

Jan. 3, 1950

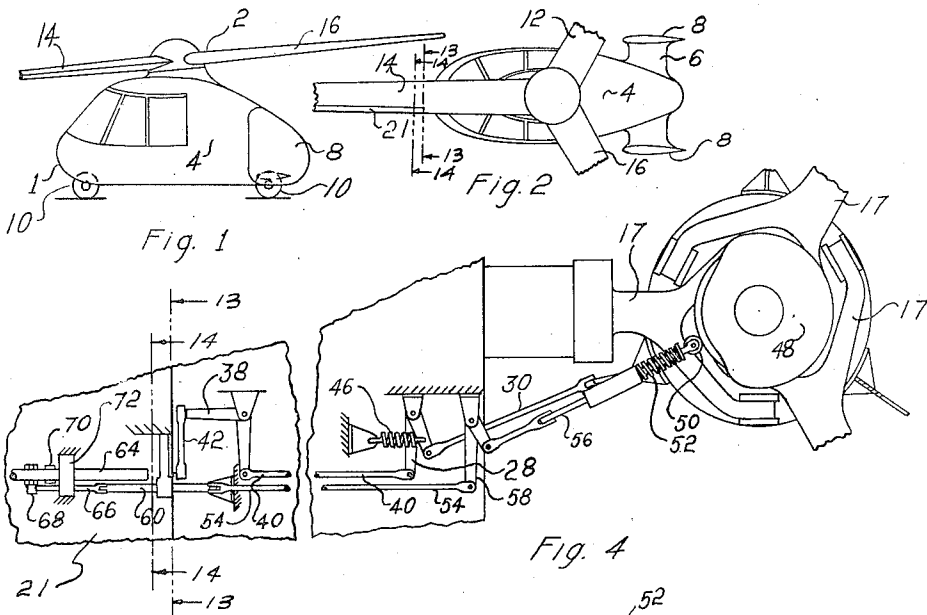
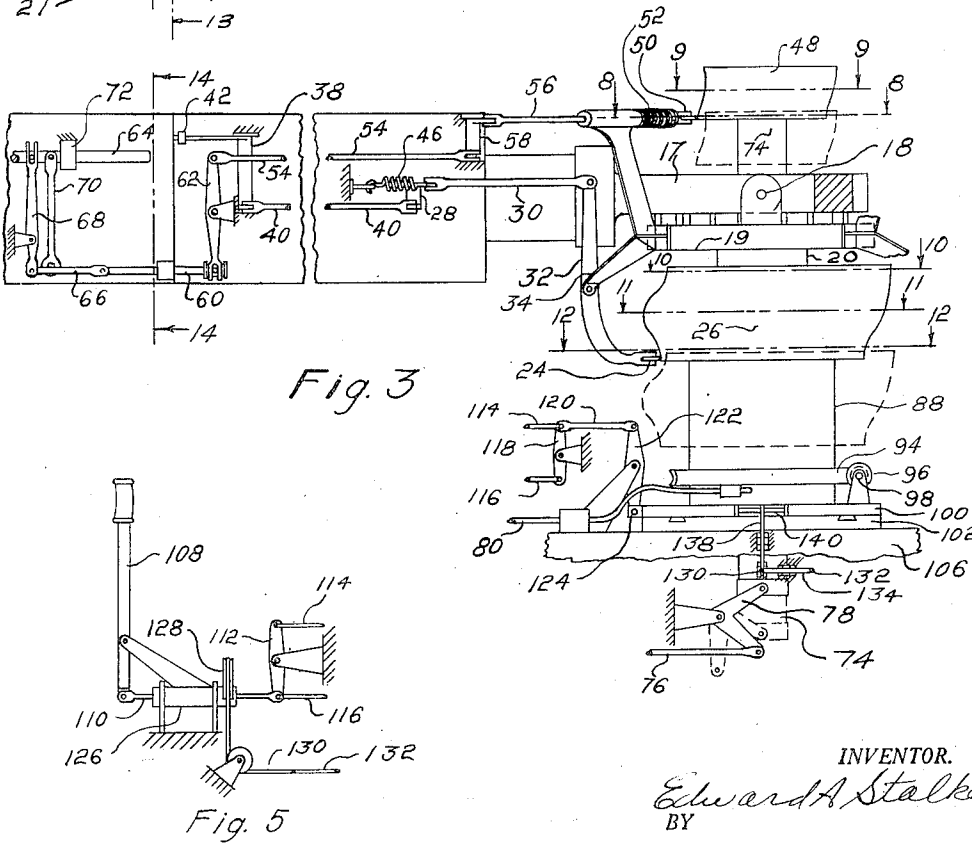
E. A. STALKER

2,493,042

DIRECT LIFT AIRCRAFT

Filed Oct. 3, 1945

2 Sheets-Sheet 1



INVENTOR.

