 and relatively to the housings 1 and 9.

Means for variously changing the angles of attack of the pivoted blades 11 are shown in FIGS. 3, 4, 10 and 11. At numeral 59 is shown a swash ring which has an outer radial flange forming in effect a cam 61. The ring 59 surrounds an upwardly directed fence 63 on the periphery of the fixed plate 35. Three support brackets 65 are provided for the swash ring, one being shown in FIG. 11 and two of them being shown on FIG. 4. The third one is hidden at the front of FIG. 4. Each support or bracket 65 through a universal joint connects with a piston rod 66 of a piston (not shown) in a double-acting hydraulic control cylinder 69 having suitable control ports (not shown). Cylinders 69 are rigidly mounted on fixed plate 35. By means of a suitably controlled system of hydraulic connections (not shown) with the control ports of cylinders 69, the brackets 65 may be hydraulically raised and lowered either simultaneously, individually or in pairs. By this means, the swash ring 59 and cam 61 may be lifted or lowered and

held while level. Or they may be tilted and held in any desired angular aspect with respect to ring 51. When simply raised or lowered while level, the angles of attack of all blades may be varied simultaneously from 0° for zero lift to a maximum. When the cam is tilted more or less from any level, each blade 11 in one-half of its circuit of revolution increases angularly to a maximum angle of attack and in the other half decreases to a minimum angle of attack. In the former case, vertical lifting thrust may be varied from zero to maximum. In the latter case, at any lift thrust from zero to maximum, the vortex thrust may be angularly modified at any elevation of the swash ring 59 above the floor plate 35. Apparatus for bringing this about follows.

The rotor rim 51 is shaped with inner flanges 71 and has six arcuate openings 73 and six pivots 87, one for each blade 11. Pivoted at 75 to the inside of the rim 51 near each opening 73 is a rocker arm 77 biased at one end 78 by a spring 79 in a direction to raise the other end 81. A slot 76 in this other end 81 receives therethrough one arm 83 of an angle bracket 84 having a second arm 85. Arm 83 forms a rigid connection with the trailing portion of the blade 11 with which it is connected. It extends through opening 73 and slot 76. Thus it and the rear end of the blade 11 may be moved up and down around the center 87. The described linkages are simple.

At the upper end of the vertical arm 85 is attached a conical follower roller 88 which through the biasing action of spring 79 on rocker arm 77 engages the flange 61 of the swash ring 59. The underside of cam 61 is also conical to provide rolling contact with each roller 88 when the cam is horizontal. If the swash ring is hydraulically adjusted to be in a plane parallel to the rotor 51, then, as above remarked, the angles of attack of all blades in making a complete circuit will remain equal. By simultaneously lifting or lowering all of the brackets 67 the attack angles of all of the blades 11 may be simultaneously varied in equal amounts so as to control lift thrust, as stated.

When the swash ring is tilted through suitable hydraulic control actions on the pistons in the hydraulic cylinders 69, the follower rollers 88 ride opposite high and low parts of the flange 61, in which aspect the flange is in the nature of a cam. When engaging a low part of the cam 61 the angle of attack of the corresponding blade 11 will be increased and when engaging the opposite high part, the angle of attack will be decreased. Since through suitable hydraulic circuitry the slope of the swash ring may be adjusted from cylinders 69 to be along an axis having any desired angular position relative to housings 1 and 9, reactive moments may be established offsetting any and all moments tending to tilt the craft from level flight, as by shift of payload, external air gusts or the like. Thus the craft is capable of being trimmed for horizontal flight in any direction even when it turns at lower speeds. If desired, this same mechanism can be used to trim the craft to any non-level attitude, so that it may, for example, be caused to bank in a turn or tilt for any other purpose.

As shown in FIG. 3, the annular toroidal housing 1 and the housing dome 9 are rigidly held together to form a fuselage by suitable members 89, 91, 93 and parallel bars 94. The latter are paired in quadrature (FIGS. 2 and 6). The upper members 89 which are struts extend from a rigid fastening 95 on the top of the post 17 to a rigid fastening 97 on a rigid hydraulic cylinder 99 in housing 1. This cylinder 99 extends from the top of the housing 1 to and through the floor 2 therein, being held by braces 91 which extend to fastening means on the inside wall of toroid 1. The members 93 extend from a connection at 103 with cylinder 99 to a collar 105 pinned at 107 to the post 17. These members 93 are circular for rotatably supporting radially disposed counterrotation fins 109 below the rotor blades 11. The fins 109 are affixed to sleeves 111 which rotate on the struts 93 respectively.

