

July 12, 1966

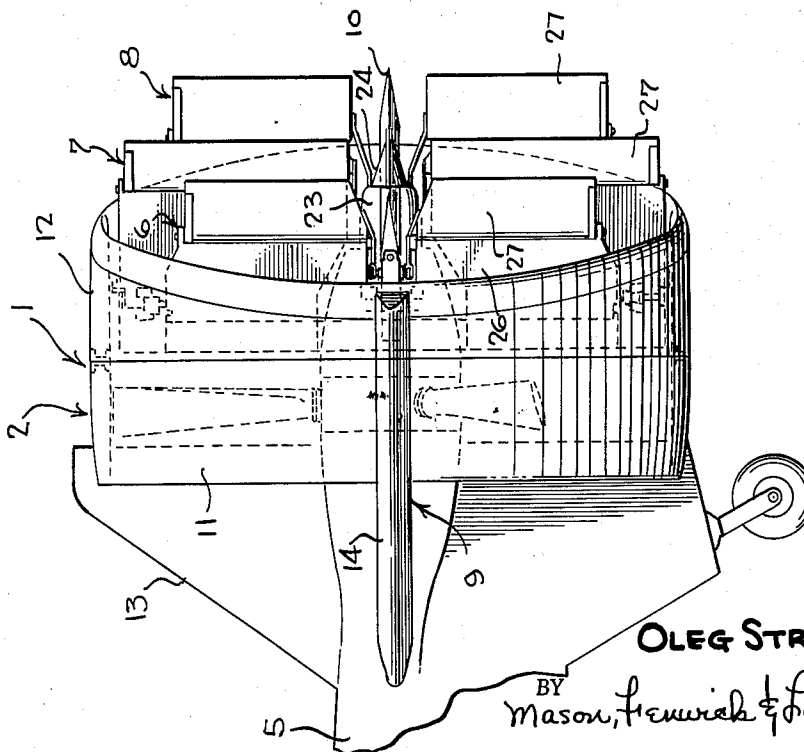
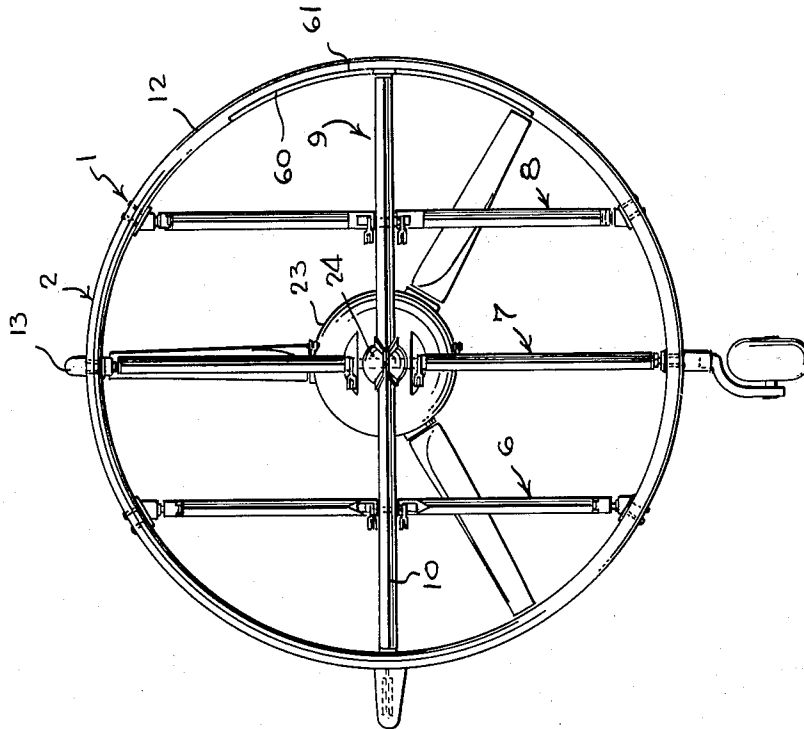
O. STROUKOFF

