Dec. 29, 1964 P. E. BARNES ETAL 3,163,231

TWO-PART PITCH CHANGING MECHANISM

Filed April 29, 1963 4 Sheets-Sheet 1

FIG_1

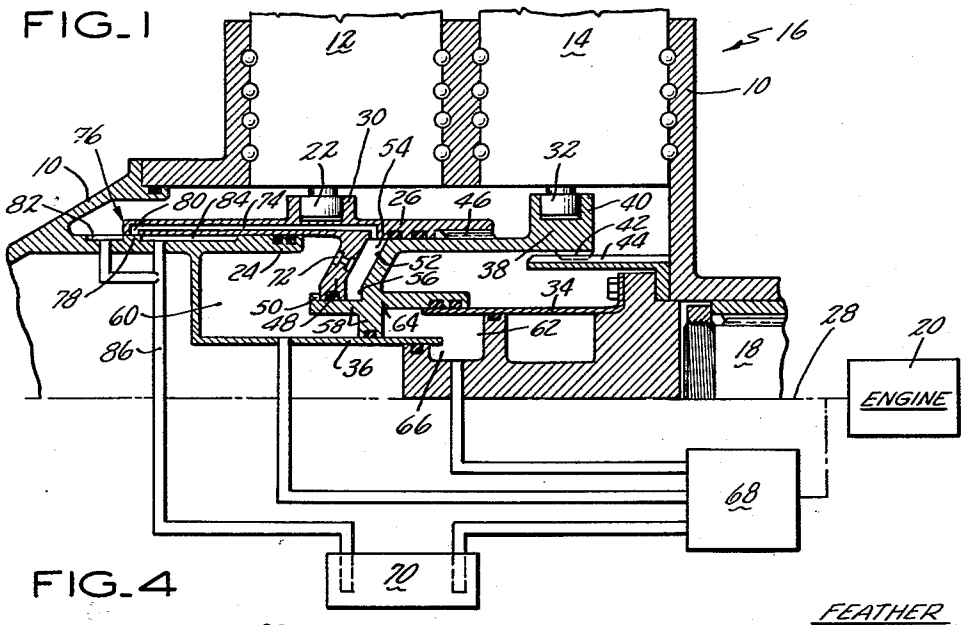
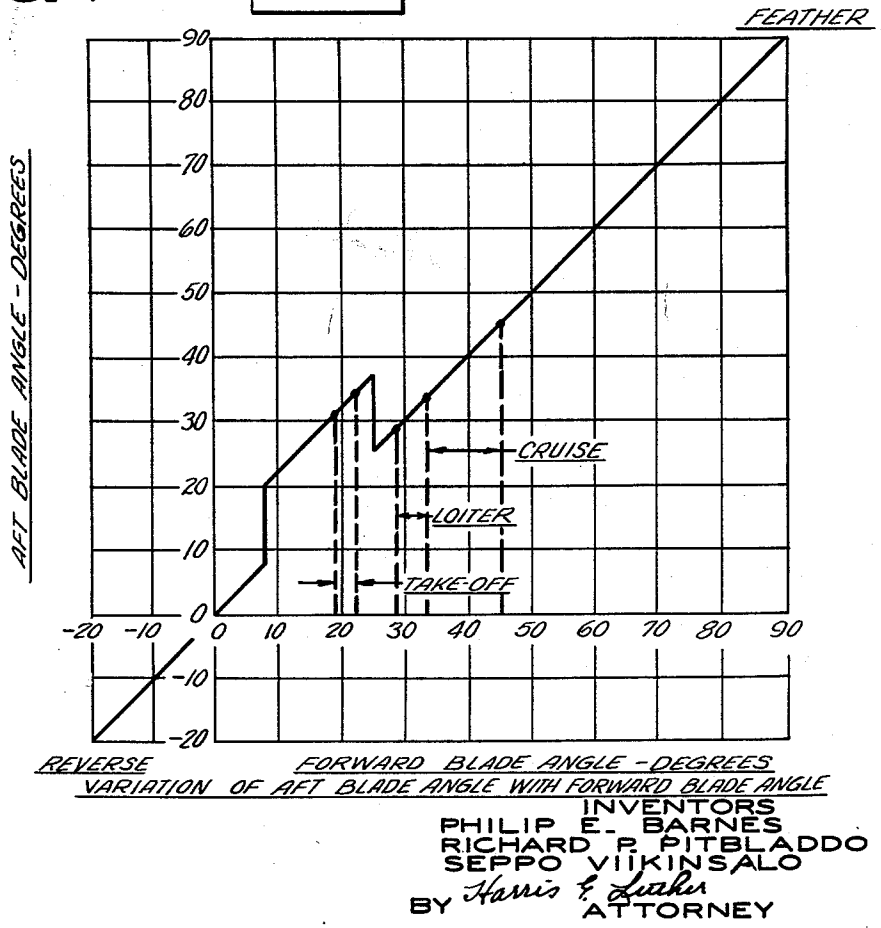


