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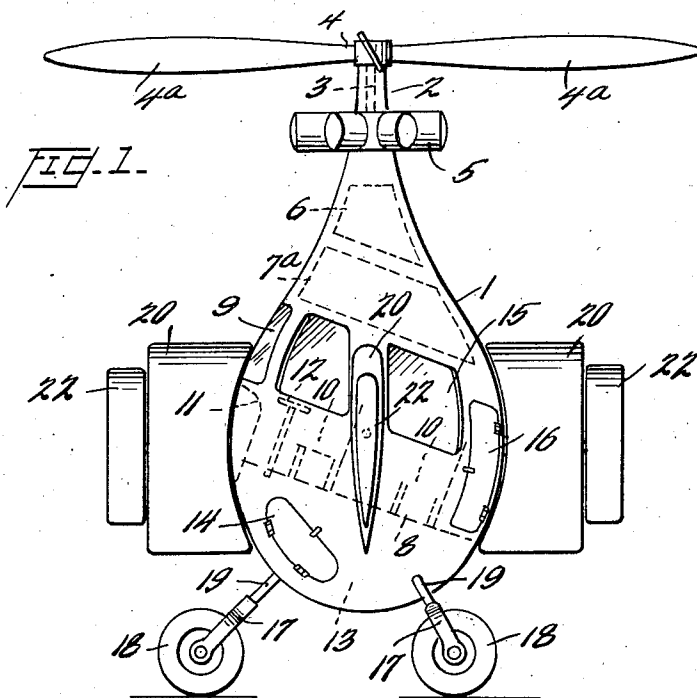
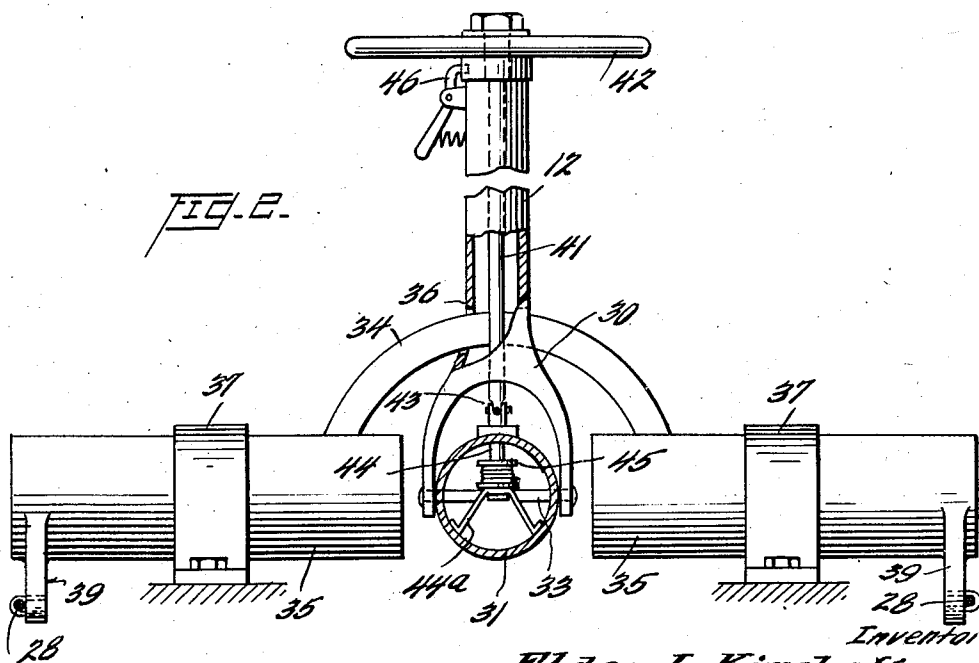
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HELICOPTER STEERING SURFACE CONTROL