3,260,482

DIRECTIONAL CONTROL ASSEMBLY

Filed Dec. 3, 1964

5 Sheets-Sheet 1



INVENTOR

OLEG STROUKOFF

BY
Mason, Fenwick & Lawrence
ATTORNEYS

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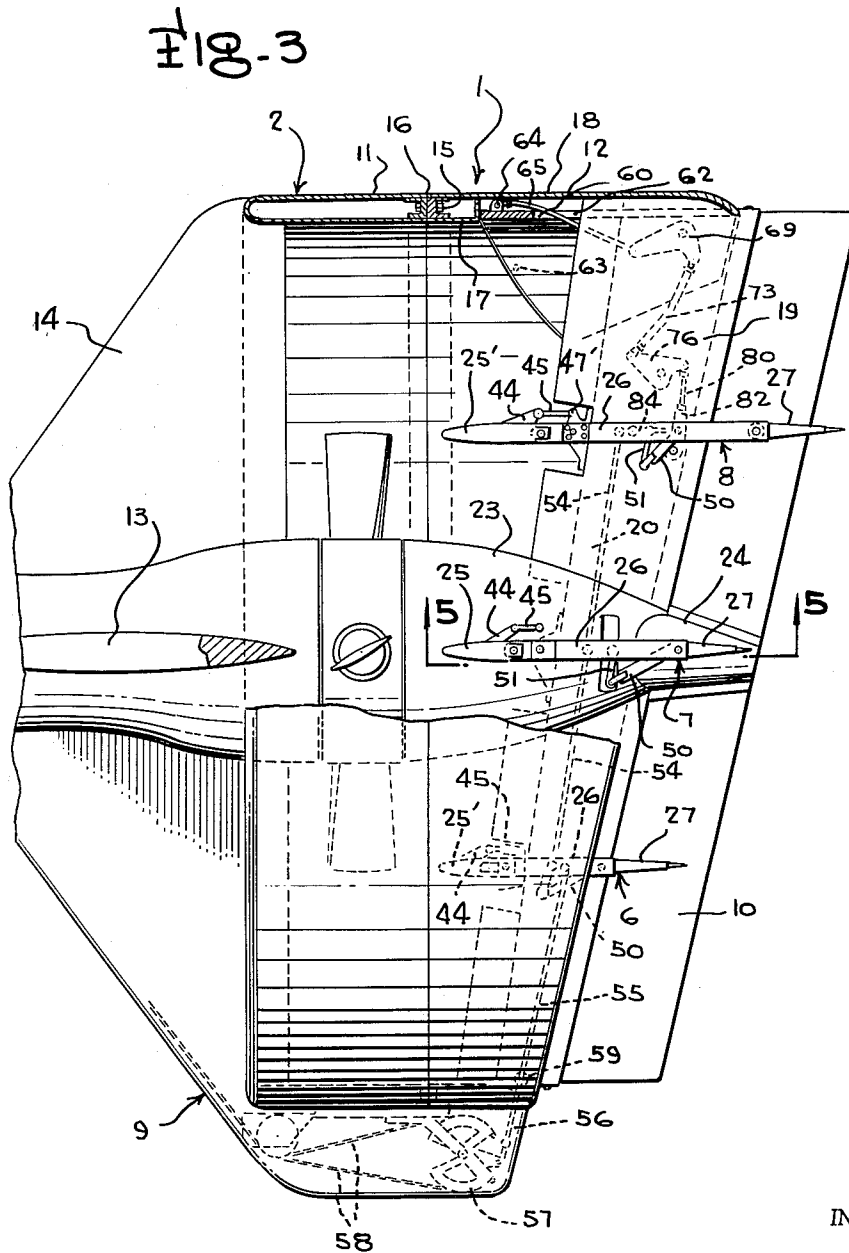
O. STROUKOFF

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INVENTOR

OLEG STROUKOFF

BY
Mason, Fenwick & Lawrence
ATTORNEYS

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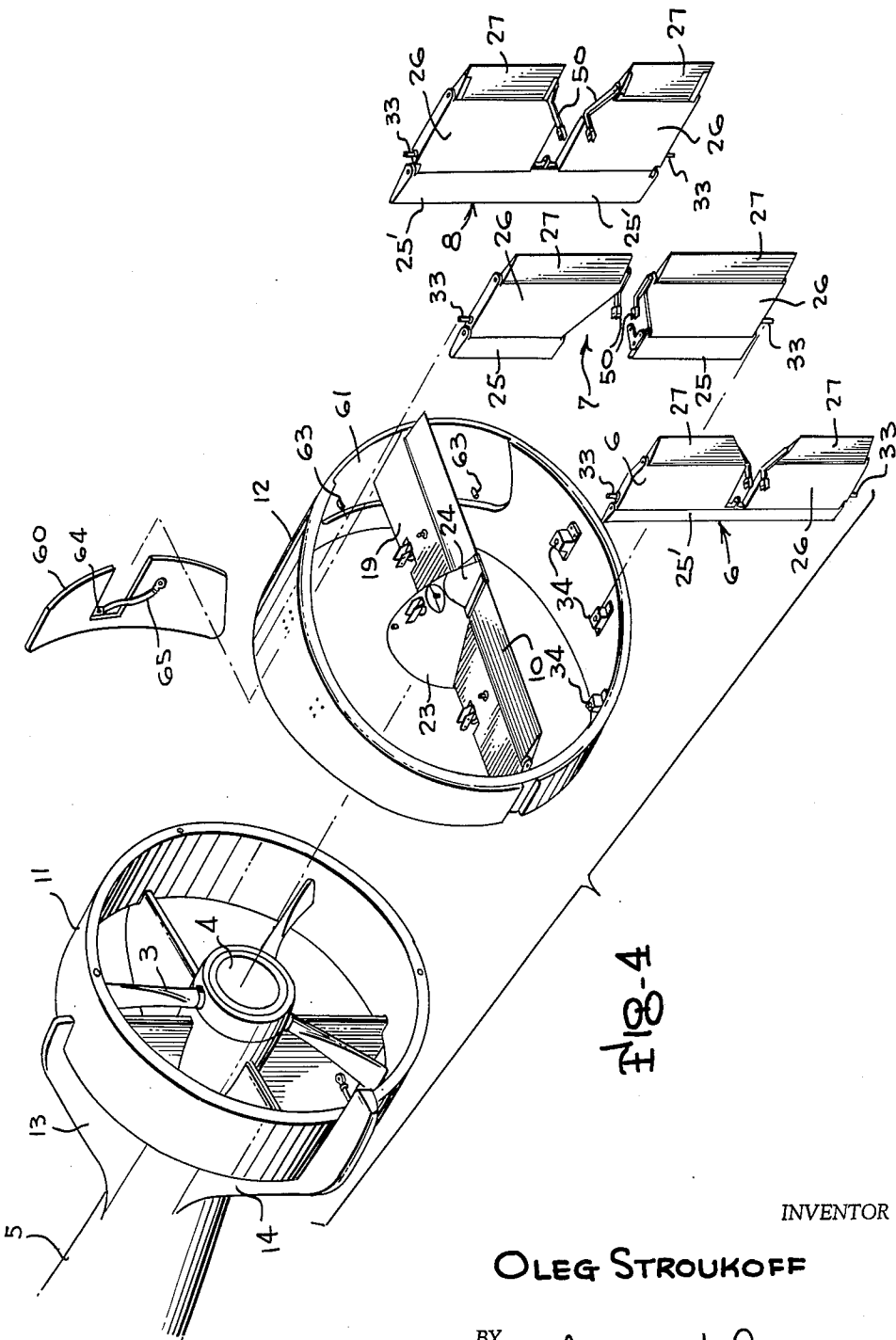