FIG_4



VARIATION OF AFT BLADE ANGLE WITH FORWARD BLADE ANGLE

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TWO-PART PITCH CHANGING MECHANISM

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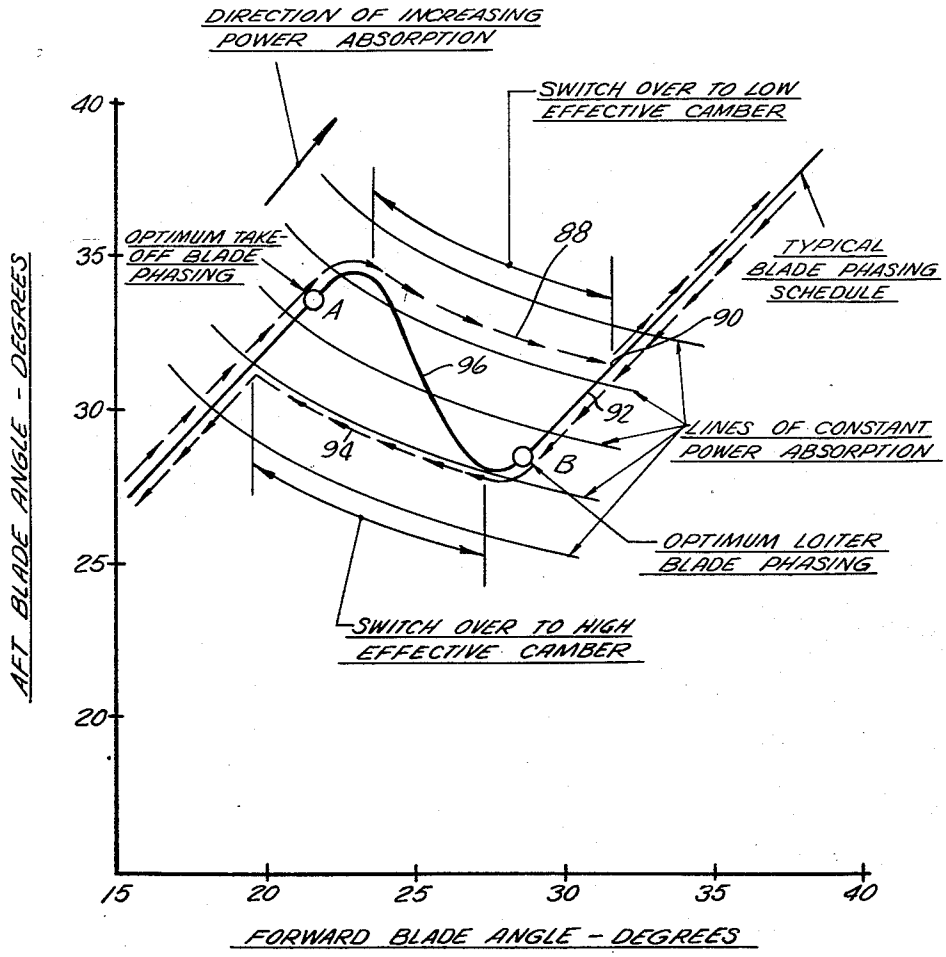
FIG. 2



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TWO-PART PITCH CHANGING MECHANISM

