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(71)(72) Applicant and Inventor: McDONNELL, William, R. [US/US]; 54 Roan Lane, St. Louis, MO 63124 (US).

(74) Agents: HIND, Ronald, W. et al.; Cohn, Powell & Hind, P.C., Suite 103, 7700 Clayton Road, St. Louis, MO 63117 (US).

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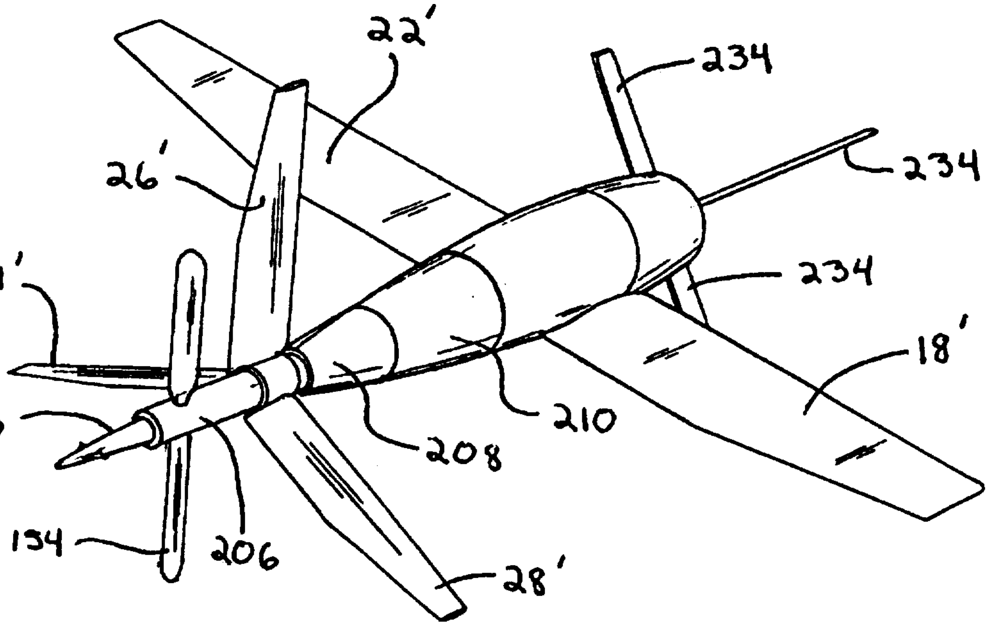

(57) Abstract

An aircraft (12) adapted for flight in helicopter mode with its longitudinal axis oriented generally vertically and in airplane mode with its longitudinal axis oriented generally horizontally is provided with the capability of launching and landing with the tail end (202) directed skyward. The invention also includes improvements to the controllability and efficiency of aircraft (12) in helicopter mode provided by the stabilizer wings (24, 26, 28) and relative rotation of the fuselage section (14) about the aircract's longitudinal axis. The aircraft (12) may have an elongate boom (83) for engagement with a base structure (81). The base structure (81) may be attached to a building, a trailer transporter, a ship or some other structure.

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LANDING AND TAKE-OFF ASSEMBLY FOR VERTICAL TAKE-OFF AND LANDING AND HORIZONTAL FLIGHT AIRCRAFT

FIELD OF THE INVENTION

The present invention relates to the field of aircraft capable of converting between vertical flight, or helicopter mode flight, and horizontal flight, or airplane mode flight, where the rotors are employed as both helicopter rotor blades in vertical flight and as a fixed wing in horizontal flight. The invention also relates to docking structures for aircraft which are capable of operating in vertical flight.

BACKGROUND OF THE INVENTION

This application is a continuation in part of U.S. Patent Application Serial Number 08/680,000, filed July 15, 1996. Aircraft capable of taking off vertically in helicopter mode flight with the fuselage oriented vertically and then converting to horizontal flight in airplane mode with the fuselage oriented horizontally are known in the art. However, these aircraft have low stability in helicopter mode because the stabilizing wings are fixed and positioned below the center of gravity and in the rotor downwash. These aircraft also have high drag in helicopter translational flight mode because the aerodynamic surfaces are fixed and must be dragged sideways through the air.

Furthermore, conventional vertical attitude take off and landing and horizontal flight aircraft require a very wide based, heavy landing gear because the aircraft's center of gravity is relatively high off the ground due to the tail sitter configuration. These aircraft require a wide landing gear to keep them from overturning while landing or sitting on the ground and to reduce helicopter ground resonance or dynamic roll-over problems. This problem can be especially severe when trying to land on the deck of a ship which is pitching, rolling and heaving.

To keep the center of gravity of the aircraft as low as possible, shorter, fatter fuselages have been used. However, these configurations can increase the aircraft's weight and drag.

Most prior art aircraft lift vertically with the front fuselage directed skyward. Additionally, there is an aircraft in the prior art, U.S. Pat. No. 3,142,455, that takes off with the rear fuselage directed skyward. However, this aircraft has unstable landing gear and a fixed main wing in the rotor downwash which makes helicopter translational flight and landings with winds more difficult. Stability during conversions between airplane and helicopter mode would also be poor.

Additionally, these conventional aircraft do not have acceptable stabilizing wing designs that would cause the fuselage to weathervane into the wind in helicopter mode flight which is desirable for yaw stability and controlling the alignment of the aircraft in the direction of travel. Prior art aircraft in this category usually have a symmetrical stabilizing wing arrangement around the longitudinal axis of rotation.

The present invention overcomes these and other disadvantages in a manner not revealed in the known prior art. Applicant is aware of the following U.S. Patents, the disclosures of which are incorporated by reference herein:

U.S. Patent No. 2,043,704
U.S. Patent No. 2,084,464
U.S. Patent No. 2,328,786
U.S. Patent No. 2,382,460
U.S. Patent No. 2,387,762
U.S. Patent No. 2,444,781
U.S. Patent No. 2,479,125
U.S. Patent No. 2,866,608
U.S. Patent No. 3,116,040
U.S. Patent No. 3,142,455
U.S. Patent No. 3,844,431
U.S. Patent No. 4,890,802
U.S. Patent No. 5,516,060

SUMMARY OF THE INVENTION

The present invention provides improvements in the take off and landing operation of vertical take off and landing and horizontal flight aircraft in powered flight. Applicant's invention engages a ground based beam at a point on the fuselage above the rotor blades. The aircraft can be configured as a jet engine, rocket engine or propeller driven aircraft. Further, the aircraft can be configured as an a glider.

It is an object of the invention to provide a method of selectively launching and landing an aircraft adapted for flight in a helicopter mode and in a conventional airplane mode, the method including hovering the aircraft in a tail skyward position; positioning the aircraft adjacent a base docking structure; selectively engaging the base docking structure with a boom portion of the aircraft; attaching the base docking structure to the boom of the aircraft; and storing the aircraft on the base docking structure. Or, when multiple aircraft are using one base docking structure, then transferring the aircraft for storage to a support hanging from the hangar ceiling and suspending the aircraft by a loop on the boom.

It is a further object of the invention to provide a pivotable docking structure for shock absorption as is normally provided by aircraft landing gear.

It is an object of the invention to provide the step of rotating the base docking structure for selective engagement of the base docking structure with the boom.

It is a further object of the invention to provide the step of rotating the base docking structure with the attached aircraft to a storing position.

It is an object of the invention to provide the steps of launching the aircraft from the base docking structure by disengaging the latching means attached to the boom of the aircraft and flying the aircraft away from the base docking structure.

It is a further object of the invention to provide the step of rotating the base docking structure away from the boom.

It is an object of this invention to provide an aircraft capable of taking off and landing with the fuselage oriented vertically and the stabilizing wings of the aircraft pointed skyward.

It is a further object of this invention to provide an aircraft having a fuselage that connects with a support base for suspending the aircraft.

It is another object of this invention to provide an aircraft that can take off and land efficiently on a ship or on a ground transporter.

It is an object of this invention to provide an aircraft that can carry a passenger or a payload and be operated remotely as a drone.

It is an additional object of the invention to provide an aircraft having stabilizer wings configured to cause the non-rotating portion of the fuselage in helicopter mode to weathervane about its longitudinal axis, thus providing directional or yaw stability.

It is an object of the invention to rotate the stabilizing wings, or large control surfaces on the stabilizing wings, in line with the airflow in helicopter mode to reduce drag.

It is an object of the invention to provide an aircraft having a front fuselage portion and a rear fuselage portion, the portions having a common longitudinal axis, the aircraft being adapted for flight in a helicopter mode with the longitudinal axis oriented generally vertically and in an airplane mode with the longitudinal axis oriented generally horizontally, the aircraft comprising an elongate boom extending longitudinally from the fuselage for engagement with a base docking structure.

It is an object of the invention to provide an aircraft which has a simpler and more stable conversion between helicopter mode and airplane mode.

It is an object of the invention to provide an aircraft which uses aft fins which counter-rotate in the helicopter mode to balance the torque created by the rotating lifting wings.

It is a further object of the invention to provide that the aircraft includes a rod disposed within the boom.

It is an additional object of the invention to provide that the aircraft boom has opposed ends and a middle portion, one of the ends having a larger diameter than the middle portion.

It is an object of the invention to provide that the larger diameter of the boom supports the boom when suspended from the base docking structure.

It is a further object of the invention to provide that the aircraft base docking structure is a beam having a latching assembly.

It is also an object of the invention to provide that the latching assembly includes a latching arm pivotally mounted to the beam.

It is an additional object of the invention to provide an aircraft having an end above the rotor and an elongate boom having means for attachment to a base structure with the end above the rotor directed generally skyward.

It is an object of the invention to provide an aircraft having a fuselage with a longitudinal axis, the aircraft being adapted for flight in a helicopter mode with the longitudinal axis oriented generally vertically, and in an airplane mode with the longitudinal axis oriented generally horizontally, the aircraft comprising a plurality of stabilizer wings connected to the fuselage and means for suspending the aircraft disposed on at least one of the stabilizer wings.

It is an object of the invention to provide that the means for suspension includes an elongate member extending outwardly from the stabilizer wings.

It is an object of the invention to provide an aircraft landing and take off assembly for aircraft adapted for flight in a helicopter mode with the longitudinal axis oriented generally vertically and in an airplane mode with the longitudinal axis oriented generally horizontally, the assembly comprising a boom and a structural base having attachment means for engagement of the boom.

It is a further object of the invention to provide that the attachment means includes a latching arm pivotally connected to a beam.

It is also an object of the invention to provide that the beam includes means for disengaging the boom.

It is an object of the invention to provide that the means for disengaging the boom includes an actuator for moving the latching arm in and out of engagement with the boom.

The aircraft and the launching and landing assembly of the invention is inexpensive to manufacture, simple to use and efficient in operation. Further objects and features of the present invention may be obtained by reference to the description of the preferred embodiments of the invention and in the drawing figures.