FIG-4

INVENTOR

OLEG STROUKOFF

BY
Mason, Fenwick & Lawrence
ATTORNEY

July 12, 1966

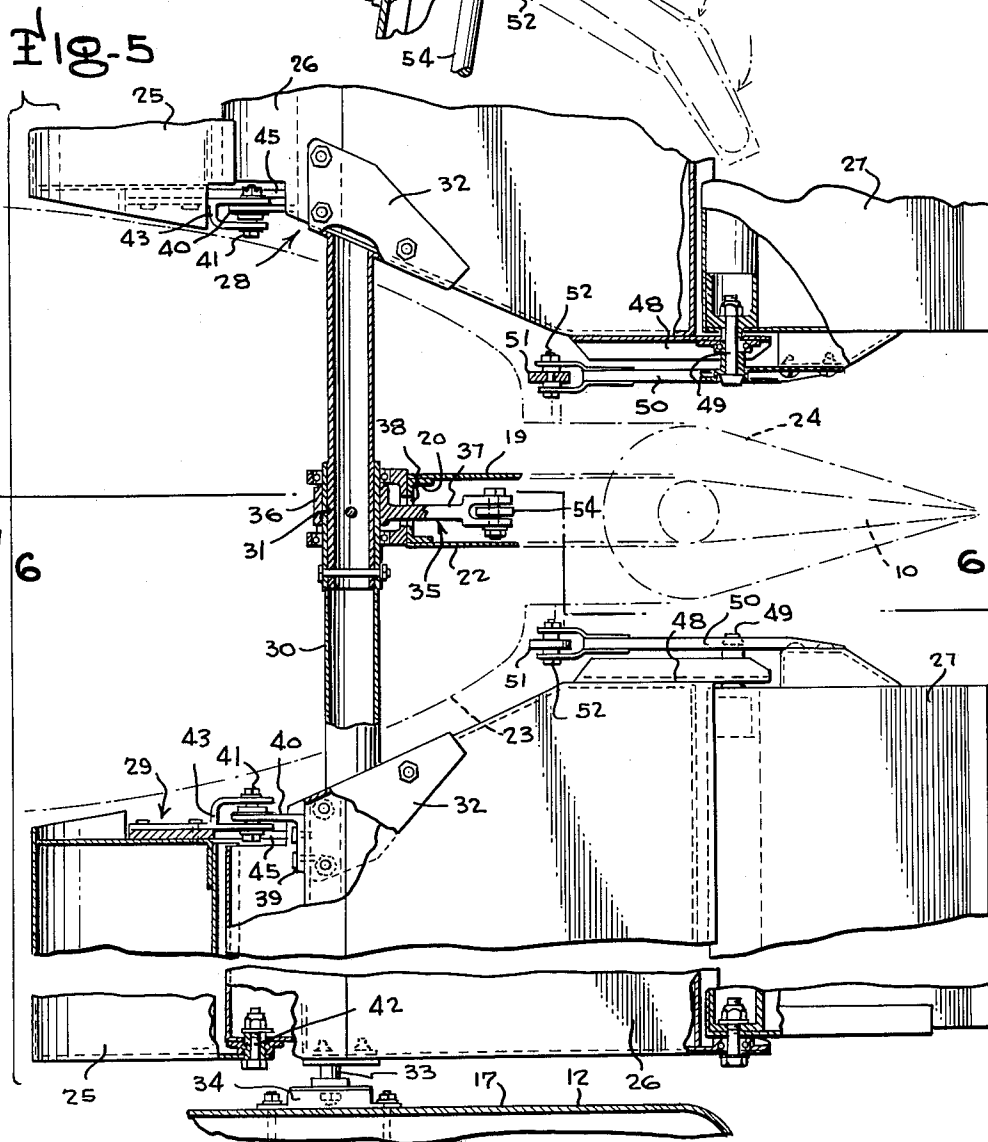
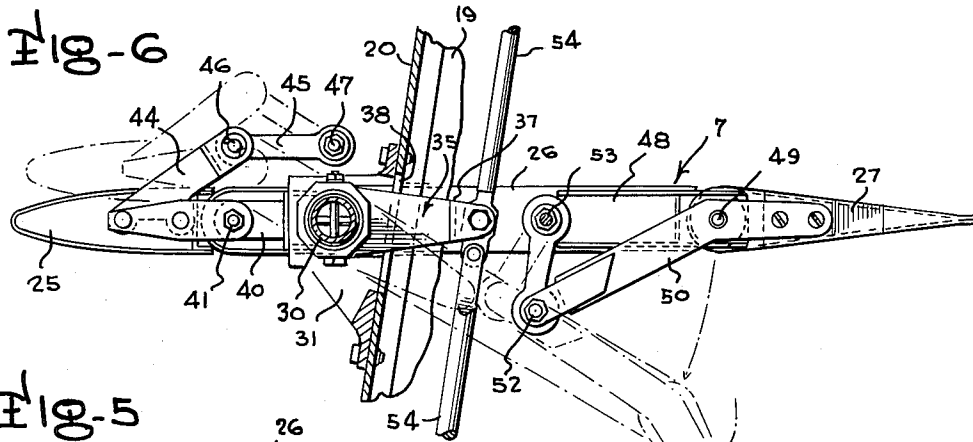
O. STROUKOFF