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DIRECT LIFT AIRCRAFT

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2 Sheets-Sheet 2

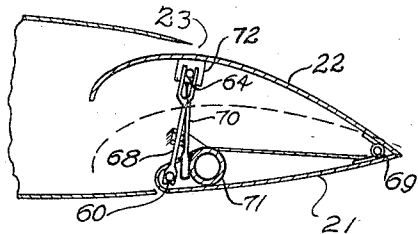


Fig. 14

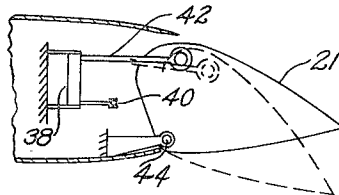


Fig. 13

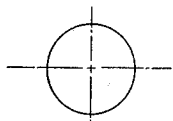


Fig. 8

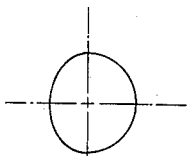


Fig. 9

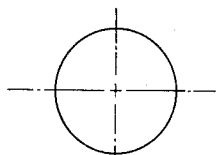


Fig. 10

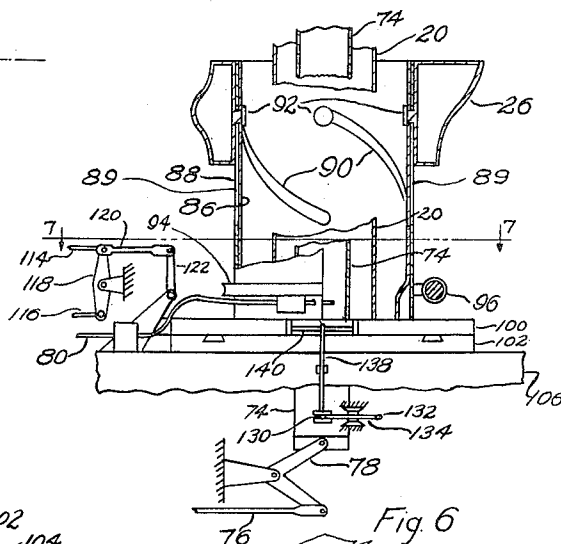


Fig. 6

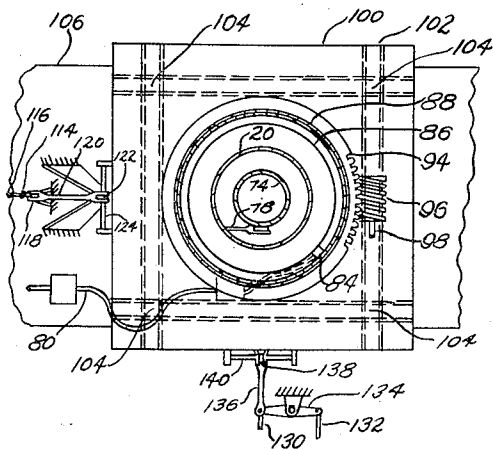


Fig. 7

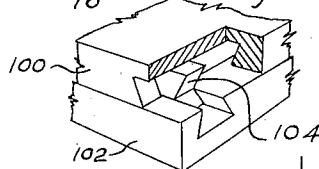


Fig. 15

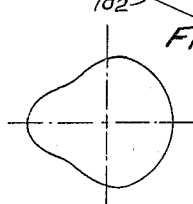


Fig. 11

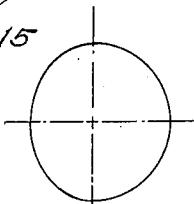


Fig. 12

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UNITED STATES PATENT OFFICE

2,493,042

DIRECT LIFT AIRCRAFT

Edward A. Stalker, Bay City, Mich.

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10 Claims. (Cl. 170—135.4)

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My invention relates to direct lift aircraft.

It has as an object the provision of means to provide orbital patterns of variations of lift throughout the blade orbit which belong to different mathematical families.

It is another object to provide means of changing the pattern of orbital lift variation to accommodate a change in advance ratio.

Another object is to provide means of changing patterns or orbital jet thrust with changing advance ratios.

Still another object is to provide a blade structure adapted to the lift varying function.

Other objects will appear from the description and drawings.