DESCRIPTION OF THE DRAWINGS:

FIG. 1 is a perspective view of one embodiment of the aircraft in horizontal airplane mode flight;

FIG. 2 is a side elevational view of the aircraft in vertical flight;

FIG. 3 is a perspective view of the aircraft attached to the base docking structure;

FIG. 4 is an alternative arrangement of the stabilizer wings;

FIG. 5 is a top plan view of the aircraft approaching the base docking structure;

FIG. 6 is a partial cross-sectional view of the base docking structure;

FIG. 7 is a side phantom view of the attachment arm;

FIG. 8 is a side phantom view of the attachment arm when the cable is tightened;

FIG. 9 is a partial cross-sectional top plan view of the attachment assembly;

FIG. 10 is a partial cross-sectional side view of the attachment assembly;

FIG. 11 is a perspective view of a further embodiment of the invention with the aircraft in horizontal mode flight;

FIG. 12 is a side elevational view of the aircraft shown in FIG. 11 shown in vertical mode;

FIG. 13 is a partial view of the tail mechanism of the aircraft shown in FIG. 11;

FIG. 14 is a perspective view of the main rotor control system of the aircraft of the invention; and

FIG. 15 is a perspective view, in schematic, of an embodiment of the invention operating from a ship landing site.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now by reference numerals to the drawings and first to FIG. 1, it will be understood that the vertical take off and landing and horizontal flight aircraft is generally indicated by 12. The "nose end" of the aircraft is generally indicated by 200 and the "tail end" of the aircraft by 202. The aircraft 12 includes first 14 and second 16 fuselage sections with a pair of rotor blades 18, 22 projecting laterally from the first fuselage section 14. Stabilizer wings 24, 26, 28 project laterally from the second fuselage section 16.

The aircraft 12 may be constructed on a scale to carry a pilot 148 in the second fuselage section 16 or may be unmanned and designed to carry other payloads 148, such as sensors, and be operated remotely as a drone.

As shown in FIG. 2, the first fuselage section 14 has a generally cylindrical configuration with an exterior skin 32 having conventional structural framework (not shown) in its interior to provide rigidity to the fuselage section 14. Some of the major internal component parts, such as the engine 44, transmission 45 and fuel tank 46, of the aircraft are located in the forward first fuselage section 14, The fuel tank 46 is connected to the engine 44 in a manner known in the art to supply fuel to the engine 44. In the preferred embodiment, the fuel tank 46 is located near the aircraft's center of gravity so that the aircraft's center of gravity does not change appreciably as fuel is consumed in flight.

The control connections (not shown) between the first 14 and second 16 fuselage sections that control the engine 44, its fuel supply source 46 and the pitch of the rotor blades 18, 22 are conventional connections that provide continued communication between the two fuselage sections 14, 16 even when the first fuselage section 14 is rotating relative to the second fuselage section 16. These conventional control connections may be provided by a mechanical swash-plate connection between the fuselage sections or by conventional electrical slipping connections between the two sections that enable the sections to rotate relative to each other while providing constant electrical communication.

A rod 38, such as the hollow tube shown in FIG. 2, extends transversely through the interior of the first fuselage section 14. The rod 38 has opposed ends 39, 40 projecting through diametrically opposite sides of the fuselage skin 32. Rotor blades 18, 22 are connected about the ends 39, 40 of rod 38 to permit rotation of the blades.

As can be seen in FIG. 2, the first 14 and second fuselage sections 16 are connected for relative rotation of the sections about the aircraft's longitudinal axis. A shaft 55 is disposed along the longitudinal axis and extends from the tail end 202 of the aircraft through the second fuselage section 16 and into the first fuselage section 14. The first fuselage section 14 is connected to the rod 55 with bearings (not shown) to allow rotation about the longitudinal axis, as is well known in the art. The second fuselage section 16 is integral with a portion of rod 55.

As can be seen in FIG. 1, three stabilizer wings 24, 26, 28 are rotatably mounted to the second fuselage section 16. The wings 24, 26, 28 are configured to provide generally equal spacing between each wing such as at 120^0 intervals as shown. Alternatively, four wings 24, 26, 28, 30 could be spaced at 90^0 intervals as shown in FIG. 4. These balanced configurations stabilize the aircraft in pitch and yaw during aircraft mode flight. In both configurations, stabilizer wing 26 is generally larger, longer or more highly swept than the other wings to better catch the wind in helicopter horizontal flight mode so that it will cause the second fuselage section 16 to rotate about its longitudinal axis until stabilizer wing 26 is pointing away from the relative wind and direction of travel. Stabilizer wing 26 causes the second fuselage section 16 to weathervane and, thus, orients the second fuselage section 16 about the longitudinal axis to align the aircraft in the appropriate direction in helicopter mode. Stabilizer wing 26 also aids the pilot in orienting and controlling the aircraft. Stabilizer wing 26 could be painted a different color than the other wings to allow a remote pilot to determine the direction of the aft fuselage 16 and, therefore, orient the aircraft 12 about its longitudinal axis. It will be recognized that the stabilizer wings 24, 26, 28 could be of the same design if the entire assembly is located aft of the longitudinal axis of rotation in helicopter mode.

Stabilizing wings 24 and 28 may be folded aft to the dashed position shown in FIG. 4 by actuators (not shown) if it is desired to reduce drag or pitching moments in helicopter mode flight. By changing the stabilizing wing position to be either fully folded back or partially folded back, the aircraft can trim its helicopter pitching moment and relieve the rotor from having to perform this function.

Alternatively, the stabilizing wings 24 and 28 or conventional control surfaces on the stabilizing wings may be constructed so as to weathervane about their respective lateral axis. Weathervaning of the stabilizing wings assists the aircraft in horizontal flight in helicopter mode. Rods (not shown) are disposed within the stabilizing wings and extend from the wings to the second fuselage section 16. The rods are connected to the second fuselage 16 with bearings (not shown) to permit free rotation, or weathervaning, of the wings about their lateral axis when the aircraft is flying in horizontal helicopter mode. When the aircraft is in airplane mode, an electric powered rotary actuator (not shown) rotates the rods. The rods then rotate the wings in the desired rotational position for airplane mode flight, as known in the art. It is desirable to rotate the stabilizing wings for aircraft having stabilizing wings positioned below the rotor in hover because powerful destabilizing forces will be generated unless a majority of the wing surface area is capable of rotating or weathervaning into the wind. It is beneficial for all configurations if drag or pitching moment reduction in helicopter translational mode is desired.

The aircraft 12 of the invention is capable of both vertical flight in helicopter mode and horizontal flight in airplane mode. Landing and take off of the aircraft 12 is accomplished in helicopter mode, as explained below.

In helicopter mode, aircraft 12 operates in a manner well known in the art. The invention 12 takes off from a position with the tail end 202 skyward and the nose 200 toward the ground, as shown in FIG. 3. Rotor blades 18, 22 are attached to the first fuselage section 14 with the top surface 34 of rotor blade 18 and the underside surface 37 of rotor blade 22 directed skyward, as shown in FIG. 3. Engine 44 provides the torque to power propeller assembly 154 through transmission 45 which in turn provides part of the lift for the aircraft in helicopter mode. The propeller blades are generally positioned perpendicular to the aircraft's longitudinal axis but with leading edges angled upwardly toward the stabilizing wings to operate in a "pusher" propeller manner, as is known in the art. Because the engine 44 and transmission 45 are providing a torque to the propeller assembly 154 they produce an equal and opposite torque to the first fuselage section 14 causing it to rotate together with rotor blades 18, 22 about the longitudinal axis in the opposite direction of rotation as the propeller assembly 154 by the torque exerted on the first fuselage section 14 by the engine 44. Thus, engine 44 powers the propeller assembly 154 and rotates the first fuselage section 14 together with the rotor blades 18, 22 relative to the second fuselage section 16 to operate the aircraft 12 in vertical flight or helicopter mode.

In a jet or rocket powered embodiment, engine 44 can provide torque to turn the rotor blades 18, 22 by routing exhaust gases out through blades 18, 22 and ejecting the gases tangentially to the rotor plane, as is known in the art.

For vertical lift, the pilot increases power to the engine and pulls up on his collective control lever, raising the leading edges 19, 23 of the rotor blades 18, 22 toward the stabilizing wings and raising the leading edges 7, 8 of the variable pitch propeller blades. This causes the aircraft 12 to lift vertically or generally along the aircraft's longitudinal axis. As the aircraft 12 lifts vertically, its altitude can be adjusted by varying the power and raising or lowering the leading edges 19, 23 of the rotor blades 18, 22 and leading edges 7, 8 of the propeller blades. Translational or horizontal helicopter mode flight can be controlled with adjustments to the cyclic pitch of the rotor blades 18, 22 as is done in conventional helicopters. Adjustment of the cyclic pitch is accomplished by altering the rotor blade pitch as a function of the position of the rotor blade about the plane of rotation of the rotor blades. The resulting difference in aerodynamic forces on the opposite sides of the rotor blades 18, 22 causes the aircraft 12 to tilt in a particular direction of movement in the horizontal plane resulting in the aircraft 12 moving in that direction. Horizontal flight of the aircraft 12 is accomplished by tilting the rotor plane circumscribed by the rotation of the rotor blades 18, 22 with cyclic pitch controls, as is done in conventional helicopters. Since the aircraft hovers upside down relative to prior art patent #5,516,060 the vehicle needs a larger range of travel in rotor blade pitch angles with the leading edges 19,23 needing to rotate further up in order to angle the chord line at the leading edges up toward the tail far enough to generate adequate lift for hover and vertical climb. In the prior art patent #5,516,060 the leading edges only rotated far enough to be angled a few degrees toward the tail for the autorotation condition. The rotor blade movements and swash plate movements are also reversed from the prior art vehicle. For example the aircraft of the current invention has the chord line of its rotor blade leading edges 19,23 angled toward the tail in hover and angled away from the tail in autorotation which is exactly reversed from the prior art patent. Also for example in order to raise the vehicle from a hover in helicopter mode and keep the rotor rpm constant the rotor blade leading edges 19,23 are rotated further toward the tail instead of away from the tail as in the prior invention. Also the swash plate for the proposed vehicle in helicopter mode needs to tilt in the opposite direction than that of the prior art relative to the structure in order to obtain the correct direction of travel. For example, if the aircraft were being flown by a remote pilot looking out of a laterally pointing camera (not shown) in payload compartment 148 then not only would the camera be mounted upside down relative to the prior art structure so that the image was upright for the pilot in the proposed invention but the swash plate would have to be tilted in the opposite direction relative to the prior art structure or else the vehicle would start moving away from what the pilot was looking at when the pilot commanded a forward movement. The tilt of the swash plate for lateral cyclic control would also have to be reversed relative to the prior art structure so that the vehicle wouldn't go left relative to the pilots field of view when commanded to go right. Figure 14 shows an isometric view of one possible control system for the proposed aircraft from the same angle as Figure 3. Actuators 240 and 242 in the non-rotating aft fuselage 16 provide forward and aft cyclic control and lateral cyclic control by tilting swash plate 243 in the same manner as a conventional helicopter. Different from most conventional helicopters the non-rotating 244 and rotating 246 portions of the swash plate do not translate up and down for collective pitch control because this function is provided by actuators 256 and 258 in the rotor blade leading edges in order to achieve collective pitch changes of well over 90 degrees. As a result only one control rod 254 is attached to the rotating portion of the swash plate 246 portion to rotate rod 252 for cyclic control through moment arm 250. Collective control is achieved with actuators 256 and 258 which are mounted in and rotate blades 18, 22 in pitch about the lengthwise axis of rod 252 through gears 260, 262 which engage gears 264, 266 which in turn are attached to rod 252. Potentiometers 268 and 270 are mounted in rotor blades 18, 22 and attached to the ends of rod 252 in order to provide a rotor blade position feedback signal to actuators 260, 262 via electrical connecting, not shown. Although other approaches are possible this approach has the advantage of minimizing the space required for the swash plate mechanism, places the weight of actuators 256 and 258 in the rotor blade leading edges 19, 23 where ballast is usually required anyway and makes the logic for roll control and g control in airplane mode a little simpler. As aircraft 12 moves horizontally, stabilizing wing 26 orients the second fuselage section 16 in the direction of flight by rotating the second fuselage section 16 about the longitudinal axis.