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DIRECTIONAL CONTROL ASSEMBLY

Oleg Stroukoff, Gloucester City, N.J., assignor to Piasecki Aircraft Corporation, Philadelphia, Pa., a corporation of Pennsylvania

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12 Claims. (Cl. 244—51)

This invention relates to tail structure for compound helicopters, and more particularly to improvements in so-called ring tail structures, and the means for counteracting rotor torque and providing azimuth control which form part of such structure.

In co-pending application Serial No. 305,269, filed August 29, 1963, now U.S. Patent 3,222,012 entitled Slip Stream Deflector Assembly for Aircraft, Frank N. Piasecki, inventor, a ring tail for compound helicopters is disclosed, which includes a circular shroud having a propeller mounted therein on a shaft concentric to the shroud and parallel with the longitudinal axis of the helicopter fuselage. At the trailing edge of the shroud, there is a plurality of vertical vanes of several sections each, mounted for simultaneous operation for deflection and camber change. Operation of the propeller with the vanes deflected serves to counteract rotor torque when the aircraft is in hovering regime, and the propeller becomes a pusher propeller and the vanes provide lateral directional control for forward flight.

The principal object of the present invention is to provide an improved tail assembly of the above described general type.

A more specific object is the provision of such a tail assembly wherein the vanes and their control linkages are mounted in a demountable section of the shroud, to permit removal of the vanes as a unit for access to the propeller, and remounting of the demountable section without requiring re-rigging, or readjustment, of the vanes or their controls.

Another object is the provision of an auxiliary vane, movable from a position forming part of the inner surface of the shroud during forward flight to a fully deflected position at an angle to the shroud surface during hovering.

A further object of the invention is to provide controls for the auxiliary vane, which are interconnected with the primary vanes and arranged to cause movement of the auxiliary vane during only a predetermined portion of the range of movement of primary vanes.

It is also an object to provide for locking the auxiliary vane in its open and closed positions to reduce the control load of this vane to zero in these positions and thus reduce the work necessary to control the primary vanes to which the auxiliary vane is attached.

Yet another object of the invention is to provide improved mounting for the primary vanes, and improved means for controlling their movement.

Other objects of the invention will become apparent from the following description of one practical embodiment thereof, when taken in conjunction with the drawings which accompany, and form part of, this specification.