I accomplish the above objects by the means illustrated in the accompanying drawings in which—

Figure 1 is a fragmentary side elevation of the aircraft;

Figure 2 is a fragmentary top view of the aircraft;

Figure 3 is a fragmentary view of the hub and one adjoining blade showing the control mechanism, taken along the lateral axis of the aircraft;

Figure 4 is a fragmentary top view of Figure 3;

Figure 5 is a fragmentary view of the associated pilot control;

Figure 6 is a fragmentary section of the hub of Figure 3;

Figure 7 is a section along line 7—7 in Figure 6;

Figure 8 is a section through the cam along line 8—8 in Figure 3 showing the cam contour;

Figure 9 is a section through the cam along line 9—9 in Figure 3 showing the cam contour;

Figure 10 is a section through the cam along line 10—10 in Figure 3 showing the cam contour;

Figure 11 is a section through the cam along line 11—11 in Figure 3 showing the cam contour;

Figure 12 is a section of the cam along line 12—12 in Figure 3 showing the cam contour;

Figure 13 is a fragmentary section of the blade along line 13—13 in Figure 3 shown with the flap actuating mechanism which is inboard of the section plane;

Figure 14 is a fragmentary section along line 14—14 in Figure 3; and

Figure 15 is a fragmentary cut-away view of the way plates and the connecting block.

This invention provides a control of the lift of blades which is functionally flexible enough to provide orbital variations in lift of the proper magnitude for various ratios of forward flight speed to peripheral speed of the blades. These ratios are commonly called advance ratios.

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Contemporary control of the orbital variation in lift of the blades of a helicopter rotor is accomplished by a swash plate. Tilting of the plate imposes a sinusoidal variation in lift throughout the orbit for all degrees of tilting. Hence the patterns of lift variation for different degrees of tilt all belong to the same mathematical family.

In my invention the pattern of variation might be sinusoidal for one advance ratio and not sinusoidal for another advance ratio. The non-sinusoidal might follow any mathematical function.

For a given advance ratio there is a proper pattern of lift variation to provide smooth operation and a cam can be designed to provide this pattern. As soon, however, as the advance ratio changes, the pattern provided by the cam is no longer correct and vibration results.

This invention provides a cam which has a great or infinite number of cam contours so that as the advance ratio changes the pilot selects a new cam contour. These contours are peripheral about a cylindrical body of substantial length transverse to the contours just mentioned. In fact, the cam can be thought of as a great number of cylinders of varying contour stacked one upon the other with one cam surface faired into the adjacent one.

A contactor rides against the cam surface and its displacements, responsive to the cam contour, governs the orbital variation in lift of the blades. As the advance ratio increases, the pilot reduces any vibration by sliding the contour longitudinally of the contactor. He controls the aircraft generally by shifting the cam bodily either longitudinally or transversely.

The contactor is arranged to make a circuit of the cam contour while a blade makes an orbital circuit about the axis of rotation of the rotor. The main point however is that the contactor transverses the cam periphery in coordinated relation with the rotation of the blade about the rotor axis.

Another cylindrical cam is employed to govern the propulsive jet discharged from a slot in the blade so that progressively more propulsive fluid is discharged from the advancing blade as the machine proceeds from hovering to maximum forward speed.

Figures 1 and 2 show a side elevation and a top view of the aircraft composed of the fuselage 1 and rotor 2. The fuselage consists of the main body 4, the horizontal fin 6, the vertical fins 8, and the wheels 10. The rotor has three blades 12, 14 and 16 hinged with forks 17 by pins 18 to hub plate 19 which is fixed to hub shaft 20. Each

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blade has a flap 21 hinged along its forward edge for varying the camber of the wings.

Figures 3 and 4 are a side and top view respectively of the control mechanism which operates the flap 21 and the flap leaf 22 in Figure 14.

The variation in the flap position is accomplished by the cam follower 24 which runs on the surface of the cam 26. The radial movements of the follower as it follows the cam contours actuates the bell crank 28 by means of link 30 and crank 32. Crank 32, to which the cam follower 24 is mounted, is held in position relative to the blade by means of bracket 34 which is mounted on hub plate 19. Bell crank 28 in turn transmits motion to bell-crank 38 by means of the link 40. The bell-crank 38 transmits a chord-wise motion to rod 42 causing flap 21 to be pivoted about its hinge 44, thus varying the flap position according to the cam contour. The cam follower 24 is kept in constant contact with the surface of cam 26 by means of the preloaded spring 46.

The helicopter rotor is to be rotated by a propulsive jet discharged from the slot 23 formed at the junction of the flap 21 and the main body of the blade. For hovering the slot is to be open wide for all orbital positions of a blade. However as the aircraft assumes forward flight the slot is to be controlled so that more air or fluid is discharged from the blade in the advancing position than in the retreating position so as to improve the propulsive efficiency. Only enough fluid is discharged from the retreating blade to provide the proper amount of lift.