Conversion from helicopter mode or vertical flight to airplane mode or horizontal flight is performed at a safe altitude above the ground. Starting from a hover, the thrust of the propeller assembly 154 is converted from reverse thrust used in helicopter flight to forward thrust used in airplane mode flight by rotating the leading edges of the propeller blades down away from the stabilizing wings, as is known in the art for variable pitch propellers. Concurrently, the leading edges 19, 23 of rotor blades 18, 22 are rotated more than 90^0 about rod 38 until they point generally straight downward toward nose end 200. Aerodynamic forces exerted on the rotor blades 18, 22 stop their rotation along with the rotation of the first fuselage section 14. The aircraft is now positioned for airplane mode. At this point, the aircraft 12 is dropping downward. When sufficient airspeed has been obtained, rotor blades 18, 22 are rotated to a position with the leading edges 19, 23 angled to provide positive incidence to generate lift for a "pull up" into conventional horizontal airplane mode flight. After conversion to horizontal flight, the rotor blades 18, 22 have been rotated with the leading edges 19, 23 directed generally along the longitudinal axis to generate lift as aircraft wings instead of helicopter rotor blades. In the jet powered embodiment, forward thrust can be provided by exhausting the combustion gases through aft facing exhausts at the rotor tips, or the exhaust can be re-direct out of the fuselage, as shown in U.S. Patent 5,516,060.

Controlling the aircraft's roll is accomplished by controlling the collective pitch of the rotor blades 18, 22 similar to the method used for controlling the blade pitch in the helicopter or vertical flight mode, as is well known in the art. For example, the roll of the aircraft 12, about its longitudinal axis, can be controlled by increasing the lift on one rotor blade by rotating the blade's leading edge 19 upward and decreasing the lift on the other rotor blade 22 by rotating its leading edge 23 downward. This allows the right and left turning of the aircraft to be accomplished by decreasing the lift of the blade on the side to which a turn is desired and increasing the lift of the blade on the opposite side.

The aircraft's ascent and descent in airplane mode is controlled by altering the pitch of both rotor blades 18, 22 simultaneously to either raise the leading edges 19, 23 of both blades 18, 22 or lower the leading edges 19, 23 of both rotor blades. By controlling the pitch of the rotor blades 18, 22, the aircraft 12 is controlled in horizontal flight while the stabilizer wings 24, 26, 28, 30 stabilize the aircraft 12 in pitch and yaw.

To convert from airplane mode to helicopter mode, the upper surface 34 of rotor blade 18 is directed toward the tail end 202 and the upper surface 36 of rotor blade 22 is directed toward the nose end 200 by rotating the blades 18, 22 about rod 38 approximately 90^0 until the rotor blades 18, 22 are directed generally perpendicular to the aircraft's longitudinal axis. In this position, the leading edges 19, 23 are angled a few degrees away from the tail in an auto-rotation position. This causes the rotor blades 18, 22 to spin the first fuselage section 14 relative to the second fuselage section 16. By rotating the rotor blades 18, 22 approximately 90^0 in opposite directions, the aircraft's horizontal velocity slows and the aircraft 12 begins to drop vertically. When the aircraft is dropping, the stabilizing wings 24, 26, 28, 30 help keep the nose end 200 of the aircraft 12 pointed straight down in the direction of flight. The first fuselage section 14 is rotating relative to the second fuselage section 16. The aircraft is now auto-rotating, with the leading edges 19,23 of the rotor blades 18,22 angled slightly down away from the stabilizing wings. By changing the propeller assembly 154 to the reverse thrust position, by angling the leading edges 19, 23 of the blades 18, 22 upwards toward the tail end 202 to increase lift, and by increasing engine power, the aircraft 12 is again in powered helicopter mode.

DESCRIPTION OF GLIDER VARIANTS

A glider would not have an engine, but would otherwise operate in the same manner, but would in general only angle the leading edges 19 and 22 toward the stabilizing wings to use the kinetic energy in the rotor to temporarily reduce or stop the descent of the aircraft such as to make a soft landing.

A glider could for example be a smart weapon, re-useable or disposable sensor platform with sensors 148 pointing downward and to the sides in helicopter mode, or a means for transporting other devices or cargo. A vehicle could also be powered for airplane mode flight, but be recovered as a glider by auto-rotating in helicopter mode instead of using a parachute. The fuselage could be one piece or could be divided into aft and forward fuselage sections 14 and 16 that are free to rotate relative to each other about the vehicles longitudinal axis if it were desired not to have a portion of the payload rotate with the rotor in helicopter mode or if it were desirable for the sensors to be rotating and scanning the surroundings in airplane mode. For example the stabilizing fins 24, 26, and 28 could be mounted on the aft fuselage 16 slightly angled relative to the longitudinal axis (see aft center fin in Figure 2) so that in airplane mode the aft fuselage 16 would be slowly rotating about its longitudinal axis so that sensor 148 would be continually scanning the surroundings. In helicopter mode the friction in the bearings between fuselage sections 14 and 16 as well as the upflow of air past fins 24, 26 and 28 would assure that the aft fuselage 16 and sensor 148 would continue to rotate and scan the surroundings in helicopter mode as well. Any sensors in the forward fuselage section 14 would be rotating at the speed of the rotor in helicopter mode and scanning the surroundings and would be non-rotating in airplane mode. It should be understood that for powered or unpowered variants of the invention the entire fuselage could rotate with the rotor in helicopter mode or the rotating fuselage portion 14 could be just a small ring surrounding fuselage section 16 where the rotor attaches to the fuselage or there could be any variation in-between. The sensors 148 can also be pointed in a particular radial direction by an electric motor (not shown) at the bearing interface between the two fuselage sections that can rotate and control fuselage section 16 by applying a torque about the longitudinal axis on fuselage section 14.

This vehicle would convert to helicopter mode in the same manner by rotating one wing down approximately 90 degrees and rotating the other wing up approximately 90 degrees so that both wings are approximately at right angles to the fuselage, but with the leading edges angled away from the stabilizing wings which causes the vehicle to start and continue to spin about its lateral axis and point nose down where it stays in this stable attitude. The speed of rotation and descent rate can be changed by changing the pitch on the rotor blades 18,22. A maximum rpm is achieved at a particular pitch angle which is dependent on the weight and design of the vehicle. Incrementally rotating the leading edge of the rotor blades farther away from the stabilizing wings will cause the vehicle to drop faster and rotating the leading edges toward the stabilizing wings will cause the vehicle to drop slower until it reaches its minimum sink rate position.

In this spinning helicopter mode, any sensors in the forward fuselage 14 are also spinning and scanning 360 degrees around the vehicle and sensors 148 may either be spinning, free to float or controlled and pointed in a particular radial direction by the electric motor described earlier. The vehicle can radio back to a receiver what it is seeing or can autonomously attack a target it might find by firing a projectile, flying into the target in helicopter mode or converting back to airplane mode and flying into the target. Conversion back to airplane mode (like the current application) consists of rotating the wings back to their airplane mode position. This causes the vehicle to stop spinning with the nose still pointed down. Because of the incidence on the wing the wing generates lift and the vehicle pulls up into level flight. In order to make a soft vertical landing from helicopter mode, just prior to touchdown, the leading edges of the rotor blades could be rotated toward the stabilizing wings to generate more lift using the kinetic energy in the rotor blades. Alternatively a gas generator 44, such as a jet engine or solid propellant could provide gas out to the tips of the rotor in order to spin or power the rotor as is known in the art as a tip drive rotor.

It will be understood by those familiar with the art that the aircraft 12 would operate in the same manner in helicopter mode, but fly in the opposite direction if designed as a "canard" winged aircraft. For a canard aircraft, a propeller assembly would not reverse thrust from helicopter to airplane mode and the leading edges of the blades 18, 22 would be rotated slightly less than 90^0 in the opposite direction to point toward tail end 202 of the aircraft. Also, for a canard aircraft, the stabilizing wings would consist of either wings 26 and 30 or wings 24 and 28. Additionally, in a canard aircraft, directional stability would be provided by stabilizing wing surfaces oriented generally vertically in airplane mode and mounted in the rear of the fuselage (the nose end 200 in FIG. 2). It will also be understood that as a canard aircraft, the component parts may be named differently, for example, the rear fuselage might be called the forward fuselage.

As can be seen in FIG. 2, the aircraft includes a boom generally indicated by 83, capable of engagement with a support structure such as beam 81. The boom 83 is generally elongate and cylindrical in shape. It may be formed as an extension of the rear fuselage 16. The boom 83 extends generally between the stabilizing wings or tail end 202 and the rear fuselage 16. It can be seen that the boom 83 has an increased diameter as it approaches the stabilizing wings. Since the boom 83 is basically an elongate extension of the rear fuselage 16, its structural framework is similar to that of conventional rear fuselages. As seen in FIG. 1, rod 55 is disposed within the aircraft and extends generally the entire length of boom 83, the rear fuselage 16 and into a portion of the forward fuselage 14. Rod 55 extends along the aircraft's longitudinal axis. Rod 55 increases the strength and stability of boom 83 and is preferably cylindrical and partially integral with the boom portion 83 of rear fuselage 16 for maximum support. For example, the composite structures of the rear fuselage 16 can be built onto the perimeter of rod 55.

The elongate structure of boom 83 can be used for engagement with many different support bases or foundations. For example, the boom 83 can engage structural beam 81, shown in FIGS. 3 and 5. Beam 81 may be connected to various bases or foundations 60, such as a ground based pole, a trailer transporter, a building or a ship. Preferably, beam 81 is well padded to absorb shock and avoid damage to the boom 83 and stabilizer wings 24, 26, 28. As can be seen in FIG. 3, beam 81 is preferably pivotable about its base 60 to further absorb shock. Or shock absorbers of some type (not shown) could be used between the beam and base. For example, a hinged connection of beam 81 to base 60 with a spring and shock absorber could be used to allow vertical deflection of the outer end of the beam, thus cushioning the vertical load as the aircraft's weight is transferred to the beam. Beam 81 may pivot about the base 60 freely or movement may be controlled, such as by a motor, to allow the entire beam 81 to be pivoted to another location such as onto a ship's deck or into a hangar.