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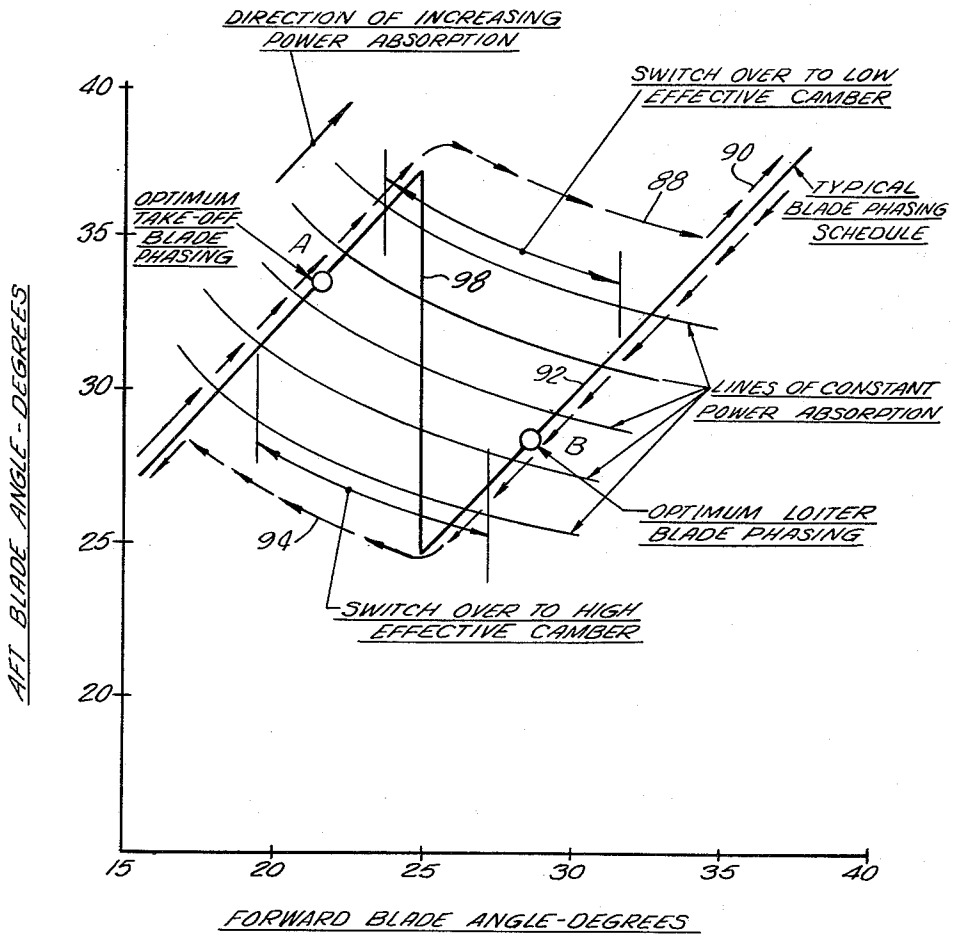
FIG_3



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TWO-PART PITCH CHANGING MECHANISM