Filed Feb. 16, 1945

2 Sheets-Sheet 1



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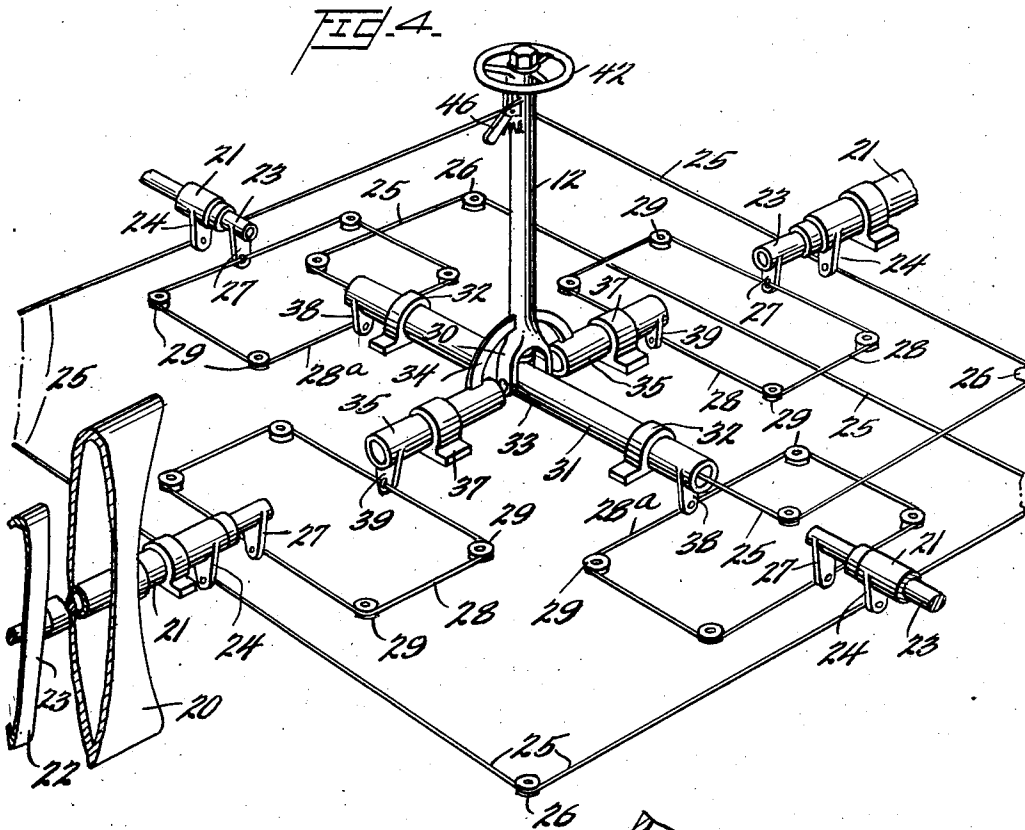
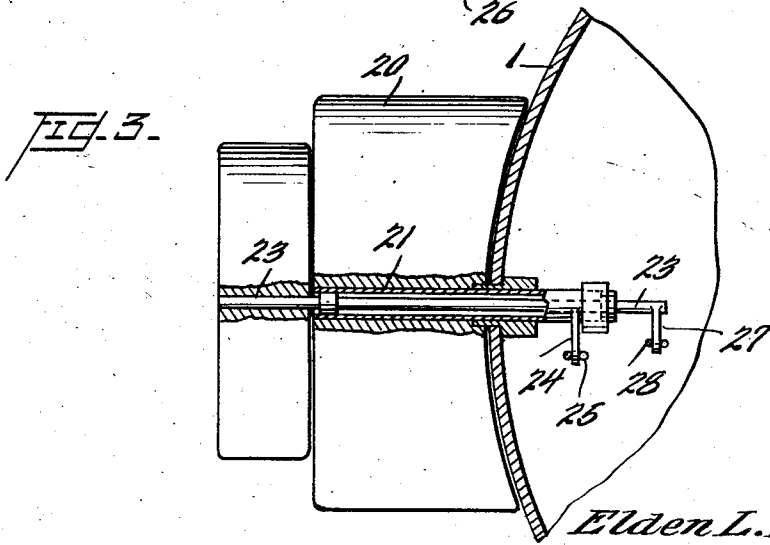
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2 Sheets-Sheet 2



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HELICOPTER STEERING SURFACE
CONTROL

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6 Claims. (Cl. 244—17)

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This invention relates to helicopters of the type in which vanes located in the slipstream of the gondola-sustaining rotor are adjustable to intercept the slipstream at different angles to thereby impart an unbalanced force to the gondola about its longitudinal axis and allow directional control of the helicopter while it is in flight. One such type of helicopter is shown in the patent of Vern Keith Fry, No. 2,058,678, dated October 27, 1936.