Each sleeve 111 is provided with a control arm 113 (see FIGS. 3, 5 and 13). Not all are shown on FIG. 5 but it will be understood that there is one arm for each sleeve. Each arm 113 terminates in a clevis 115 at the end of a rod 117 connected to a piston (not shown) of a double-acting hydraulic

control cylinder 119. It has control ports 121 for hydraulic circuitry (not shown). By this means each of the fins 109 may be angled in the same amount in a given direction to be impinged upon by the downwash of vortex air (FIG. 7). The angle employed is such as to provide a balancing torque on the fuselage against the reactive torque of the engine on the fuselage in driving the rotor blades 11. Thus the fins 109 may be set to prevent backward spin of the fuselage (housings 1 and 9, etc.) as the rotor blades 11 are driven. In short, the fuselage is thus stabilized against turning around an axis extending through the center of post 17.

Below the counterrotation fins 109 are located the pairs of parallel bars 94. The pairs are arranged in quadrature across the space 13 between the housings 1 and 9. One of their functions has been mentioned, namely, they serve as bracing between these housings. However, their main function is to carry ladder banks of horizontal motion fins 123 pivoted on and extending between the members of each pair. The pivots are in the form of bearings 125 on the braces 94 (see FIGS. 2, 3, 6 and 8). Articulated as at 127 to the lower end of each fin 123 in each bank is a control rod 129. This rod extends between the housings 1 and 9, being supported in suitable sleeve bearings 131 in each.

The rods, where they terminate within the housings 9, are connected to pistons of hydraulic control cylinders 133 having connections at 134 for suitable hydraulic control circuitry for shifting the angles of the fins 123 back and forth across vertical positions thereof. The controls are arranged such that the angular motions of the ladders of fins in opposite banks are the same in one direction or the opposite. When the fins are vertical in all banks, there will be no sidewise thrust on the fuselage, as when lifting vertically on takeoff. When proper elevation is attained, the angles of the fins in the fin ladders of either or both oppositely paired ladder banks may be set at equal angles for motion in one direction or the opposite. The darts on FIG. 6 illustrate this. If it is desired to cruise in an intermediate direction not along the axes of either the ladders of fins 123, then the ladder banks of fins 123 in each of the pairs may be appropriately adjusted to give any directional force according to the laws of vector addition, resulting in the direction of motion desired while cruising, with or without change in lift.

In FIGS. 1 and 3, landing gear is illustrated. This comprises gastight resilient air- or like-inflated landing pads 135, each of which is mounted on supporting plates 137, the latter being attached to a piston rod 139. The attachment includes braces 141. The piston rod 139 carries a piston (not shown) in the hydraulic cylinder 99. By appropriate hydraulic circuitry to connections leading into cylinder 99, the landing pads 135 may be extended from or retracted into enclosed spaces 145 provided for them below the floor 2 of the housing 1.

In order to minimize drag on the craft when cruising, the annular compartment 1B under floor 2 is provided with openings 147. Thus air enters whatever openings are in leading positions to receive air, flows around compartment 1B, and leaves by trailing openings to reduce the partial vacuum formed behind the craft in motion.

Mention has been made above of the use of suitable conventional hydraulic circuitry for the various pistons in the double-acting hydraulic cylinders. It is to be understood that these will include the conventional connections, valves, electric relays, switches, etc., for operating them and for control of the power units 53 in housing 9 as known in the art. Although the control panels and pilot are in the annular housing 1, connections may be made across the vortex space by making hollow the various crossmembers such as 89, 93 and 94, so as to carry the circuitry and if necessary by adding other cross conduits for the purpose. Thus further details of the hydraulic circuitry, electrical circuitry for hydraulic valve controls, engine operation, etc., are not shown because a detailed description of them would not serve further to clarify the essence of the invention to those skilled in the art.