Variation of the slot width is made independent of variation of the flap attitude by the flap construction employed.

The variation in the exit slot 23 with azimuth position of the blade is accomplished by varying the position of the flap leaf 22 in Figure 14. This is done by means of the cam 48 and cam follower 50 which is kept in contact with the cam surface by spring 52. The radial movements of the cam produces a spanwise motion on rod 54 by means of push-pull rod 56 and bell-crank 58. In turn push-pull rod 54 transmits a spanwise motion to the rod 60 through crank 62. Push-pull rod 60 which is located on the flap hinge line transmits a spanwise motion to the push-pull rod 64 by means of the link 66 and crank 68. This spanwise motion of rod 64 causes the connecting link 70 which is connected at one end to the primary structural element 71 of the flap and the other end to the rod 64 to assume a slanted position, thus causing the flap leaf 22 to pivot at its hinge point 69 thus moving closer to the main structural member 71 of the flap since rod 64 is connected to the flap leaf through the slide bearing 72. Thus the flap leaf position is determined by the contour of the cam 48.

The cams can be moved in a vertical direction thus changing the contour over which the cam followers run. This change in cam contour makes it possible to have the flap 20 and flap leaf 22 in the proper position for all flight speed conditions as well as azimuth positions.

The vertical movement of the cams is accomplished as follows: Cam 48 is mounted on tube 74 which is free to move in a vertical direction. This vertical movement is transmitted from a control stick in the cabin via push-pull rod 76 and crank 78. Cam 26 is caused to move vertically by means of Bowden cable 80 which receives its motion from a control stick in the cabin. The motion of the push-pull cable 80 is transmitted to the lug 84 which is secured to drum 86 as shown

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in Figure 7. This drum 86 is free to revolve within drum 88 on which cam 26 is mounted in a manner which permits the cam to move vertically in slots 89 but not rotationally. The rotation of the drum 86 causes cam slots 90 cut into drum 86 to act on pins 92 to which the cam 26 is fixed, thus causing cam 26 to move in a vertical direction. The slots 89 in drum 88 accommodate the vertical movement of pins 92.

In addition, the angular displacement or lag in flap effectiveness may be "trimmed" by mounting the gear 94 on the flap cam drum 88 and driving the gear by means of the worm 96 and flexible shaft 98 from a control means in the cabin providing for the flap cam 26 and drum 88 to be rotated in either direction.

For maneuvering control of the aircraft the cam 26 is fixed to plate 100 which is mounted on fixed plate 102 for movement in any direction perpendicular to the axis of rotation of the blades. (Plate 102 is fixed to the aircraft structure 106.) To provide for this movement, plates 100 and 102 are equipped with ways. A square block 104 is slideably accommodated in two ways one above the other at right angles to each other. See Figure 15.

The plate 100 is moved by means of the control column 108, Figure 5. Movement fore and aft of the control column 108 is transmitted to plate 100 by means of the push-pull rod 110 and crank 112 which transmits the motion to cables 114 and 116 and thus by means of crank 118 and push-pull rod 120 and crank 122 to plate 100. Crank 122 is connected to this plate by means of rod 124 which permits the plate to move at right angles relative to the crank 122.

Movement right and left of the control column transmits a similar motion to the plates 130 by means of the torque tube 126 to which segment 128 is fixed and thus caused to rotate about the center line of the torque tube 126 and thus transmitting motion to cables 130 and 132 fixed to segment 128 which in turn transmits this motion to the plate 100 through crank 134, push-pull rod 136 and crank 138. Crank 138 is also attached to plate 100 by means of a rod 140 which permits motion at right angles relative to the crank.

I have now described suitable embodiments of my invention which are now preferred. It is to be understood however that the invention is not limited to the particular construction illustrated and described and that I intend to claim it broadly as indicated by the scope of the appended claims.

I claim:

1. In combination in a direct lift aircraft, a blade mounted for rotation about a vertical axis, lift varying means to alter the lift of said blade, a cylindrical cam having different camming contours at different cross sections along the longitudinal length thereof, a contactor making running contact with said camming surface and having its rotation about said cam coordinated with the rotation of said blade about its said axis, said cam over the longitudinal length thereof contacted by said contactor having progressively and continuously changing camming contours transverse to the length thereof, means operably connecting said contactor with said lift varying means to vary the lift of said blade in coordination with the changing contour of said camming surface, and means to change the relative longitudinal position of said contactor and cam and the offset position of said cam transversely with respect to said axis.