An important object of my invention is to provide in a helicopter of the above character vanes of improved construction and arrangement, whereby to more efficiently utilize the air currents generated by the rotor for tilting the helicopter during flight.

Another object of my invention is to provide in a helicopter of the above character control means of improved construction and arrangement for varying the angular adjustment of the vanes for steering the helicopter while in flight.

Still another object of my invention is to provide in a helicopter of the above character improved control means for varying the angular adjustment of both the vanes for directional control and the blades for opposing the torque developed by the rotor, such control means being associated with a single control "stick" conveniently located with reference to the pilot.

Other objects and advantages will be apparent from the following detailed description of the invention, reference being had to the annexed drawings, in which:

Figure 1 is a side view of a helicopter having its longitudinal axis disposed vertically, showing its position when on the ground or in direct vertical flight;

Figure 2 is a detail view of the control stick, parts thereof being shown in cross-section for greater clearness;

Figure 3 is a detail view of one of the stabilizing blades and its companion steering vane, showing the manner in which they are associated with each other and with the gondola of the helicopter; and

Figure 4 is a perspective view, mainly diagrammatic, showing the control mechanism for adjusting the positions of the blades and vanes about their axes.

Referring to the drawings, in Fig. 1 is shown a helicopter comprising a downwardly and outwardly flared gondola 1 of generally teardrop shape having its longitudinal axis disposed vertically and terminating at its upper smaller end in a tapering neck 2. Through this neck and

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fixedly supported in line with the longitudinal axis of the helicopter, extends a driven shaft 3 (indicated in dotted lines) upon the upper projecting end of which is secured a rotor 4 comprising a plurality of blades 4a. The shaft 3 is coupled to and driven by a motor 5, such as an internal combustion engine, mounted within the neck of the gondola with its cylinders projecting therefrom into the slipstream of the rotor to promote their cooling. Within the area of the neck below the motor are contained oil and fuel tanks, designated 6 and 7 respectively, for supplying the motor. A floor 8 extends across the gondola sufficiently far below the fuel tank to afford space 15 for a passenger cabin 9 in which are provided chairs 10, instrument panel 11 and steering control member 12 known as a "stick." The floor is disposed at a downward slope with respect to the horizontal from the front (that is, the direction faced by the pilot in operating the stick 12) to the rear wall of the cabin, so that when the helicopter is in flight with its longitudinal axis normally tilted forward the floor will assume an approximately horizontal position. The space below the floor 8 forms a compartment 13 for the stowage of cargo, access being provided to this space through a door 14. A window 15, made of Plexiglas or the like material, entirely encircles the gondola throughout an appropriate distance above the seat level to afford visibility in all directions. For providing admission to and exit from the cabin 9, to a door 16 is mounted in the rear wall of the gondola. A tricycle landing gear 17, which may or may not be retractable, and comprising wheels 18 mounted upon oleo struts 19, supports the helicopter on the ground with its longitudinal axis extending substantially vertically.

In order to offset the torque imparted to the gondola by the rotation of the rotor when the helicopter is in flight, which torque tends to turn the gondola about its longitudinal axis in a direction opposite to the rotation of the rotor, there are provided four generally rectangular shaped blades 20. The blades, as best illustrated in Fig. 3, are fixedly mounted upon hollow tubular shafts 21 extending horizontally outward through the wall of the gondola at equidistantly spaced points about its girth. These shafts lie within a common plane disposed at right-angles to the longitudinal axis of the gondola and intersecting the gondola at or adjacent to its maximum diameter. The blades are so arranged as to extend into the slipstream of the rotor 4 and act as stabilizers to neutralize the torque produced by the rotation

of the rotor. By rocking the shafts 21, the angle of interception of the blades may be adjusted to offset changes in torque such as may result from variations in the speed of the rotor or due to other factors. In order to operate most effectively, the blades are of substantial length and breadth so as to present an adequate deflection area to the slipstream, with their inner edges spaced a short distance from but corresponding in contour to the curved exterior face of the gondola.