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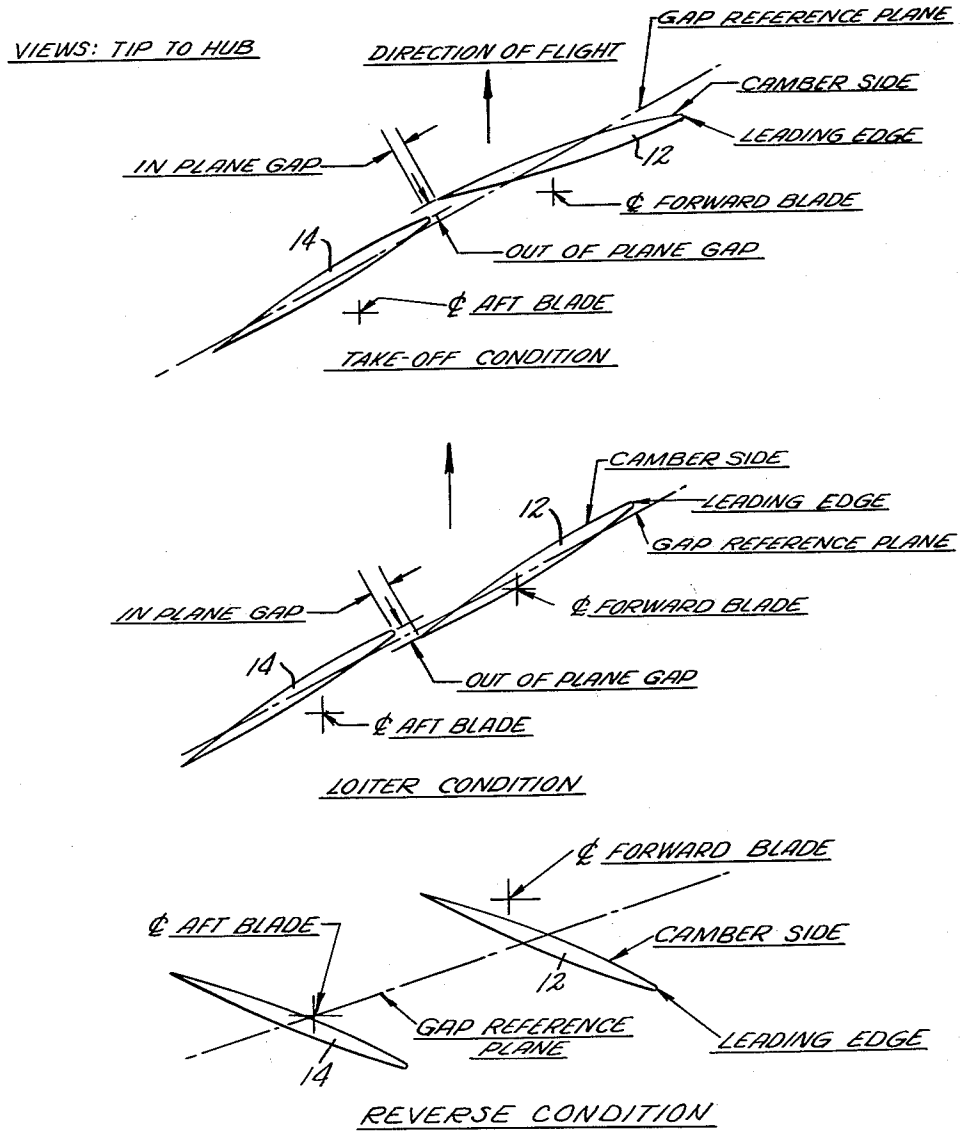
FIG_5



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TWO-PART PITCH CHANGING MECHANISM

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23 Claims. (Cl. 170—135.24)

This invention relates to propeller pitch changing mechanism and particularly to mechanism for changing the pitch together of two sets of blades and changing the pitch of one set with respect to the other.

An object of this invention is pitch changing mechanism for a variable pitch, variable camber propeller.

A further object is mechanism which will automatically change the propeller effective camber.

A further object is mechanism which will control the propeller pitch and at a preselected position change the propeller effective camber.

Other objects and advantages will be apparent from the following specification and the attached drawings in which:

FIG. 1 is a schematic view showing the pitch changing mechanism of the invention mounted in a hub supporting the two sets of blades;

FIG. 2 is a diagram showing one set of blade motions during pitch change switch over;

FIG. 3 is a diagram similar to FIG. 2 in which the switch over is initiated at the same forward blade angle for either increase or decrease pitch;

FIG. 4 is a diagram showing the relation of the two sets of blades over the entire range; and

FIG. 5 is a schematic cross-section showing the blade alignment for several operating conditions.

In operating a propeller of the type shown in Rosen Patent 2,982,361, issued May 2, 1961, it is desirable, under certain conditions, to change the effective camber of the propeller at preselected positions of the blades in their pitch changing movements. One such set of conditions would be in an airplane where it is desired to have the high effective camber for takeoff and a low effective camber for loiter and cruise conditions, in which the highest governing forward blade angle in the high camber regime is almost equal to the governing forward blade angle the low camber loiter regime. The present invention provides a structure which will accomplish the above results with a minimum of complications and mechanism.