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

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:
an annular housing surrounding a central circular housing to form an annular air duct, and means for substantially rigidly joining said housings extending across said duct to form a fuselage;
said central housing having therein a center support and a hub rotatable relative to said support, means connecting said hub and a rotatable ring disposed around the central housing;
rotor blades, pivots therefor on said ring, said blades extending from said ring towards the annular housing and across said duct;
power means in the central housing for rotating said hub and ring to drive said blades around the duct, said power means being carried by a platform affixed to said support;
a swash ring forming a tilting cam within the circular housing and means carried on said platform for tilting said cam in any of various directions relative to the fuselage and for changing the elevation of the cam relative to said ring at any or no tilt while preventing rotation of the ring relative to the platform;
followers engageable with said cam at any tilt and elevation thereof, linkages connecting said rotor blades with said followers for engaging the followers with said cam thereby pivoting the blades on said ring, on the one hand to change their angles of air attack of the blades simultaneously and equally by changing the elevation of the cam, and on the other hand upon tilting the cam at any of its elevations changing the angles of attack of each blade from a maximum to a minimum during one revolution thereof around said duct;
counterrotation fins, pivots therefor on the fuselage, said counterrotation fins extending substantially radially across said space below said rotor blades for impingement thereon of downwash of air engendered by movements of said blades around said duct, and means for adjusting the angles of said counterrotation fins around their pivots to prevent rotation of said housings in response to driving reactions from said power means;
horizontal motion fins, pivots therefor on the fuselage, said horizontal motion fins extending tangentially relatively to said annular duct and below the counterrotation fins, said horizontal fins being arranged in quadrature around the duct; and
means for controlling the angular position of said horizontal motion fins around their pivots for modifying the axial flow and thrust of air through said duct for navigating the craft.
2. An aircraft according to claim 1, wherein said annular housing is of toroidal form and said circular housing is of a dome shape to provide a downwardly tapering annular venturi-shaped air duct for said rotor blades.
3. An aircraft according to claim 1, wherein each of said linkages comprises a rigid extension from a trailing portion of a blade, each extension carrying a follower which is in the form of a roller, a rocker pivoted to the ring and articulated with said extension, and means biasing said rocker to force the follower into contact with said cam which is formed by a flange on the swash ring.
4. An aircraft according to claim 1, wherein the annular housing contains a floor dividing it horizontally into upper and lower annular compartments, and a series of ports extending around the lower compartment permitting flow of outside air through said lower compartment from leading to trailing portions thereof to reduce air drag on the craft while navigating.

5. An aircraft according to claim 4, including resilient landing pads extendable and retractible relative to the annular housing.

6. An aircraft according to claim 5, including recess means in the lower compartment of said annular housing for receiving the pads when retracted.

7. An aircraft according to claim 6, wherein said pads are constructed for flotation on water.

8. An aircraft according to claim 6, wherein said landing pads comprise resilient gas-inflated means for flotation of the craft on water, a piston rod extending from each inflated means and into a hydraulic cylinder in the annular housing for control of extension and retraction of said pads.

9. An aircraft comprising:

a toroidal housing spacedly surrounding a central circular dome forming a central housing to form an annular downwardly and inwardly tapering air-vortex duct, support means for substantially rigidly joining said housings extending across said duct to form a fuselage, said means including four pairs of parallel bars, the pairs being arranged in quadrature whereby each pair has an opposite pair across the duct;

said central housing having therein a support and a hub rotatable relative to said support, means connecting said hub and a rotatable ring disposed around the central housing;

rotor blades, pivots therefor on said ring for changing their angles of air attack, said blades extending from said ring towards but short of the toroidal housing and across said duct;

a prime mover in the central housing for rotating said hub and ring to drive said blades around the duct, said prime mover being carried by a platform affixed to said support;

a swash ring forming a tilting cam within the circular housing and means carried on said platform for tilting said cam in any of various directions relative to the fuselage and for changing the elevation of the cam relative to said ring at any of no tilt while preventing rotation of the ring relative to the platform;

followers engageable with said cam at any tilt and elevation thereof, resiliently biased linkages connecting said rotor blades with said followers for engaging the followers with said cam thereby pivoting the blades on said ring, on the one hand to change their angles of air attack of the blades simultaneously and equally by changing the elevation of the cam, and on the other hand upon tilting the cam at any of its elevations changing the angles of attack of each blade from a maximum to a minimum during one revolution thereof around said duct;

counterrotation fins, pivots therefor on the fuselage, said counterrotation fins extending substantially radially across said space below said rotor blades for impingement thereon of downwash of air engendered by movements of said blades around said duct, and means for adjusting the angles of said counterrotation fins around their pivots to prevent rotation of said housings in response to driving reactions from said power means;

ladder banks of horizontal motion fins, pivots therefor on said four pairs of bars respectively, whereby said horizontal motion fins are caused to extend tangentially relatively to said duct and below the counterrotation fins, said ladder banks of horizontal motion fins being arranged in quadrature around the duct; and

means for equally and reversely changing the angular positions in one or both pairs of opposite banks of the horizontal motion fins around their pivots with reactions to the air vortex to provide thrusts on the fuselage along one or both of two perpendicular axes lying in the general plane thereof.

10. An aircraft according to claim 9, wherein the toroidal housing contains means therein forming an annular air duct and a ring of airports in said toroidal housing extending entirely around the same and communicating with said duct.

11. An aircraft according to claim 10, including a ring of resilient and flotation landing pads, means for extending and retracting said pads, said air duct being provided with a ring of enclosed spaces for reception of said pads when retracted.

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