Arranged outwardly of and in laterally-spaced relation to the blades 20 are rectangular vanes 22 which serve to provide directional control for the helicopter when in flight. These vanes, which may be of less length and breadth than the blades since they are not required to present so much area to the slipstream, are mounted upon the outer ends of shafts 23 (Fig. 3) which fit within and project beyond the outer end of the hollow shafts 21. The shafts 21 and 23 are capable of being rocked about a common axis independently of each other, and to this end the following operating mechanism is provided: Inside the gondola each shaft 21 is provided with an arm 24 connected to a cable 25 winding over pulleys 26 rotatably supported on the wall of the gondola in such a manner that the cable extends in out-of-the-way position with respect to the passenger space of the cabin. By moving the cable in one or the other directions, the blades 20 are swung in unison in the same clockwise or counter-clockwise direction. The inner ends of the shafts 23 project beyond the ends of hollow shafts 21 within the cabin and are provided with arms 27 attached to cables 28 or 28a which wind over pulleys 29 suitably supported upon the gondola structure. Because the vanes 22, unlike the blades 20, serve to utilize the force of the slipstream to unbalance the helicopter laterally and to tilt it and the rotor in the desired direction of flight, these vanes must be operated in pairs, each pair comprising the two vanes upon diametrically opposite sides of the gondola. That is, each pair of vanes is capable of moving the helicopter at right angles to the direction of the other pair so that by suitably adjusting the pairs of vanes relative to the slipstream the component of the forces acting on the vanes may be so directed as to cause the helicopter to tilt, and hence travel, in any desired direction while in flight.

The steering control for operating the cables 25 and 28, and through them the blades 20 and vanes 22, comprises the upright tubular stick 12 located in front of the pilot's seat in the passenger cabin. The lower end of the stick is branched so as to form a pair of arms 30 which bridge a hollow shaft 31 journaled for oscillatory movement in bearings 32 supported upon the gondola structure. The arms are pivotally connected to a pin 33 extending radially across the shaft 31 and having its ends projecting beyond the circumference of the shaft so as to be received within eyes formed in the arms. A segmental guide 34 having its ends connected to a pair of trunnions 35 arches upwardly and freely passes through slots 36 formed in the hollow stick. The trunnions 35 are located in line on opposite sides of the shaft 31 and at right-angles thereto, and are rotatably journaled in bearings 37 fixedly secured to the helicopter structure. By virtue of this construction, the stick is capable of being rocked toward and from the pilot upon the pin 33 so as to rotate the trunnions 35, and also it may be rocked to the right or left in order

to rotate the hollow shaft 31; or the stick may be so displaced as to describe a combination of such movements.

A pair of lugs 38 are provided on the circumference of hollow shaft 31 and located in spaced relation upon opposite sides of the stick 12; and similarly lugs 39 are provided upon the trunnions 35. Each of these lugs is connected to one of the endless cables 28 or 28a winding over the pulleys 29 and fastened to the arm 27 of one of the four vane-supporting shafts 23. As diagrammatically shown in Fig. 4, movement imparted to the hollow shaft 31 by reason of rocking the stick 12 to the right or left will transmit a pull through the cables 28a to swing the vanes 22 which are located fore and aft of the gondola in the same direction and to the same extent. In the same manner, rocking of the stick forward or backward will rotate the trunnions 35 so as to shift the cables 28 to adjust the positions of the vanes 22 located on opposite sides of the gondola.

In order to position the torque-stabilizing blades 20, a rod 41 is mounted so as to extend longitudinally within the hollow stick 12, and upon its end which projects beyond the upper end of the stick is secured a wheel 42 serving both as a hand grip for the pilot as well as a means for turning the rod. Coupled through a universal joint 43 to the lower end of the rod is a stub shaft 44 which projects freely through an opening in the wall of the hollow shaft 31 and is supported at its lower end for rotation within a bracket 44a. A spool 45 is keyed to the stub shaft and upon this spool is wound the endless cable 25 which extends over the pulleys 26 and leads back to the spool in opposite directions through the hollow shaft 31. The cable 25 is connected to the arms 24 associated with each of the blade-supporting shafts 21 so that by rotating the rod in either direction, a pull is transmitted through the cable 25 to the arms 24 to simultaneously adjust the position of the four blades 20 located about the gondola in the same clockwise or counterclockwise direction, and to the same extent. For maintaining the blades in adjusted position, a releasable latch 46 is provided upon the upper end of the stick 12 conveniently adjacent the wheel 42 whereby the wheel may be locked to the stick after the correct trimming of the blades has been attained.