As shown in FIG. 1 a hub 10 carries a forward set of blades 12 and a rearward set of blades 14 both mounted for pitch changing movements in the hub 10. Although only one blade of each set has been shown it should be understood that each set can contain any desired number of blades. The hub 10 and the blades 12 and 14 mounted therein provide a propeller indicated generally at 16 which is driven in any suitable manner by the shaft 18 and the engine 20. Secured to and depending from the blade 12 and eccentric to the pitch changing axis thereof is a roller 22. Mounted on an inturned projection 24 of the hub 10 is a piston 26 which may be reciprocated axially along the hub axis 28 but held in a predetermined rotative position with respect to the hub 10 by means to be described hereinafter. Carried on the piston 26 and cooperating with the roller 22 is a slotted member 30 which may be either a scotch yoke or a cam track. Reciprocation of the piston 26 will thus impart pitch changing movements to the blade 12. Depending from and secured to the blade 14 is a similar roller 32. Mounted for reciprocation along the axis 26 of the hub 10 on extensions 34 and 36 of the hub 10 is a piston 38 telescoping with and freely movable with respect to the piston 26. Mounted on the piston 38 and cooperating with the roller 32 is a slotted

member 40 which may be a cam slot or a scotch yoke. Piston 38 carries a spline member 42 mating with a spline member 44 carried by the hub 10 to prevent relative rotation of the hub 10 and the piston 38. A similar spline connection 46 connects the pistons 26 and 38 to thus locate the piston 26 circumferentially with respect to the hub 10. These splines are preferably axially extending splines. The piston 26 carries a depending flange member 48 received between the lip 50 and the face 52 of the piston 38 and with the piston 38 forms a hydraulic motor having an expansible chamber 54. The depending flange 48, the lip 50 and the face 52 form a lost motion connection between the piston 26 and the piston 38. This connection has a limited motion or travel, one limit of which is determined by the contact of the flange 48 with the lip 50 and the other limit of which is determined by the contact of the flange 48 with the up-standing portion 56 of the face 52 of piston 38. Motion of the piston 38 along the axis 28 of the hub 10 will impart pitch changing movements to the blades 14.

The extensions 24 and 36 of the hub 10 form with the depending flange 48 of the piston 26 and the portions 58 of the piston 38 and expansible or enclosure 60. In a similar manner hub extensions 34 and 36 together with hub extensions 62 form with the portions 64 of the piston 38 an expansible chamber 66. A governor 68 which may be driven in timed relation with the propeller 16, by being connected with the drive shaft 18, may in a manner well know in the art selectively introduce hydraulic fluid under pressure into the hydraulic motors formed by chambers 60 and 66 to actuate the pistons 26 and 38 to change the propeller pitch to control the propeller speed. Hydraulic fluid may be introduced into these chambers by means well known in the art such as drilled holes in the hub or tubes in the propeller shaft, but for the sake of simplicity the fluid connections are shown schematically. A fluid reservoir 70 is associated with the governor. A restricted orifice 72 in the flange member 48 connects the chambers 54 and 60. A conduit 74 in the piston 26 connects the hydraulic motor chamber 54 with a valve indicated generally at 76. The valve 76 comprises a land 78 on hub extension 24 which cooperates with an opening 80 connected with the conduit 74 in the piston 26. Slots or recessed areas 82 and 84 are formed in the hub extension 24 and are connected by conduit 86 with the reservoir 70 and act as drains. The opening 80 and the drains 86 have a larger capacity than the orifice 72. Hence the pressure in the chamber 60 and the opening 80 blocked by land 78 pressure will build up in the chamber 54 equal to that in chamber 60 and twisting moments operating on blades 12 will separate the pistons 26 and 38 moving the lost motion connection to its limit 50. Pressure acting against the forward face of piston 38, including face 52 tends to move both blades toward a higher pitch position. Movement of the piston 26 and accordingly the blade 12 to a predetermined pitch position, determined by the land 78 and the opening 80, will connect the opening 80, conduit 74 and the chamber 54 with drain thus relieving the pressure in chamber 54. The centrifugal twisting moment acting on blade 14 together with the low pitch oil pressure in the chamber 66 will tend to reduce the pitch of blade 14 and force the piston 38 toward the piston 26 thus moving the lost motion connection between the two pistons to its other limit as determined by the up-standing portion 56 of the piston 38. Such a movement will reduce the propeller pitch of the rearward blade 14 with respect to the forward blade 12.