The beam 81, shown in FIGS. 3, 5 and 6, is comprised of a latching arm assembly 85 positioned along the length of beam 81 for trapping the aircraft boom

83. Individual latching arms 86 are pivotally connected to rods 87 in a spring-loaded fashion. Rods 87 extend generally perpendicular from beam 81 with latching arm 86 being pivotally mounted about point 88 generally perpendicular to rod 87 and parallel to beam 81. When boom 83 applies pressure to latching arm 86, as shown in FIG. 9, latching arm 86 pivots about point 88 toward beam 81 then traps boom 83 between beam 81 and latching arm 86 in recess 5 when latching arm 86 is urged back to its original position.

As shown in FIGS. 5 and 6, the latching arm assemblies 85 are positioned along the length of beam 81 and are connected by a rope or cable 89 that wraps around the rods 87 to provide a type of pulley system. For example, as seen in FIG. 6, one end of cable 89 is attached to an actuator 90, such as a hydraulic mechanism or solenoid, that can be activated to pull or release the cable 89. Cable 89 extends from actuator 90 around each of the rods 87, to a spring 70 at its other end. The latching arms 86 are kept generally parallel to the beam 81 by spring 70 as shown in FIG. 7. By pulling or tightening the cable 89, rods 87 and, therefore, the latching arm assemblies 85 are rotated approximately 90^0 in a downward motion, as shown in FIG. 8. This causes latching arms 86 to rotate downwards and away from boom 83, thereby releasing the boom. The aircraft 12 can then be flown away from boom 81 or boom 81 can be swung away from aircraft 12 about the base 60. By deactivating the actuator 90, spring 70 urges rods 87 and, therefore, the latching arm assemblies 85 to return to their original extended position for trapping boom 83.

The latching arm assembly 85 may be constructed as shown in FIGS. 9 and 10. The rod 87 is connected to the beam 81 using a fastener 71, which is fastened into rod 87 through beam 81. Flanges 72 may be disposed along the outside of cable 89, which is wrapped around rod 87 in pulley fashion. A hub or shoulder 73 is provided on rod 87 adjacent the beam 81 to fix the position of the latching assembly 85 along the beam 81. A stopping assembly is provided on rod 87 to control the movement of the latching assemblies 85 when the actuator 90 is activated. The stopping assembly may be comprised of an ear 74 and a fixed stop 75, as shown in FIG. 9. The ear 74 may be an elongate member extending from rod 87 that is long enough to engage fixed stop 75 when rod 87 is rotated. The fixed stop 75 may be an elongate member attached to the beam 81 and extending outwardly therefrom for engagement with the ear 74.

As previously stated, latching arm 86 is pivotally mounted to rod 87. This may be accomplished with a pin 88 and bore arrangement where a bore is provided on the end of rod 87 through which a pin 88 pivotally mounts the latching arm 86. A spring 76 is provided within this arrangement, such as the coil spring shown. The spring 76 tends to urge the latching arm 86 outwards, opposite the direction shown in FIG. 9.

The latching arm 86 has opposed sides 78, 79 with a spacer 77 there between. The spacer 77 is positioned adjacent rod 87 when the latching arm 86 is parallel to the beam 81 and prevents the latching arm 86 from rotating further outward as the spring 76 urges the arm 86 outwardly.

Operation of the aircraft's launching and landing will be briefly described with reference to the drawings. As seen in FIG. 5, during landing, aircraft 12 is flown near beam 81 until boom 83 and beam 81 engage or beam 81 may be swung towards boom 83 until the two engage. As shown in FIG. 9, engagement is accomplished from the boom 83 pressing on latching arm 86 and urging it inward, against spring 76 resistance, toward the beam 81. Once the boom 83 clears latching arm 86, the latching arm 86 swings back to its original position where it is stopped by spacer 77. The boom is now positioned in recess 5 between the latching arm 86 and beam 81. Once engaged, the aircraft 12 is lowered until the portion of the boom 83 that widens toward the stabilizer wings 24, 26, 28 rests on beam 81 to support the aircraft 12. It will be understood that stabilizer wings 24, 26, 28 can be used in conjunction with the tail boom 83 to help support the aircraft 12. Or stabilizing wings 24, 26, 28 can be used to support all of the aircraft 12. If desired, the beam 81 with aircraft 12 can then be rotated into a hangar or other storage area. An attachment means, such as the loop 204 shown at the tail end 202 of the aircraft 12 in FIG. 3, can be used to hang the aircraft from a ceiling hook located within a hangar.

During take off, the aircraft 12 is raised vertically and stabilizer wings 24, 26, 28 no longer rest on beam 81. The aircraft hovers while actuator 90 is activated to swing latching arm 86 downwards. Ear 74 hits stop 75 to keep the latching arms 86 in an approximate 90^0 rotation. The aircraft 12 can now be flown away and/or beam

81 can be pivoted away from the aircraft. The actuator 90 is deactivated to return the latching assemblies to a landing state.

As mentioned, beam 81 may extend from the side of a ship 60 to allow aircraft 12 to land at a point away from conventional landing pads. The boom can also be swung along with the aircraft into a hangar. Since the aircraft will already be hooked, it is not necessary for sailors to hook the aircraft onto ceiling hooks in the hangar unless more than one aircraft per beam is used. With the invention, the roll, pitch and yaw positions of a ship are less critical for landing and take off and the beam 81 can be either manually or automatically stabilized with a control system to hold the beam in a fixed point in space to provide an easier landing. Additionally, roll over and other problems normally experienced with conventional helicopter landings are eliminated. With the improved landing and take off of the invention, the weight and drag of conventional landing gear is eliminated. Furthermore, the longer boom 83 allows smaller stabilizing wings 24, 26, 28 which reduces drag.

In the embodiment, shown in FIG. 1, spikes 103 are provided on the stabilizing wings 24, 26, 28 for landing the aircraft 12 in an emergency situation, for example, the spikes 103 could also be used for extended airborne reconnaissance or ground loiter. The spikes 103 will keep a stabilizer wing hooked onto lines such as power lines, ship riggings or overhead structures such as bridges, cranes, street signs or lights. Wires or beams placed in areas requiring extended airborne reconnaissance, such as by fire towers or over a downtown high crime area, allow the aircraft 12 to monitor large areas for extended periods of time. The aircraft 12 could then be remotely operated when required.

Because of the landing approach disclosed, it should be understood that the forward and rear fuselage structures could be built in one piece without the need for bearings between the two portions if the base docking structure supported the aircraft boom by rollers or if the aircraft boom has a rotating collar that allowed support of the rotating aircraft. In this case, swash plate actuators would be mounted with a gyroscope so as not to rotate about the longitudinal axis with the rest of the aircraft to facilitate control of the aircraft.

ALTERNATE AND PREFERED PROPELLER POWERED CONFIGURATION

In the preferred propeller powered configuration, thrust in airplane mode flight would be provided by an aft mounted pusher propeller 154 as shown in Figure 11 which is driven through shaft 206 and transmission 208 by engine 210. Secondly, the aircraft flies as a torque reaction helicopter in vertical flight mode using the tail fins 24', 26' and 28' rotated a little more than 90 degrees about the tail fins' lengthwise or pitch axis to generate lift like a large rotor or propeller in a counter-rotating mode to the main rotor as can be seen in Figure 12. In hover mode engine 210 provides torque to spin tail fins 24', 26' and 28' through transmission 208 and shaft 206. Because the engine 210 and transmission 208 are providing a torque to the tail fins 24', 26' and 28' they produce an equal and opposite torque on the aft fuselage 16 causing it to rotate together with rotor blades 18' and 22' about the longitudinal axis in the opposite direction of rotation as the tail fin assembly. Although the torque reaction approach just described is preferred it should also be understood that engine 210 could provide torque to the tail fins 24', 26, 28' and rotor blades 18',22' through two different shafts so that the engine isn't spinning with rotor blades 18',22'. This however adds an unnecessary complexity. It should also be understood that for simplicity the tail fins 24',26',28' could be fixed in the airplane mode position, however, this would be less efficient in hover since the fins wouldn't be adding to the lift of the vehicle and the vehicle would not be able to fly as fast in helicopter translational mode due to the large drag of the aft tail fins. Using the tail fins 24',26' and 28' as the counter-rotating lifting system to rotor blades 18',22' is better than using the propeller 154 for three reasons: 1) For efficiency in airplane mode the propeller 154 needs a large amount of twist in the blade which would hurt its static thrust in helicopter mode especially in reverse thrust needed for helicopter mode where the desired blade twist would be reversed. In contrast, the tail fins 24', 26' and 28' can either be untwisted or have a beneficial blade twist for hover which can be on the order of 10 degrees greater pitch near the hub than at the rotor tip. If the blades are twisted then the lowest drag approach during airplane mode flight is to have the tail fin airfoils at the root aligned with the longitudinal axis of the aircraft and the fins would be rotating slowly in the opposite direction as that in helicopter mode due to the twist in the blades. 2) The blades on the propeller 154 want to be small for efficiency in airplane mode whereas the tail fins 24', 26' and 28' are larger and better sized for the helicopter mode in a counter-rotating role with the main rotor. 3) The tail fins 24', 26' and 28' would have to be rotated into a streamlined position anyway if it is necessary for the aircraft to fly at moderate to high speeds in translational helicopter modes. The tail fins 24', 26' and 28' could continue to be powered in airplane mode to act as both the stabilizing wings and the propeller, but would be less efficient than using the smaller propeller 154 for forward propulsion. Propeller 154 would also have the advantage of having a blade twist optimized for forward flight, as is known in the art. Figure 13 shows a close up of the tail assembly. Tail fin 24' is shown in its airplane mode position (fins 26' and 28' are deleted for simplicity) oriented inline with the fuselage centerline 216 and attached to ring 212 which in turn is mounted on propeller shaft 206 through bearings (not shown) that allow fins 24', 26' and 28' to remain stationary while shaft 206 rotates to power the propeller 154.

Conversion from airplane to helicopter mode is initiated in the same way as previously described with rotor blades 18', 22' spinning up first in an auto-rotation mode, causing the aircraft to decelerate and start descending straight down with the nose pointed down. At this point actuator 216 begins to retract and through slip ring 218, control rod 220 and gear 214, starts rotating the tail fins 24', 26' and 28' about their long axis. The airflow passing up through the stabilizing wings 24', 26' and 28' causes the entire fin assembly, including structural ring 212 to start spinning in an auto-rotation mode. When the stabilizing wings 24', 26' and 28' start approaching the rotational position used for gliding in helicopter mode which is close to perpendicular to the fuselage centerline 217, cam member 222 has rotated far enough that it no longer is holding ratchet lever 224 in a retracted position and compression spring 225, shown in schematic, pushes ratchet lever 224 up and into engagement with drive ring 226 which is attached to drive shaft 206. At this point the engine is near idle and the wing assembly mounting ring 212 is turning faster than the drive shaft 206. As the engine power is increased, power shaft drive ring 226 catches up in rpm with ring 212 and starts providing torque to the wing assembly as ramp 228 engages and pushes on lever 224. Propeller 154 can be fixed or variable pitch and can either remain engaged to shaft 206 or can be disengaged in helicopter mode using a similar approach to the ratchet lever just described. A Sprague clutch type of arrangement can also be used.

At this point the aircraft can increase power further and raise the leading edges of the main wing/rotor blades 18' and 22' and the stabilizing wings 24', 26' and 28' to enter into powered helicopter mode flight.