In the drawings:

FIGURE 1 is a side elevation of a tail section of a compound helicopter embodying the principles of the present invention;

FIGURE 2 is an end view of the structure shown in FIGURE 1;

FIGURE 3 is a top plan view of the improved tail structure shown in FIGURES 1 and 2, but on a larger scale, parts being broken away to show the interior of the shroud;

FIGURE 4 is an exploded perspective view of the principal components of the tail structure;

FIGURE 5 is a fragmentary vertical section through the tail in the region of the intermediate primary vane, taken substantially along the line 5—5 of FIGURE 3, but shown on an enlarged scale, parts being broken away to show interior structure of the vane;

FIGURE 6 is a partial horizontal section taken on the line 6—6 of FIGURE 5; and

FIGURE 7 is a horizontal section through the starboard side of the shroud, showing the starboard primary vane, the auxiliary vane, the linkage interconnecting the sections of the starboard primary vane, and the linkage interconnecting the primary and auxiliary vanes to provide for movement of the auxiliary vane during a predetermined range of the movement of the primary vanes.

Referring to the drawings in detail, there is shown a tail section 1 of a compound helicopter of the type shown in detail in the above mentioned co-pending application, Serial No. 305,269, and reference to that application may be had for the arrangement of the complete aircraft. The tail section is what is known as a ring tail, consisting of an annular shroud, or ring, 2 in which is mounted a propeller 3, on a shaft 4, extending longitudinally of the fuselage 5 and positioned concentrically to the shroud. The propeller is in the forepart of the shroud and a plurality of vertically positioned, direction control vanes 6, 7 and 8 are mounted adjacent the trailing edge. A rigid, horizontal stabilizer 9 spans the shroud diametrically aft of the propeller, and a trim tab 10 is pivotally mounted along the trailing edge of the horizontal stabilizer. This much of the structure is shown in the mentioned co-pending application.

In accordance with the present invention, the shroud is divided along a lateral, vertical plane just aft of the propeller to provide a fixed shroud section 11 and a demountable shroud section 12. The fixed section is rigidly mounted at the aft end of the fuselage and connected to the vertical stabilizer 13 and a forward section 14 of the horizontal stabilizer 9. The removable section 12 is attached to the fixed section by bolts 15. All of the control vanes, and their control means, are mounted on the demountable shroud section, as will be described, so that the section, with the fully rigged control vanes, may be removed as a unit, and re-connected to the fixed section without disturbing the control assembly.

Although the fixed section of the shroud has its fore and aft edges parallel and at right angles to the longitudinal axis of the aircraft, the demountable section has its forward edge at right angles to the axis, for flush mating with the fixed section, but its trailing edge is inclined laterally, so that the port side of the section is relatively narrow and the section increases in thickness from port to starboard. The increased thickness on the starboard side is required because of the necessity for greater airstream deflection to the left to counteract torque when the overhead rotor is rotated counterclockwise when viewed from above. When the rotor turns in a reverse direction, the shroud design must be reversed. The directional control vanes 6, 7 and 8, mounted in the shroud sections 12, are graduated in length, with the port vane 6 being the shortest and the starboard vane 8 the longest. This will provide for maximum turning power in the deflected position during hovering, while adding minimum drag in the high speed forward flight arrangement, as will be described.

The demountable shroud section 12 may be constructed in any desired manner, but it is shown as comprising an annular channel 16 at its forward end, to which the edges of inner and outer surface-forming members 17 and 18 are attached. The sheets, or members, 17 and 18 are shaped to define a desired air-foil contour, and are joined

at the trailing, feather edge of the shroud. Any other desired, or required, strengthening, or forming, members may be used within the shell formed by the surface sheets 17 and 18.

An aft unit 19 of the horizontal stabilizer 9 traverses the shroud section 12 adjacent the trailing edge. The stabilizer is supported upon a spar 20 which spans the shroud and has its ends fixed to channels 21 welded, or otherwise suitably attached, to the outer shroud surface sheet 18. The stabilizer has its surfaces defined by an outer skin 22 to provide the desired air-foil contour. The pitch trim tab 10 is hingedly connected to the trailing edge of the stabilizer unit 19. Suitable fairings 23 and 24 from the propeller hub across the stabilizer and trim tab may be used.

The three primary direction-controlling vanes mounted in the shroud section 12 are quite similar except for size. The port and starboard vanes are substantially identical in construction and control, but there are some minor differences between these vanes and the center vane, caused by the presence of the fairings 23 and 24 extending above and below the stabilizer. In view of the similarity between the vanes, the center vane 7 will be described in detail and the same reference numerals will be used in connection with the vanes 6 and 8 insofar as they apply, and the differences between the outside vanes and the center vane will be pointed out.

Vane 7 is composed of three members, a nose portion 25, a main member 26 and a trailing portion 27. The main member is pivotally mounted in the shroud for turning about a vertical axis, and the nose and trailing portions are pivotally mounted at the leading and trailing edges, respectively, of the main member. Linkage is provided so that when the main member is rotated on its axis, the nose and trailing portions will be moved bodily in opposite lateral directions, and, at the same time, the nose and trailing portions will be turned in opposite directions about their pivotal connections with the main member to provide or change the degree of, camber in the working surface of the vane. The vane is a divided one, having an upper section 28 and a lower section 29, with each section having three vane members as described, and the two sections acting in unison as a single vane. This is required as the vane is at the center of the shroud and it is necessary to avoid interference with the propeller fairing.