The operation of the helicopter just described is as follows: When the helicopter is at rest on the ground it will be supported on the tricycle landing gear 17 in upright position with its longitudinal axis extending vertically, as illustrated in Fig. 1. With the vanes 22 disposed in neutral (or vertical) position, the motor will be speeded up to cause the rotor to lift the helicopter off the ground and raise it vertically into the air. Then, by turning the wheel 42 of the steering control 12, the blades 20 will be adjusted to an angle such as to counteract the torque of the rotor and arrest any tendency of the gondola to rotate about its longitudinal axis. The proper trim of the blades 20 having been attained, ordinarily no further adjustments will be required so long as the speed of the rotor remains the same, and the blades may be locked in position by means of the latch 46 on the steering wheel.

Steering of the helicopter in flight is accomplished solely by means of the stick 12. By moving the stick forward or backward, or to the right or left, or by a combination of such movements, the appropriate vanes 22 will be rotated in a manner which has already been explained

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so as to intercept the slipstream and cause the force of the slipstream acting on the vanes to tilt the helicopter and rotor in the desired direction of travel. To go forward the pilot pushes the stick forward; to go aft he pulls the stick in the opposite direction. If he desires to go to the right or left, he rocks the stick in that direction.

By virtue of the blades 20 which serve for torque control and the vanes 22 which serve for directional control, the conditions governing the stability and forward movement of the helicopter, which conditions are largely independent of each other, may be separately controlled in a simple and natural manner on the part of the pilot and without involving a cumbersome and complicated construction. Furthermore, because of their coincident axes of rotation, the blades and vanes are each positioned so as to transmit the acting force of the slipstream directly to the gondola without interfering with the action of the companion control member.

The gondola will be suitably balanced so that its center of gravity will be sufficiently near its lower end as to provide for stable equilibrium while on the ground and in the air. This is essential in order to avoid the possibility of the helicopter nosing over under the unbalancing action produced by the vanes or under the influence of heavy winds. To this end, therefore, it may be found desirable, especially in relatively light-weight helicopter constructions, to mount the motor or fuel and oil supply, or all of them, in the bottom of the gondola in the space herein shown as reserved for the cargo compartment.

While the invention has been described in connection with a helicopter employing one rotor, it is within the scope of the invention to employ additional rotors mounted for rotation, usually in opposite directions so as to cancel their torques, about a common axis. The pitch of the rotor blades may be made variable, as is already known in helicopter construction. Also, pontoons may be substituted for the wheels 18 of the landing gear when the helicopter is intended for use over bodies of water.

Various other changes in construction, arrangement and design will occur to one skilled in the art and may be made in the preferred form of my helicopter as described above without departing from the spirit of my invention as defined by the following claims.

I claim:

1. A helicopter of the general type including a pilot-enclosing gondola having a vertically-disposed longitudinal axis and having downwardly and outwardly flared side walls, a sustaining rotor mounted above said gondola with its axis of rotation in line with the longitudinal axis of the gondola, a series of approximately equidistantly spaced-apart blades projecting outwardly from the circumference of the gondola for offsetting the torque of the rotor, vanes mounted outwardly of and in laterally-arranged relation with reference to the blades for providing directional control, the blades and vanes being arranged in pairs and the blade and vane of each pair being mounted for pivotal movement upon substantially aligned axes and control means for selectively and independently adjusting either the blades or the vanes about their pivotal axes.