Flight in helicopter mode is the same as previously described. The pitch on the stabilizing wings 24', 26' and 28' can remain fixed or can be raised and lowered along with the blades 18' and 22' if desired to keep the ratio of rpm between the two constant. Although not necessary, slip ring 218 could be substituted with a full swash plate if it was desired to have cyclic control on the upper wings 24', 26' and

28' which would be advantage for flying fast in helicopter translational mode and increasing helicopter control power. Control rods extending up from the lower swash plate could be used to tilt this upper swash plate similar to other co-axial type rotor helicopters. In addition, for very large vehicles a two bladed rigid rotor generates large vibrations in translational helicopter mode and a teetering hinge could be added to the lower rotor to eliminate the vibrations with the upper rotor swash plate being used to control the aircraft.

To convert back to airplane mode the process is reversed. Engine power is reduced and the leading edges of blades 18', 22', 24', 26' and 28' are lowered so the aircraft goes back to a descending and auto-rotating helicopter mode. Actuator 216 extends further to rotate stabilizing wings 24', 26' and 28' back to a position where they are aligned with the aircraft's longitudinal axis 217. This also causes cam 222 to retract lever 224 to disengage the stabilizing wing assembly from shaft 206. The conversion to airplane mode is completed as described previously with the wings 18' and 22' being rotated to their airplane mode position aligned with the longitudinal axis of the aircraft. The aircraft descends and pulls out into horizontal airplane mode flight.

This preferred propeller powered aircraft could land in a tail hanger manner similar to that previously described, however, the tail boom 83' would be flown up against a grid or a grid would be lowered until the spike 230 engages the grid 280 and is retained by spring loaded wings 238 similar to that described in patent

#4,890,802. Figure 14 shows one aircraft about to engage the landing grid 280 on a ship and another aircraft hanging under a grid 280 with its rotors stopped, and being swung into the hanger by boom 282. For landing the aircraft flies up into engagement with the landing grid 280 suspended on a structural arm 282 off the side of the ship or preferably the landing grid 280 is lowered into engagement with the spike 230 on the top of the hovering helicopter and retained by spring loaded wings 238 which prevent the helicopter from pulling back down out of the grid. To launch the helicopter, the retaining wings 238 are retracted similar to that of prior art and the helicopter drops down away from the landing grid 280. The advantage of this landing approach is that the vehicle can always land on the grid 280 that is on the upwind side of the ship and stay out of the turbulent air wake behind the ship that makes landings and takeoffs more difficult. Also, the helicopter only needs to hover near the side of the ship without worrying about the pitching, heaving or rolling of the ship and let the landing grid 280 maneuver over and engage spike 230. After engagement the helicopter is stable hanging below the landing grid 280. The aircraft however could also land on a surface below the aircraft with legs 234 to keep the aircraft from falling over while on the ground. The legs 234 have an airfoil cross-section in order to be streamlined in airplane mode flight and with the rounded leading edge facing down in helicopter mode which provides a surface to support the vehicle on soft ground similar to skids on a conventional helicopter. The legs 234 are unsymmetrical about the longitudinal axis of rotation of fuselage section 14' for example with the two aft legs longer or wider than the two front so that the fuselage section 14' wants to weathervane into the wind in translational helicopter mode flight.

All of the invention has been described by making detailed reference to preferred embodiments. Such detail should be understood by those skilled in the art as instructive rather than in any restrictive sense. Many other variants are possible within the scope of the claims hereunto appended. The invention is not to be limited to the specifics as shown here for purposes of illustration but only by the scope of the appended claims and their equivalents.

I claim as my invention:

CLAIMS:

1. An aircraft having a front fuselage portion and a rear fuselage portion, said fuselage portions having a common longitudinal axis, the aircraft comprising:

   (a) an elongate member extending from the aircraft for engagement with a base docking structure for launching and landing of the aircraft.

2. The aircraft of claim 1, the aircraft being adapted for flight in a helicopter mode with the longitudinal axis oriented generally vertically and in an airplane mode with the longitudinal axis oriented generally horizontally, the aircraft having,

   (a) a tail end on the rear fuselage portion, and

   (b) an elongate boom extending longitudinally from the tail end, the boom having means for attachment to a base structure with the tail end directed generally skyward.

3. An aircraft having a fuselage with an aft portion and a fore portion, said fuselage having a longitudinal axis, the aircraft being adapted for flight in a helicopter mode with the longitudinal axis oriented generally vertically and in an airplane mode with the longitudinal axis oriented generally horizontally, the aircraft comprising:

   (a) at least a pair of rotor blades, each blade having a lateral axis and each blade being connected to the fuselage for rotation about its lateral axis relative to the fuselage;

(b) a plurality of stabilizer wings connected to the aft portion of the fuselage; and

(c) said rotor blades having a leading edge and being positioned generally perpendicular to the longitudinal axis with leading edges angled in the aft direction in powered helicopter mode.

4. An aircraft having a fuselage with a longitudinal axis, the aircraft being adapted for flight in a helicopter mode with the longitudinal axis oriented generally horizontally, the aircraft comprising:

(a) the fuselage having coaxial sections connected for relative rotating of the sections about the longitudinal axis;

(b) a pair of rotor blades, each blade having a lateral axis and being connected to the fuselage for rotation about its lateral axis relative to the fuselage;

(c) a plurality of stabilizing wings connected to said fuselage; and

(d) said stabilizing wings being asymmetrical about the longitudinal axis of rotation of the fuselage.

5. The aircraft of claim 4, in which:

(e) said stabilizing wings are biased to a rear portion of the fuselage in helicopter mode to cause the fuselage to weathervane into the direction of flight in helicopter mode.

6. An aircraft having a fuselage with an aft portion and a fore portion, said fuselage having a longitudinal axis, the aircraft being adapted for flight in a helicopter mode with the longitudinal axis oriented generally vertically and in an airplane

mode with the longitudinal axis oriented generally horizontally, the aircraft comprising:

(a) at least a pair of rotor blades, each blade having a lateral axis and each blade being connected to the fuselage for rotation about its lateral axis relative to the fuselage;

(b) a plurality of stabilizing wings connected to said fuselage; and

(c) at least one of said stabilizing wings has at least a portion rotatable in plane with the airflow in translational helicopter mode flight.

7. An aircraft having a fuselage with an aft portion and a fore portion, said fuselage having a longitudinal axis, the aircraft being adapted for flight in a helicopter mode with the longitudinal axis oriented generally vertically and in an airplane mode with the longitudinal axis oriented generally horizontally, the aircraft comprising:

(a) at least a pair of rotor blades, each blade having a lateral axis and each blade being connected to the fuselage for rotation about its lateral axis relative to the fuselage;

(b) a plurality of stabilizer wings connected to the fuselage; and

(c) the rotor blades and the stabilizer wings being adapted to counter-rotate in helicopter mode.

8. The aircraft of claim 7, in which:

(d) the stabilizer wings have means for disengaging rotation for airplane mode flight.

9. An aircraft having a fuselage with an aft portion and a fore portion, said fuselage having a longitudinal axis, the aircraft being adapted for flight in a helicopter mode with the longitudinal axis oriented generally vertically and in an airplane mode with the longitudinal axis oriented generally horizontally, the aircraft comprising:

(a) at least a pair of rotor blades forming a first set, each blade having a lateral axis and each blade being connected to the fuselage for rotation about its lateral axis relative to the fuselage;

(b) a plurality of wings connected to the fuselage forming a second set;

(c) the rotor blade and the wings having means for counter-rotating in the helicopter mode; and

(d) at least one of the first and second set having means for disengaging rotation for airplane mode flight.

10. An aircraft having a fuselage with an aft portion and a fore portion, said fuselage having a longitudinal axis, the aircraft being adapted for flight in a helicopter mode with the longitudinal axis oriented generally vertically and in an airplane mode with the longitudinal axis oriented generally horizontally, the aircraft comprising:

(a) at least a pair of rotor blades, each blade having a lateral axis and each blade being connected to the fuselage for rotation about its lateral axis relative to the fuselage;

(b) a plurality of stabilizer wings connected to the aft portion of the fuselage; and

(c) said rotor blades having a leading edge and being positioned generally perpendicular to the longitudinal axis with leading edges angled in the forward direction in gliding helicopter mode.

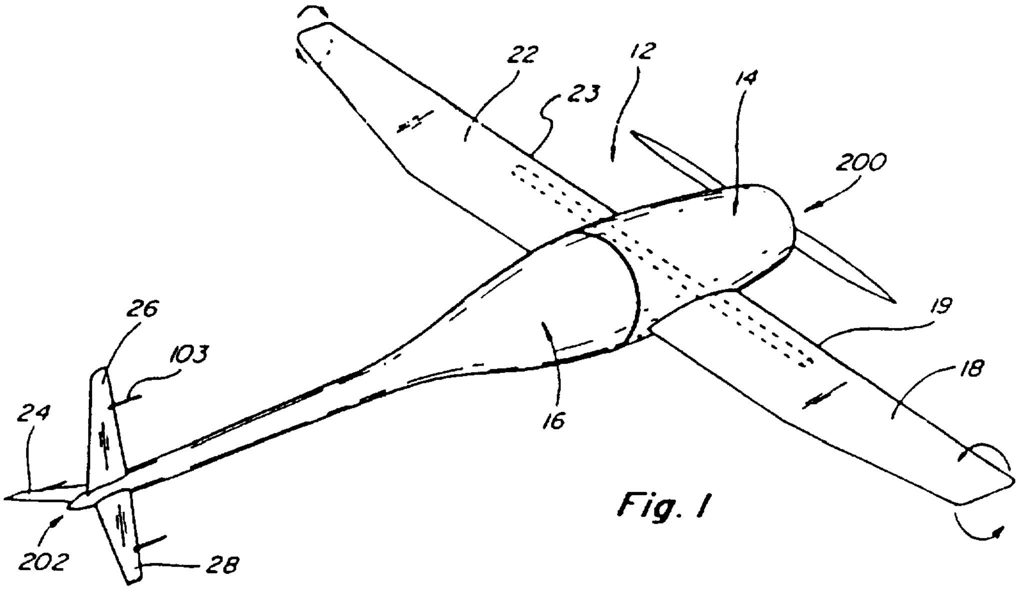
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Fig. 1