From the description of the propeller as contained in the above cited Rosen Patent 2,982,361 and in accordance with the showing of FIG. 5 it will be appreciated that when the two pistons 26 and 38 are separated and the rear propeller blade is at a higher pitch than the front

propeller blade the propeller **16** will be in its high effective camber position and when the two pistons are forced together by the draining of chamber **54** the propeller will be in its low effective camber position such as in the embodiment illustrated in FIG. 5 with the front and rear blades at substantially the same pitch angle both in the loiter position and in the reverse position. It will be apparent that in both the high effective camber and in the low effective camber positions the pistons **26** and **38** act as a unit with two sections so that the governor controls the pitch of both blades to control the propeller loading and hence the propeller speed. During filling and draining of the chamber **54** there is a relative pitch change between the front and rear blades.

As shown in FIGS. 2 and 3 the change from optimum take-off blade phasing to optimum loiter blade phasing requires an increase in forward blade angle and a decrease in the aft blade angle. It will also be noted from FIGS. 2 and 3 that this increase in forward blade angle, which is primarily the blade which is controlled by the governor, will, because of the reduction of blade angle of the rear propeller blade and the decrease in effective camber, result in reduced power absorption of the propeller. This action would normally result in an increase in propeller speed and an attempt by the governor to further increase the forward blade angle. By making the response to relative pitch changing movements of the two blades i.e. the rate of filling or emptying of the chamber **54** slower than the response of the blade pitch to the governor the blades in reducing effective camber can be caused to take a path indicated by the arrows **88** in FIG. 2 so as to fall along a line of substantially constant power absorption while changing from the optimum high camber take-off blade phasing A to the optimum low camber loiter blade phasing B while increasing the forward blade angle and decreasing the aft blade angle. Power may then be reduced to change the blade angle from the position indicated by the point **90** on line **92** to reduce the angle of both the forward and aft blades along the line **92** to the optimum loiter blade phasing position B. In returning from the optimum loiter blade phasing B to the optimum take-off blade phasing A the blades while being controlled by the governor would take the path indicated by the line **94** and the power would then have to be increased to bring the blades back to the optimum take-off position. By proper control of power while the blades are changing camber it would be possible to have them follow along the line indicated by **96** but it would be preferable to effect the camber change independent of the power change. As shown in FIG. 3, which is a specialized case of the generalized case shown in FIG. 2, the camber change is initiated at the same 25° point on the forward blade angle. For decreasing camber movements as well as increasing camber movements the blades would theoretically follow along the line **98** in going from take-off phasing to loiter phasing and also along the line **98** in going from loiter phasing to take-off phasing. In the same manner as described in connection with FIG. 2, the blade pitch will be constrained to follow the paths indicated by lines **88** and **94**.

FIG. 4 shows the relative relation of the forward and rearward blade angles from their reverse position to their forward position with the take-off, loiter, and cruise ranges indicated and the reverse and feather positions indicated. It will be noted that the relative blade angles change at about a 25° angle of the forward blade in changing between take-off and loiter or cruise conditions and that they again change at about 8° in changing from take-off to reverse positions. This latter change is of course accomplished by the co-action between the other edge of the land **78** and the opening **80** opposite to that which accomplishes the change at the 25° point.

From the above description it will be apparent that we have provided a hydraulically actuated pitch changing mechanism suitable for governing a propeller during take-off and during loiter or cruise conditions and have provided mechanism for automatically changing the effective camber of the propeller at a preselected position of the forward set of blades.

It is to be understood that the invention is not limited to the specific embodiment herein illustrated and described but may be used in other ways without departure from its spirit and that various changes can be made which would come within the scope of the invention which is limited only by the appended claims.

We claim:

1. In combination with a propeller having two axially spaced blade parts mounted in the same hub, a first hydraulically actuated piston, pitch changing mechanism connecting said piston with one of said parts, a second hydraulically actuated piston, pitch changing mechanism connecting said second piston with the other blade part, a cylinder in said first piston receiving said second piston, stops limiting movement of said second piston in said cylinder, and valve mechanism controlled by said first piston, controlling hydraulic fluid in said cylinder.

2. In combination with a propeller having two sets of blades, a pitch changing unit connected with both sets comprising, means changing the pitch of both sets in unison in accordance with a preselected schedule, and means, controlled by the position of one set of blades and operative at a preselected position of said one set, modifying said unit and changing the pitch of the other set relative to said one set.

3. A combination as claimed in claim 2 in which the propeller is a variable camber propeller, and changing the pitch of one set of blades relative to the other changes the effective camber of the propeller.