The two sections are held in spaced relation above and below the horizontal stabilizer by means of a torque tube 30 mounted in a bearing 31 bolted to the spar 20 of the stabilizer. Mounting brackets 32 at the top and bottom of the tube seat the adjacent edges of the main members 26 of the upper and lower sections. The brackets are suitably attached to the members 26. Pivots 33 are secured to the upper and lower edges of the upper and lower section main vane members 26, which are rotatably held in bearing members 34 fixed to the interior wall of the shroud. Pivots 33 and the torque tube 30 are in axial alignment and together form the pivot upon which the main vane portion turns. The use of the torque tube intermediate the two vane sections provides a rigid connector, and its mounting on the stabilizer spar provides added support for, and strengthens, the stabilizer. A driving horn 35 has a hub 36 which encircles, and is pinned to, the torque tube, and a lever arm 37 which projects through an opening 38 in the stabilizer spar 20 to lie within the stabilizer. Rocking the horn will cause rotative movement of the main vane member 26.

Angle brackets 39 are secured to mounting brackets 32, and have forwardly projecting arms 40 to receive hinge pins 41 to mount one end of each of the sections of the nose vane portion 25 to the leading edge of the main vane member 26. The opposite ends of the sections of nose portion 25 are pivotally connected by pins 42 to the opposite ends of the main vane members 26. Brackets 43, which are connected to nose vane portions 25 and through which hinge pins 41 pass, have operating arms

44 projecting at an angle to connect to links 45 by pins 46. The opposite ends of links 45 are anchored through pins 47 to the stabilizer. The pivotal connections 41, 46, 47 and torque tube 30 are arranged to form the corners of a parallelogram. Because of this, rotative movement of the main vane member 26 about the torque tube will result in bodily shifting the nose portion 25 in a lateral direction, but the nose portion will maintain a position parallel to the longitudinal axis of the aircraft. As the movement of the three primary vanes is similar, the nose portions will define between them entrances into the channels between the vanes for air delivered by the tail propeller. This will be true for all positions of the primary vanes.

At the top and bottom of each section of the main vane member, there is a mounting bracket 48, projecting rearwardly beyond the trailing edge of the main member, to which the trailing vane portions 27 are connected. Pins 49 through brackets 48 and into the trailing portions pivotally mount the trailing portions on the brackets. The adjacent edges of the upper and lower sections of the trailing vane portion carry control arms 50 rigidly attached to the vanes aft of the pivots 49 and extending forwardly of the pivots 49. Pivot pins 49 project through these control arms intermediate their lengths, and the free ends of the arms are connected to links 51 by pins 52. The opposite ends of links 51 are anchored to the stabilizer by pins 53. The axes of the pins 53 coincide with the vertical, longitudinal, central plane of the vane 7 when the vane is in its undeflected position.

As a consequence of the pivotal connection of the main member 26 of the vane to the shroud, the pivotal mounting of the nose and trailing portions of the vane on opposite ends of the main member, and the anchoring of the control linkage of the nose and trailing portions to fixed members of the tail structure, the nose and trailing portions will move bodily in opposite lateral directions whenever the main member is moved about its pivot. At the same time, the nose and trailing portions will change angular relationship with the main member. The effect of this is to change the overall vane from a straight vane in undeflected position to one having a progressively increasing concave reaction face as the degree of deflection increases, to increase the effectiveness of the vane as a lateral control member in the various operating regimes of the aircraft.

The port and starboard primary vanes differ from the one just described principally in having the nose portion 25' as a continuous member throughout its full length. Therefore, only a single parallelogram control linkage arrangement is required, and the anchor pin 47' is mounted directly on the bracket 31. The same is true for the anchor pins 53' for the control linkage of the trailing portions of these vanes. As in all other respects the vanes and their controls are the same, the same reference characters have been used.

The driving horns 35 of the three primary vanes are interconnected by drive rods 54, pivotally connected to the arms 37 of the respective horns. This will cause simultaneous movement of the three vanes. A driving rod 55 is coupled to the horn of the port vane 25 and to a connector 56, which, in turn, is connected to a control quadrant 57. Cables 58 run from the sector 57 to rudder pedals (not shown) in the pilot compartment. Thus, movement of the pedals will cause deflection of the vanes as desired. By removal of pin 59, driving rod 55 and connector 56 will be separated, leaving the entire vane assembly free for removal as part of the demountable shroud section. When the shroud section is replaced, a simple reinsertion of the pin 59 is all that is required to put the entire vane system in working order.

The present invention contemplates the use of a fourth, or auxiliary, vane 60 which will have stationary operative, and inoperative, positions, and be movable from one to the other only during a predetermined range of

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deflection of the vane 7. In the inoperative position, the auxiliary vane 60 lies completely out of the path of air from the propeller, and within a recess in the shroud inner wall to form part of that wall.