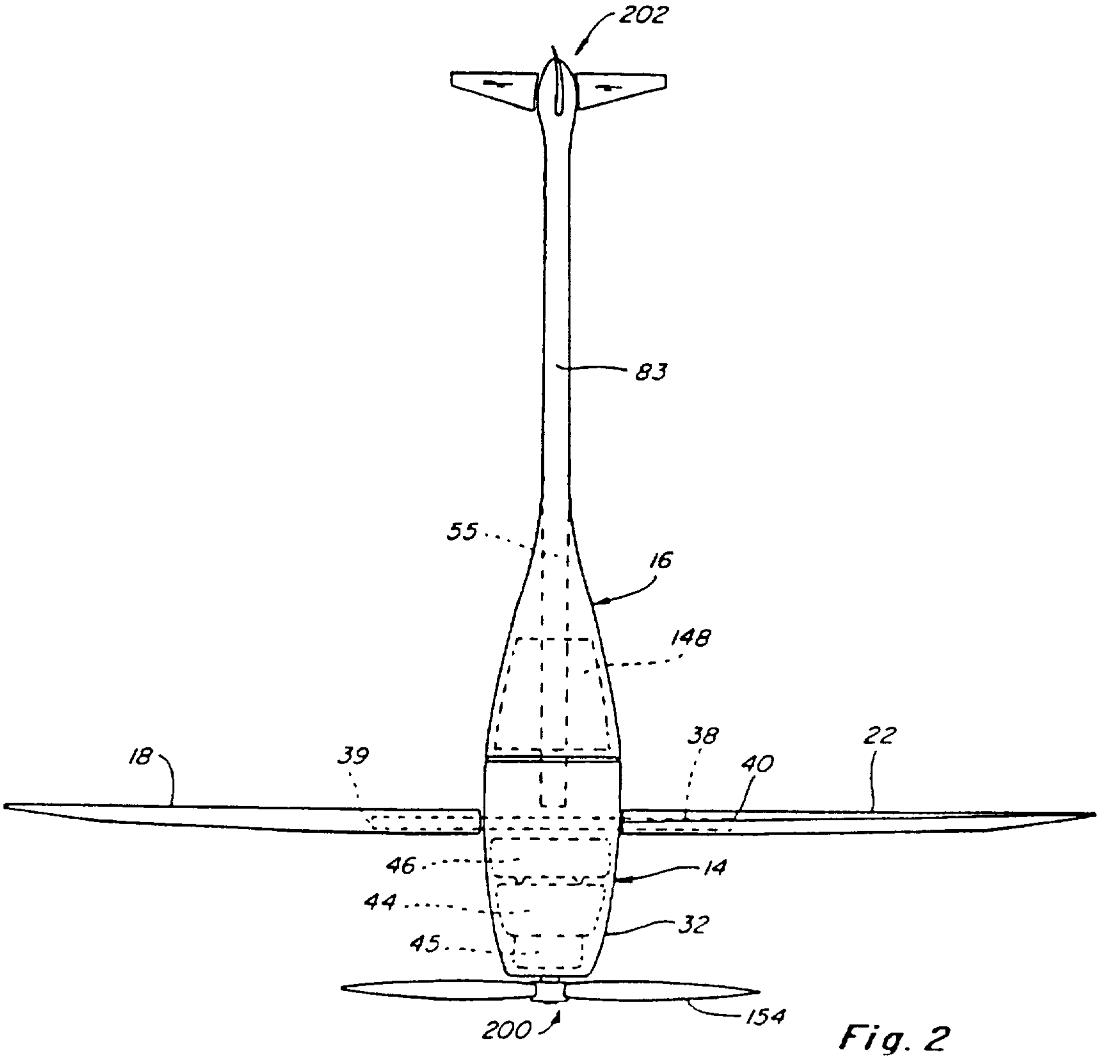
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Fig. 2

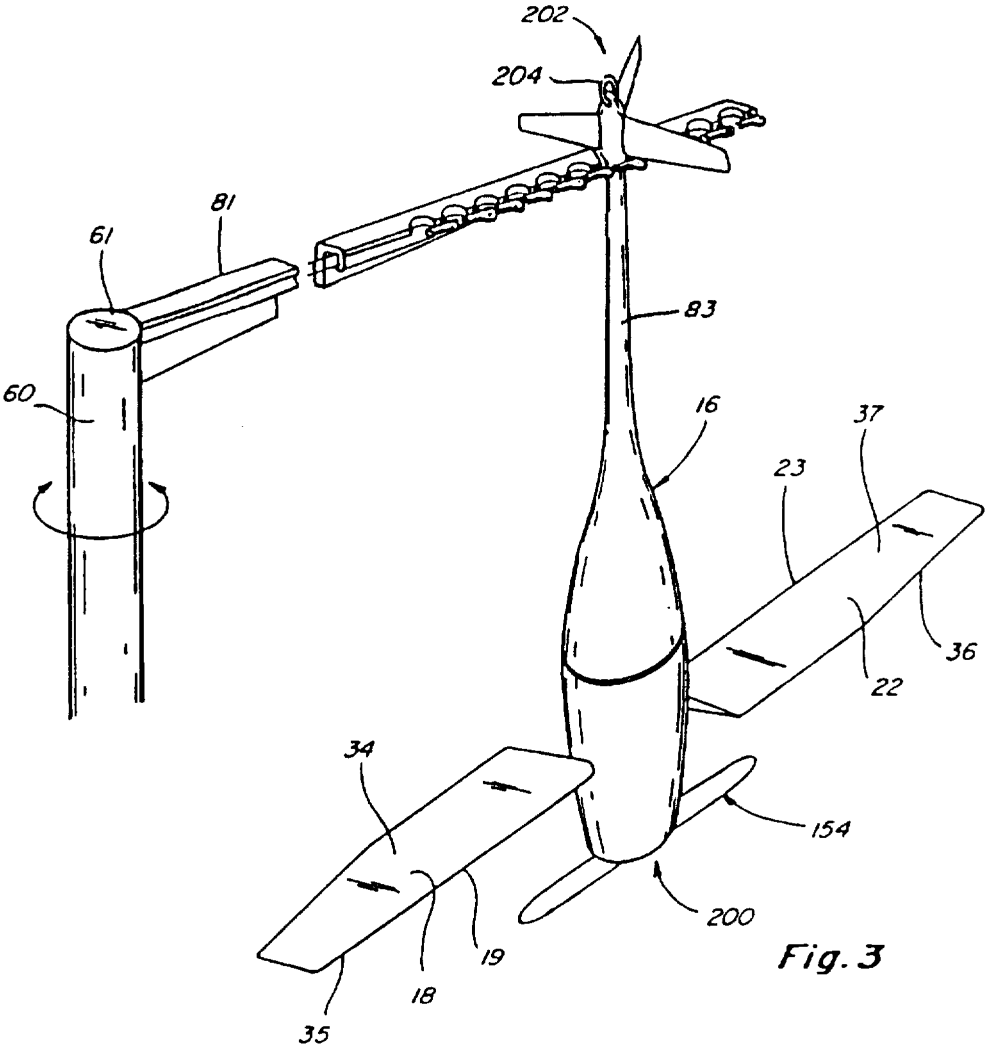

Fig. 3

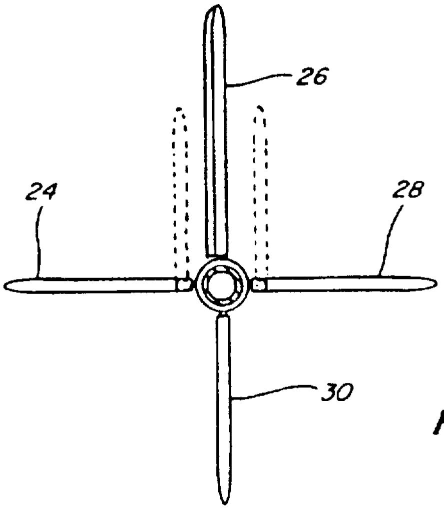

Fig. 4

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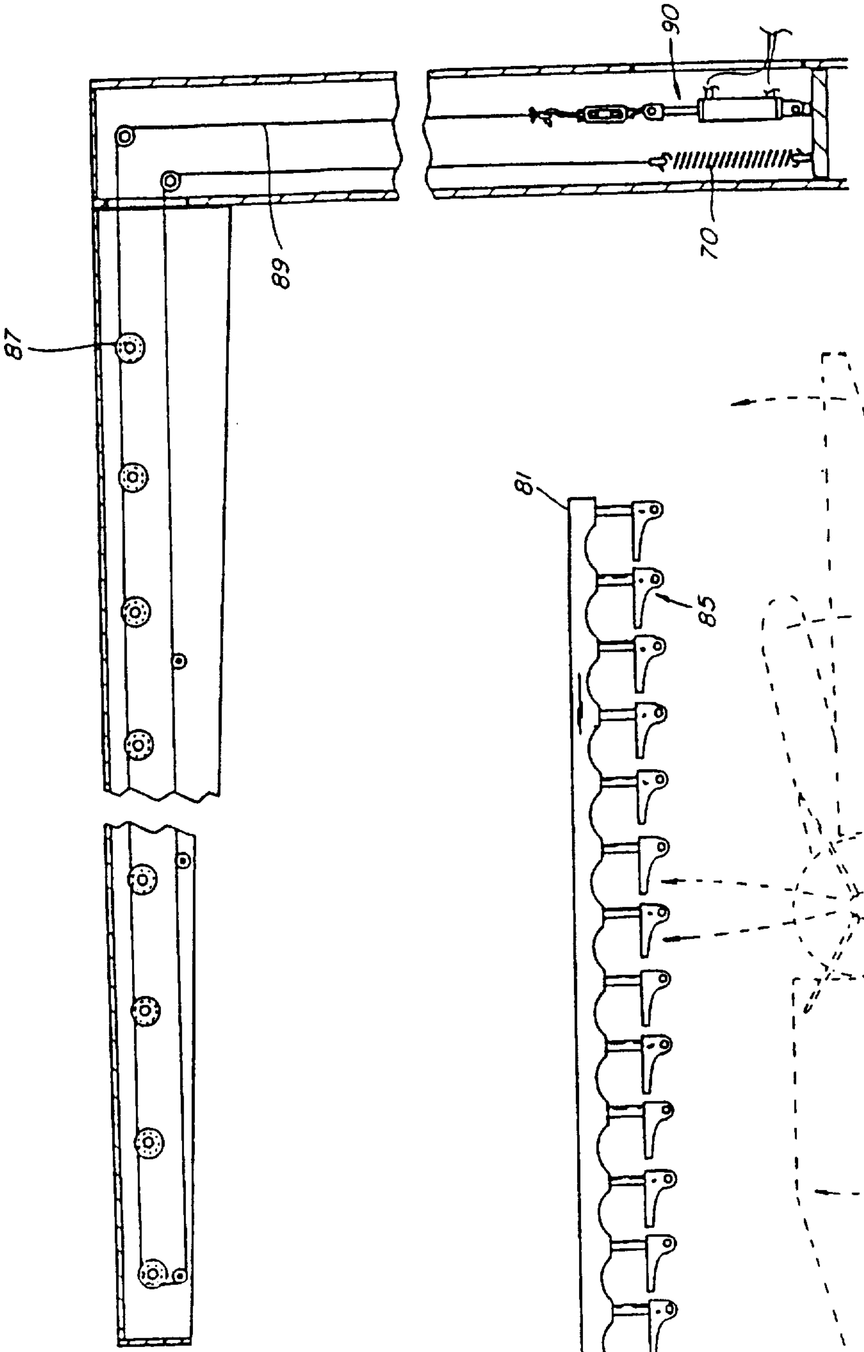