2. A helicopter of the general type including a pilot-enclosing gondola having a vertically-disposed longitudinal axis and having downwardly and outwardly flared side walls, a sustaining rotor

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mounted above said gondola with its axis of rotation in line with the longitudinal axis of the gondola, a series of laterally-extending blades mounted upon the gondola approximately equidistantly spaced apart thereabout for offsetting the torque of the rotor, vanes mounted outwardly of and in laterally-arranged relation with reference to the blades for providing directional control and operating means for selectively adjusting said vanes, said operating means comprising a control stick mounted for universal rocking movement, a plurality of cable-actuating members connected for rotation to the control stick and selectively responsive to movement of the stick in different directions, vane-supporting shafts extending through the enclosing wall of the gondola and a cable extending between each of said cable-actuating members and vane-supporting shafts.

3. A helicopter of the general type including a pilot-enclosing gondola having a vertically-disposed longitudinal axis and having downwardly and outwardly flared side walls, a sustaining rotor mounted above said gondola with its axis of rotation in line with the longitudinal axis of the gondola, a series of laterally-extending blades mounted upon the gondola approximately equidistantly spaced apart thereabout for offsetting the torque of the rotor, vanes mounted outwardly of and in laterally-arranged relation with reference to the blades for providing directional control and operating means for selectively adjusting said vanes, said operating means comprising a control stick mounted for universal rocking movement, a plurality of cable-actuating members connected for rotation to the control stick and selectively responsive to movement of the stick in different directions, vane-supporting shafts extending through the enclosing wall of the gondola and a cable extending between each of said cable-actuating members and vane-supporting shafts, said cables being arranged in pairs and the cables of each pair being simultaneously operable for moving a pair of vane-supporting shafts in unison.

4. A helicopter of the general type including a pilot-enclosing gondola having a vertically-disposed longitudinal axis and having downwardly and outwardly flared side walls, a sustaining rotor mounted above said gondola with its axis of rotation in line with the longitudinal axis of the gondola, laterally-extending blades mounted upon the gondola for offsetting the torque of the rotor, vanes mounted outwardly of and in laterally-arranged relation with reference to the blades for providing directional control and operating means for selectively adjusting said vanes and for unitarily rotating said blades, said operating means comprising a hollow control stick mounted for universal rocking movement, a plurality of cable-actuating members connected for rotation to the control stick and selectively responsive to movement of the stick in different directions, vane-supporting shafts extending through the enclosing wall of the gondola, a cable extending between each of said cable-actuating members and vane-supporting shafts, a rotatable rod extending longitudinally through the hollow control stick, a hand grip connected to said rod for rotating the rod, a spool mounted upon said rod, a plurality of blade-supporting shafts extending through the enclosing wall of the gondola and a cable extending around the sheave and connected to each of said blade-supporting shafts.

5. In a helicopter of the class described having

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laterally-disposed torque-stabilizing blades and directional-control vanes, a control mechanism for adjusting the positions of said blades and vanes about horizontal axes, said mechanism comprising a hollow control stick pivotally mounted upon a hollow tube for rocking movement in a plane extending lengthwise of the tube, trunnions mounted upon opposite sides of the tube and in line with each other and with the pivoted axis of the stick, a segmental member bridging the opposed ends of the trunnions and passing through a slot in the stick, said tube and trunnions being supported for oscillating movement, a rod extending lengthwise through the stick, a hand-grip secured to the upper end of the rod projecting above the upper end of the stick, means for releasably locking the rod to the stick, a stub shaft universally coupled to the lower end of the rod and extending through the tube, a spool mounted upon a portion of the stub shaft located within the tube and adapted to have a blade-operating cable wound thereon, and means on each trunnion for connecting a vane-operating cable thereto.

6. A helicopter of the general type including a pilot-enclosing gondola having a vertically-disposed longitudinal axis and having downwardly and outwardly flared side walls, a sustaining rotor mounted above said gondola with its axis of rotation in line with the longitudinal axis of the

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gondola, laterally-extending blades mounted upon the gondola for offsetting the torque of the rotor, vanes mounted outwardly of and in laterally-arranged relation with reference to the blades for providing directional control and operating means for rotating companion vanes and blades about a common axis for adjusting their angular position relative to the slipstream of the rotor, said operating means comprising hollow blade-supporting shafts extending horizontally through the enclosing wall of the gondola, vane-supporting shafts extending through the hollow shafts and a control stick for rotating said inner and outer shafts independently of each other.

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