Vane 60 seats within a recess 61 formed in the inner wall of the demountable section of the shroud at the starboard, or widest, side. The recess extends equidistant above and below the stabilizer 19, and opens to the trailing edge of the shroud section. The vane fits freely within the recess, and is arcuate from end to end to form part of the cylindrical shroud inner wall when in place. The vane is notched inwardly from its trailing end, as at 62, for free movement over the stabilizer. Pivot pins 63 are mounted within the recess in vertical alignment, spaced equidistant from the ends of the recess, for connection to the vane to provide for rocking movement of the vane.

An operating horn 64 is attached to the back of the vane at its center vertically, at a point forwardly of a transverse vertical plane through the shroud which includes the common axes of the pivot pins 63. A drive link 65 has one end pivotally connected to the horn 64, as at 66, and its other end pivotally connected at 67 to one arm 68 of a bell-crank 69, pivotally mounted in the stabilizer 19 on a pivot 70. The other arm 71 of bell-crank 69 is attached at 72 to one end of a drag link 73, which has its opposite end coupled at 74 to one arm 75 of a second bell-crank 76. A pivot 77 mounts bell-crank 76 on the stabilizer, and the other arm 78 of the bell-crank is connected at 79 to a link 80. Link 80, in turn is connected at 81 to one end of an actuating lever 82, pivoted at 83 to the stabilizer. A connecting link 84, attached at 85 to the lever 82 intermediate its pivot and the connection to link 80, couples the lever at 81 to the driving horn 35 of the starboard primary vane 8. The above described connecting linkage will cause the auxiliary vane to move through its full range of travel whenever the primary vanes move through their full range of deflection.

It is desired, however, that the primary vanes have movement through a limited arc of deflection without causing movement of the auxiliary vane, so that lateral directional control during horizontal flight may be accomplished through movement of the primary vanes alone. When the limited arc of deflection of the primary vanes has been exceeded, it is desirable for the auxiliary vane to move quickly from its closed to fully deflected position, to have the full effect of the auxiliary vane for added torque control during the range of movement of the primary vanes required for lateral control while hovering. This manner of movement of the respective vanes is accomplished by the above described linkage, and, at the same time, the linkage serves to lock the auxiliary vane in its two extreme positions and relieve the pilot controls of the vane load.

Referring particularly to FIGURE 7 of the drawings, it will be noted that connecting link 84 is in longitudinal alignment with the horn 35 of the vane 8. Thus, pivots 30, 86 and 85 are in alignment, and initial rocking movement of horn 35 is on the flat of the arc so that relatively no drag is placed upon link 84. This provides a dwell for the actuating linkage of the auxiliary vane, permitting independent, initial movement of the primary vanes. The arrangement permits a 10° to 12° movement of the primary vanes in either direction without movement of the auxiliary vane, and this is sufficient for normal lateral directional control in high-speed, forward flight. It will be noted also, that any tendency of the auxiliary vane to move out of the recess is blocked by reason of the fact that pivotal connection 81 is over center with respect to pivots 79 and 83 when the vane is in inoperative position. Thus, there is no load imposed by the auxiliary vane upon the pilot controls during normal forward flight. When the vane is extended, the pivots 72, 74 and 77 are aligned to withstand the load of the vane, and again,

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there is no added load upon the pilot controls. Therefore, the load of the auxiliary vane is only imposed upon the pilot controls during movement of the vane to and from extended position. As the vane moves rather quickly, for example, during movement of the primary vanes from approximately 12° to 36° deflection, the additional loading of the controls occurs during change-over between hover and forward flight conditions. In either regime, the primary vane may be operated to change, or control, lateral direction of the aircraft, and no additional load is imposed on the controls by the auxiliary vane. The effect of the arrangement is to provide additional reaction, or control surface, for the air from the tail propeller during hovering, yet provide free independent movement, without added load, of the primary vanes for steering control in either hovering or forward flight.

While in the above, one practical embodiment of the invention has been disclosed, it will be apparent that the details of construction shown and described are merely by way of example, and the invention may take other forms within the scope of the appended claims.

What is claimed is:

1. A directional control assembly for aircraft comprising, a circular shroud having a center axis, a propeller in the shroud mounted for rotation about the axis of the shroud, a plurality of control vanes pivotally mounted in the shroud in the path of the slipstream from the propeller in parallel, spaced arrangement, control linkage interconnecting the vanes to provide simultaneous movement of the vanes, the shroud having an unbroken outer wall and an inner wall having a recess adjacent the edge thereof remote from the propeller and in alignment with the parallel spaced control vanes, an auxiliary vane having the curvature of the inner wall of the shroud pivotally mounted on the shroud for seating in the recess flush with the inner wall of the shroud in an inoperative position, and auxiliary linkage connecting the auxiliary vane and the control linkage for moving the auxiliary vane about its pivotal mounting with movement of the control vanes to and from an operative position at an angle to the inner wall of the shroud.