Fig. 6

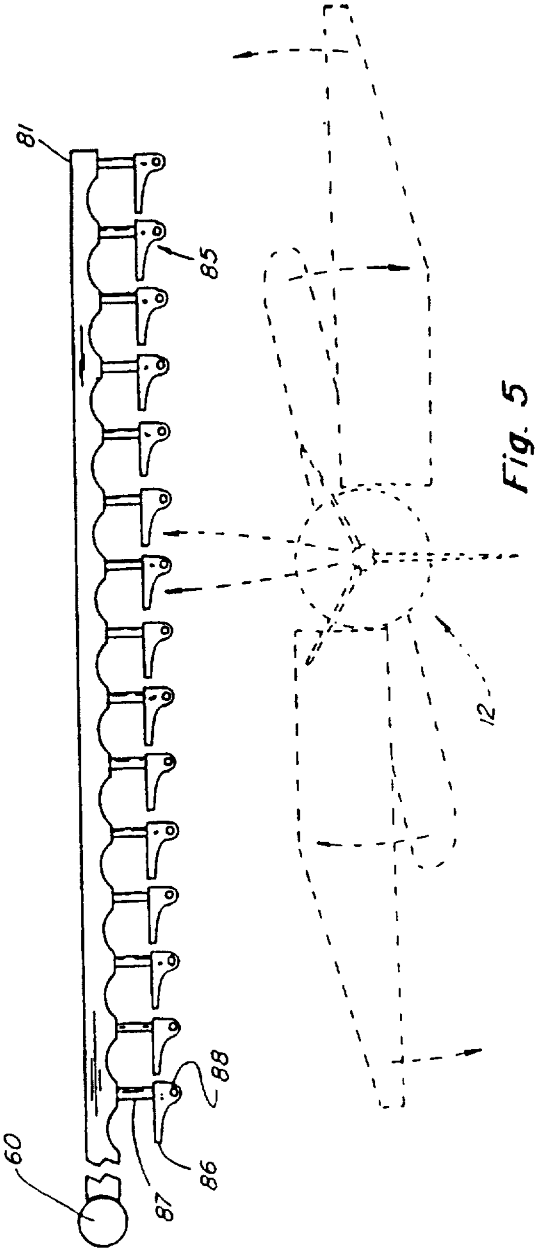


Fig. 5

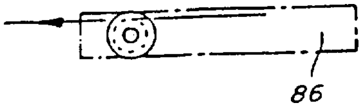


Fig. 7

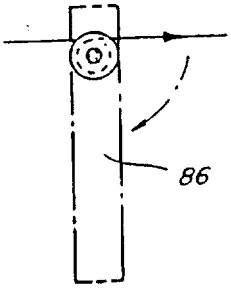


Fig. 8

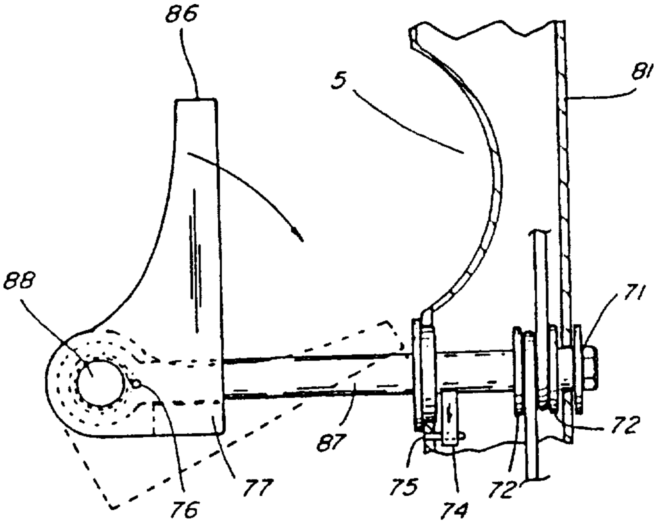


Fig. 9

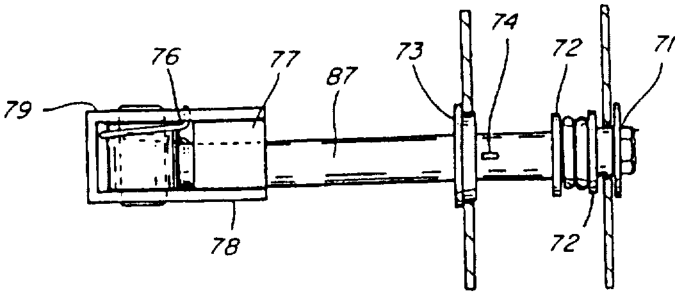


Fig. 10

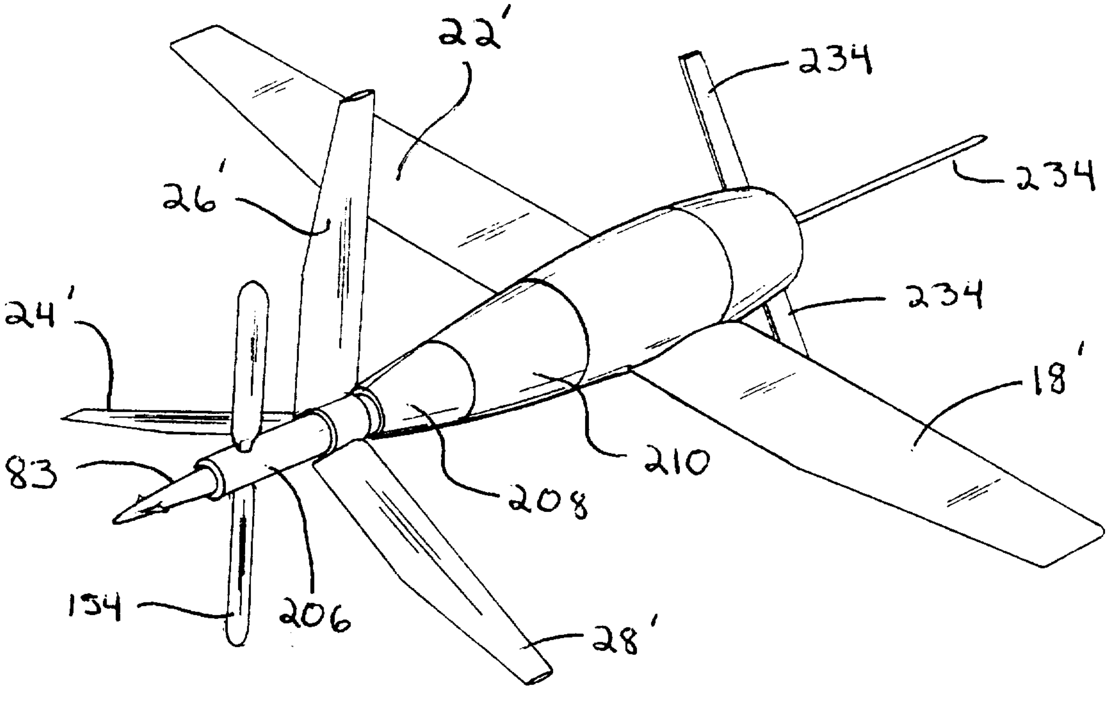


Fig. 11

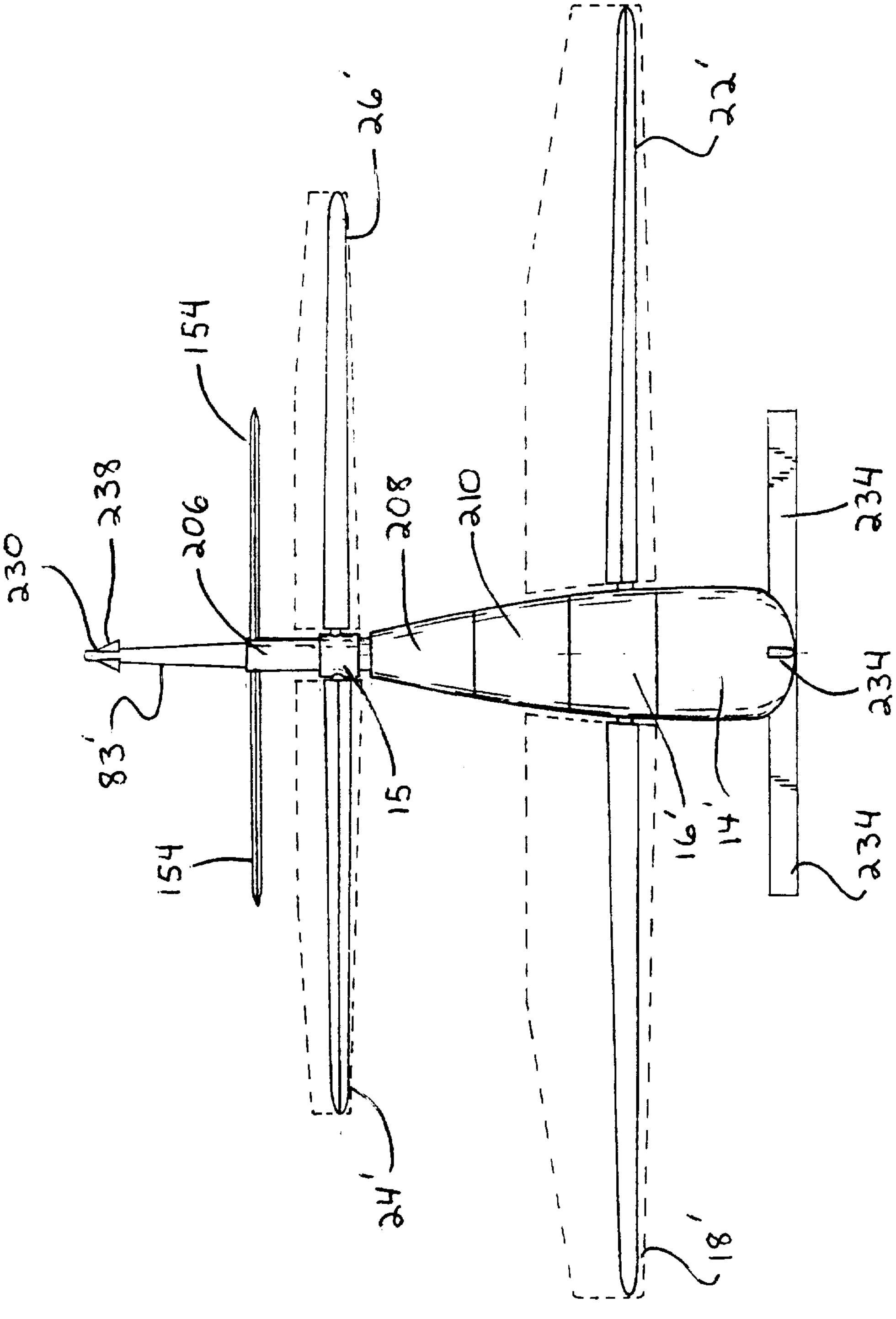


Fig. 12

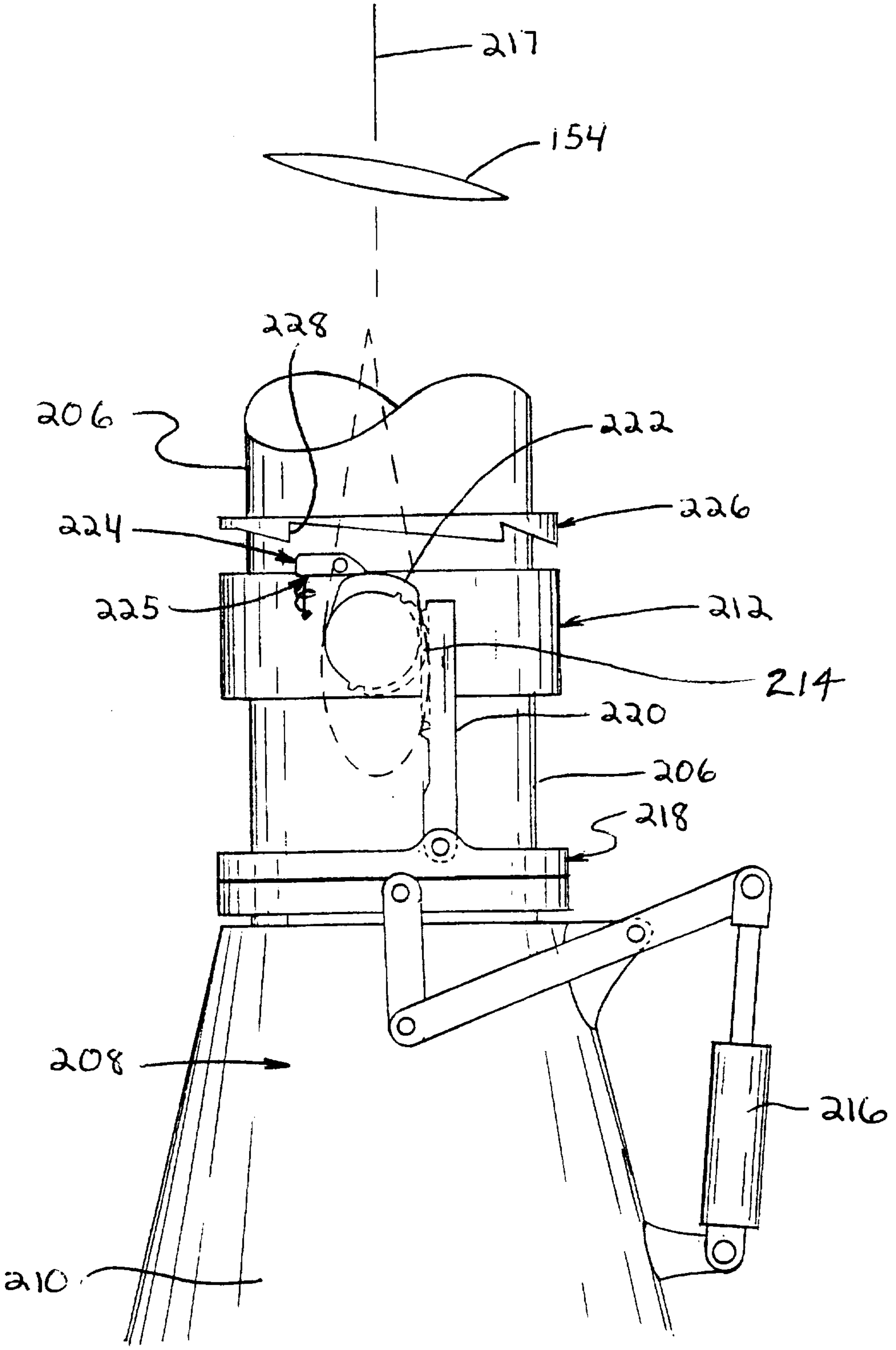
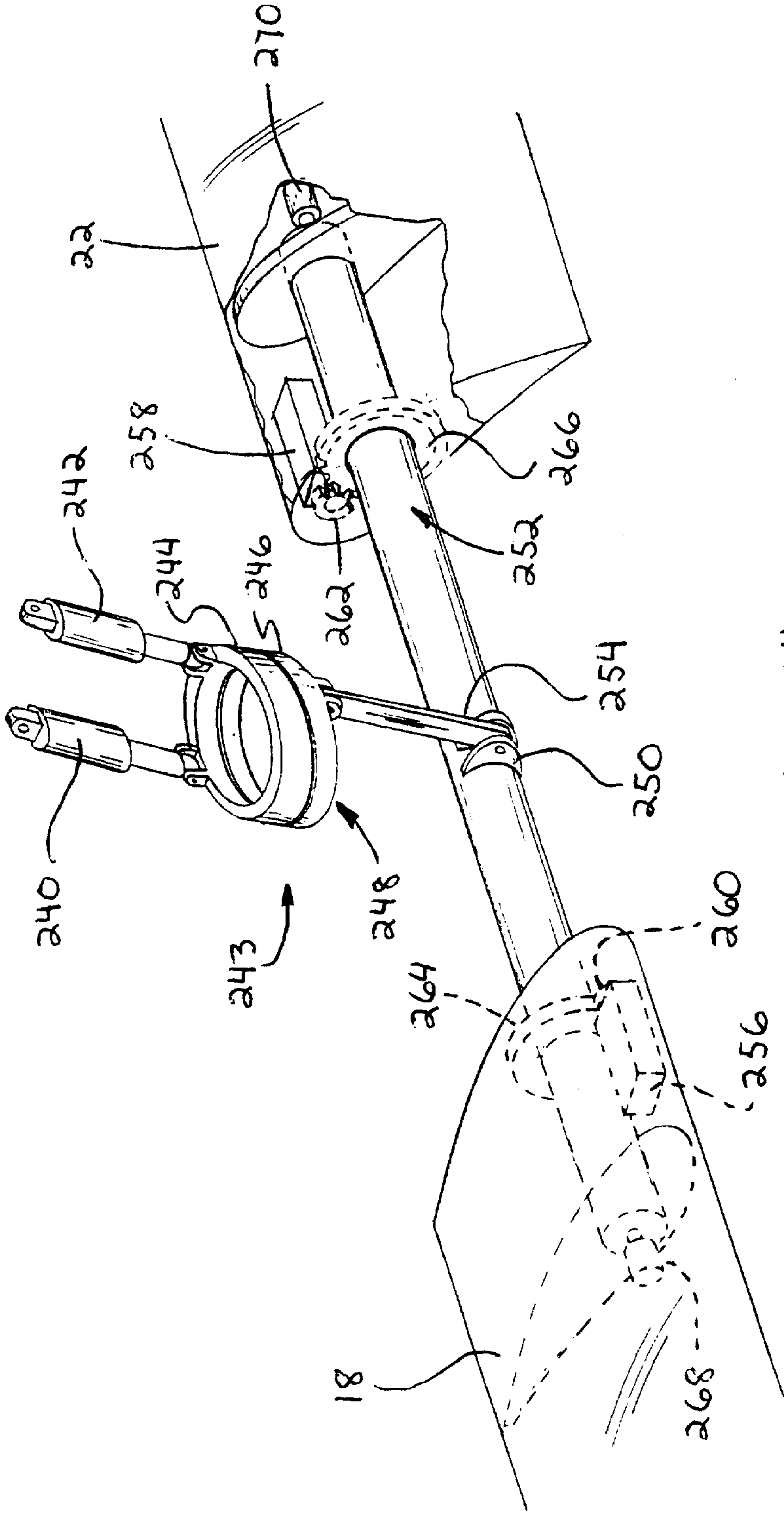


Fig. 13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268

Fig. 14

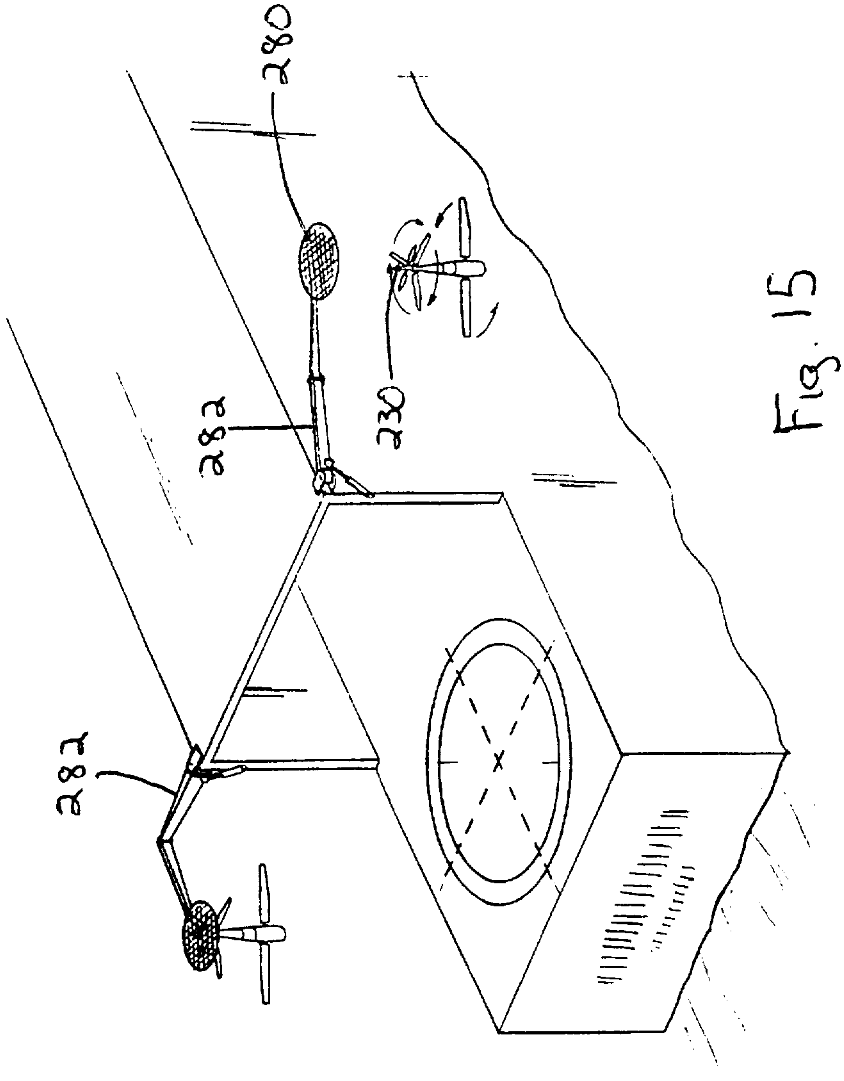

Fig. 15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/10932

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B64C 29/02
US CL :244/7r,7a,7b,7c,17.11,17.15,17.17,115,116,110c,110f,45r,45a
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 244/7r,7a,7b,7c,17.11,17.15,17.17,115,116,110c,110f,45r,45a

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

NONE

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

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2,328,786 A (CROWDER) 7SEPTEMBER1943, SEE FIGURE 2	NONE
A	US 2,552,115 A (REPLOGLE) 8 MAY 1951, SEE FIGURE 1	NONE
A	US 2,807,429 A (HAWKINS, JR.) 24 SEPTEMBER 1957, SEE FIGURE 1	NONE
X ----- Y	US 4,123,020 A (KORSAK) 31 OCTOBER 1978, SEE FIGURE 2	1 ---- 2
A	US 4,786,014 A (PESANDO ET AL) 22 NOVEMBER 1988, SEE FIGURE 1	NONE

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search 01 OCTOBER 1997	Date of mailing of the international search report 03 NOV 1997
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer GALEN BAREFOOT Telephone No. (703) 308-1113

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/10932

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y ----- X	US 5,289,994 A (DEL CAMPO AGUILERA) 1 MARCH 1994, SEE FIGURES 1 AND 5	2 ----- 3-10