2. In combination in a direct lift aircraft, a

blade mounted for rotation about a vertical axis, lift varying means to alter the lift of said blade, a cylindrical cam having different camming contours at different cross sections along the longitudinal length thereof, a contactor making running contact with said camming surface and having its rotation about said cam coordinated with the rotation of said blade about its said axis, means operably connecting said contactor with said lift varying means to vary the lift of said blade in coordination with the changing contour of said camming surface, and means to displace said cam transversely to said axis while said contactor is making a circuit about said cam.

3. The combination as defined in claim 1 including a blade having a main body and an adjustable flap forming said lift varying means and supported in variable relationship to define a slot therebetween, means to induce a flow of fluid through said slot, said flap being composed of an upper surface hinged to the lower surface, and means to displace one said flap surface relative to the other said flap surface and to said main body surface to vary the said slot width.

4. The combination as defined in claim 1 including a blade having a lower flap structure forming said lift varying means and having walls spaced apart vertically and joined at their ends to provide torsional strength, an upper surface structure hinged to said lower structure, and means to displace said upper surface from said lower surface.

5. The combination as defined in claim 1 in which the lift varying means comprises a flap and a hollow torsion structure having walls extensive along a major portion of the flap chord, an oppositely positioned outer surface articulated to said structure near its aft end, and means to displace the forward end of said surface away from said structure to vary the thickness of said flap.

6. In a direct lift aircraft, a blade supported for rotation about an axis to sustain the aircraft, said blade having lift varying means to vary the blade lift, cam means defining a plurality of cam contours, contact means adapted to follow a said cam contour in contact therewith, said contact means operably relating said cam means to said lift varying means to vary the blade lift according to changes in said cam contour, and means to shift said cam in translation in a direction transverse to the said axis.

7. In a direct lift aircraft, a blade mounted for rotation about an upright axis, said wing having a movable flap to vary the effective angle of attack of said blade, means defining a variable area slot in said blade, said slot emitting a propulsive jet of fluid, slot varying means to vary the area of said slot independently of movement of said blade, cam means defining a plurality of cam contours, contact means adapted to follow a said contour in contact therewith, said contact means operably relating said cam means to said slot varying means to vary the slot width according to changes in said contour, and means to substitute one of said cam contours for another in contact with said contact means.

8. In combination in a direct lift aircraft, a blade mounted for rotation about a vertical axis into advancing and retreating positions tending to give rise to lateral disturbing moments on the aircraft, and means to preclude the occurrence of said unbalanced moments comprising means to vary the lift of said blade, cam means having a plurality of different camming contours at a plu-

ality of different cross sections along the longitudinal length thereof, said camming contours being such that axial sections therethrough are defined by opposite curved lines, a contactor making running contact with said cam means at said camming contour and having its rotation about said cam coordinated with the rotation of said blade about said vertical axis, means operably connecting said contactor with said lift varying means to vary the orbital lift of said blade in coordination with the changing shape of said camming contour, and means to change the relative longitudinal position of said contactor and cam to vary said camming contour in contact with said contactor to provide new orbital patterns of lift.

9. In combination in a direct lift aircraft, a blade mounted for rotation about a vertical axis into advancing and retreating positions tending to give rise to lateral disturbing moments on the aircraft, the disturbing moments from said blade in said positions varying with the advance ratio, and means to preclude the occurrence of said unbalanced moments comprising means to vary the lift of said blade, cam means having a plurality of different camming contours at a plurality of different cross sections along the longitudinal length thereof, a contactor making running contact with said cam means at said camming contour and having its rotation about said cam coordinated with the rotation of said blade about said vertical axis, means operably connecting said contactor with said lift varying means to vary the orbital lift of said blade in coordination with the changing shape of said camming contour, means to change the relative longitudinal position of said contactor and cam to provide other said cam contours in contact with said contactor thereby providing new orbital patterns of lift for other advance ratios, and manual maneuvering control means operably connected to said cam means to change the relative position of said cam and contactor by a movement between the said cam and contactor in a direction transverse to the first said direction of motion of said cam.

10. In a direct lift aircraft, a blade supported for rotation about an axis to sustain the aircraft, means for varying the effective angle of attack of said blade to vary the blade lift, said blade having a variable area slot, means defining a plurality of cams, each said cam having a plurality of cam contours, contact means adapted to follow a cam contour of each said cam in contact therewith, means including said contact means operably relating said cam means to said angle of attack varying means to vary said slot area and said angle of attack independently according to respective changes in said contours, and means to change from one said cam contour to another in contact with said contact means.

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