2. A directional control assembly for aircraft as claimed in claim 1 wherein, the auxiliary linkage includes means to transmit movement from the control linkage to the auxiliary vane only during an intermediate range of deflection of the control vanes from a neutral position parallel to the center axis of the shroud, and to hold the auxiliary vane in inoperative position during an initial range of deflection of the control vanes from said neutral position and in inoperative position during a terminal range of deflection of the control vanes from the neutral position.

3. A directional control assembly for aircraft as claimed in claim 1 wherein, the auxiliary linkage includes linkages assemblies having over-center positions when the auxiliary vane is in operative and inoperative positions to prevent the load of the auxiliary vane being transmitted to the control linkage.

4. A directional control assembly for aircraft as claimed in claim 1 wherein, the shroud has separate leading and trailing sections and there are means to releasably join the shroud sections together, the propeller being mounted in the leading section of the shroud, and the control vanes, auxiliary vane, control linkage and the auxiliary linkage are mounted in the trailing shroud section.

5. A directional control assembly for aircraft comprising, a circular shroud mounted having a center axis, the shroud having separate, leading and trailing sections, means to releasably secure the shroud sections together, a propeller in the leading section of the shroud mounted for rotation about the axis of the shroud, a plurality of control vanes pivotally mounted in the trailing section of the shroud in parallel, spaced arrangement, and control linkage mounted in the trailing shroud section and interconnecting the vanes to cause simultaneous deflec-

tion of the vanes for directional control of the aircraft, whereby the trailing section of the shroud with the mounted control vanes and control linkage may be removed from the leading section without disconnecting the control linkage from the vanes.

6. A directional control assembly for aircraft comprising, a circular shroud having a center axis, a propeller in the shroud mounted for rotation about the axis of the shroud, a plurality of control vanes in the shroud in the path of the slipstream of the propeller in parallel, spaced arrangement, each vane consisting of a main member, a nose portion and a trailing portion, the main members of the vanes being mounted in the shroud for movement about pivotal axes, means pivotally connecting the nose portion to the main members to project toward the propeller in continuation of the main members when the main members occupy a neutral position parallel to a plane including the center axis of the shroud, means pivotally connecting the trailing portions to the main members to project away from the propeller in continuation of the main members when the main members are in said neutral position, means interconnecting the nose portions and the shroud to permit bodily movement of the nose portions when the main members are moved from their neutral positions and to hold the nose portions parallel to said plane, and means interconnecting the trailing portions and the shroud to permit bodily movement of the trailing portions when the main members are moved and cause angular movement of the trailing portions relative to the main members, a driving horn connected to each main member, and control links connecting the driving horns of adjacent main members to cause simultaneous movement of the main members to deflect the vanes, change the camber of the vanes and maintain the nose portions of the vanes parallel to the center axis of the shroud.

7. A directional control assembly for aircraft as claimed in claim 6 wherein, the means interconnecting the nose portions includes a parallelogram linkage with the pivotal axes for the main members and the pivotal connection of the nose portions to the main members included in one side of the parallelogram.

8. A directional control assembly for aircraft as claimed in claim 6 wherein, the means connecting the trailing portions and the shroud include a lever arm rigidly connected to the trailing portion, and a link connecting the lever arm and the shroud.

9. A directional control assembly for aircraft as claimed in claim 6 wherein, the means interconnecting the nose portions includes a parallelogram linkage with the pivotal axes for the main members and the pivotal connection of the nose portions to the main members included in one side of the parallelogram, and the means connecting the trailing portions and the shroud include a lever arm rigidly connected to the trailing portion, and a link connecting the lever arm and the shroud.

10. A directional control assembly for aircraft as claimed in claim 6 wherein, the shroud has an inner wall having a recess adjacent the edge thereof remote from the propeller and in alignment with the parallel spaced control vanes, an auxiliary vane having the curvature of the inner wall of the shroud for seating in the recess flush with the inner wall of the shroud in an inoperative position, and auxiliary linkage connecting the auxiliary vane and the control links for moving the auxiliary vane about its pivotal mounting with movement of the control vanes to and from an operative position at an angle to the inner wall of the shroud.

11. A directional control assembly for aircraft as claimed in claim 10 wherein, the auxiliary linkage includes means to transmit movement from the control links to the auxiliary vane only during an intermediate range of deflection of the control vanes from said neutral position, and to hold the auxiliary vane in inoperative position during an initial range of deflection of the control vanes from said neutral position and in operative position during a terminal range of deflection of the control vanes from the neutral position.

12. A directional control assembly for aircraft as claimed in claim 11 wherein, the auxiliary linkage includes linkage assemblies having over-center positions when the auxiliary vane is in operative and inoperative positions to prevent the load of the auxiliary vane being transmitted to the control links.

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MILTON BUCHLER, *Primary Examiner.*

B. BELKIN, *Assistant Examiner.*