4. A combination as claimed in claim 3 in which changing the pitch of both sets in unison changes the pitch of the propeller in any effective camber position.

5. A combination as claimed in claim 1 in which both pistons and the cylinder are in the hub.

6. A combination as claimed in claim 1 in which the propeller is a variable camber propeller and the first piston changes the pitch of the propeller and the second piston changes the effective camber of the propeller.

7. In combination with a propeller having a reverse pitch range, a take-off range and a cruise range, a pair of cooperating variable pitch blades, having relative positions providing a high effective camber and having other relative positions providing low effective camber, pitch changing mechanism including a first motor movable with respect to and connected with one of said blades, separate pitch changing mechanism including a second motor movable with respect to and connected with the other blade, means connecting said pitch changing mechanisms including said motors for simultaneous and equal movement by said first motor and including means providing for limited movement of one mechanism relative to the other, means for holding said mechanisms in one relative position throughout reverse and cruise ranges to provide low effective camber and means, including said second motor for holding said mechanisms in the other relative position throughout take-off range to provide high effective camber.

8. In a propeller as claimed in claim 7, means responsive to the position of one of said blades controlling the relative position of said mechanisms.

9. In a propeller as claimed in claim 8 in which said position responsive means is effective to control said second motor and hold said mechanisms in said other relative position throughout the take-off range.

10. In combination with a propeller having two axially spaced blade parts mounted in the same hub, a first hydraulically actuated piston, pitch changing mechanism connecting said piston with one of said parts, a second hydraulically actuated piston, pitch changing mechanism connecting said second piston with the other blade part, means connecting said pistons and providing for limited relative movement, means continuously urging said pis-

tons to one limit of said relative movement, and other means, controlled by the first piston, overriding said urging means and moving said pistons to the other limit of said relative movement.

11. In a propeller having two sets of variable pitch blades, hydraulically actuated mechanisms for changing the pitch of one set, means connected with said mechanism by a lost motion connection having a limited travel for changing the pitch of the other set, means continuously urging said lost motion connection to one limit of travel, hydraulically actuated means for overriding said urging means and urging said lost motion connection to the other limit of travel, and means controlled by the position of said one set of blades controlling said hydraulically actuated means.

12. In a propeller as claimed in claim 11 in which said position controlled means comprises a valve responsive to the position of said one set of blades selectively connecting said hydraulically actuated means with a source of pressure or a drain.

13. A variable camber, controllable pitch propeller comprising two sets of controllable pitch blades mounted in a hub for rotation together in the same direction with said hub and in which the effective camber may be varied by changing the pitch of one set with respect to the other set, a first pitch changing device for one set of blades, a second pitch changing device for the other set of blades, means connecting said devices including a lost motion connection having a limited movement, limits defining the extent of said limited movement, a first hydraulically actuated means acting on said first device and moving both devices to change the pitch of the blades in one direction, normal operating forces including said hydraulically actuated means and blade centrifugal twisting moment urging said connection to one limit, hydraulically actuated mechanism connected with said devices and together with said normal forces moving one device relative to the other and forcing said connection to the other limit, valve means controlled by one of said devices controlling said mechanism for controlling the propeller effective camber, a speed responsive governor selectively directing hydraulic fluid to said hydraulically actuated means, for controlling the propeller pitch.

14. A propeller as claimed in claim 13 in which said one set of blades is a forward set and said other set of blades is a rear set and said first hydraulic means increases the pitch of both sets and said hydraulically actuated mechanism increases the pitch of said rear set with respect to said forward set.

15. A propeller as claimed in claim 14 including a second hydraulic means acting on said second device for decreasing the pitch of both sets.

16. In combination with a variable effective camber propeller having two blade parts mounted in a single hub, a pitch changing unit in said hub and having two sections freely movable relative to each other, means connecting said sections and limiting relative movement of said sections including a lost motion connection, means mechanically connecting one section to one blade part, means mechanically connecting the other section with the other blade part, means continuously urging said sections to one relative position and one limit of the lost motion connection, means for moving said sections as a unit to change the pitch of both blade parts, means overcoming said continuously urging means and relatively moving said sections to another relative position and the other limit of the lost motion connection to change the pitch of one part relative to the other part.

17. A combination as claimed in claim 16 in which said overcoming means comprises an expansible chamber between said sections and means for introducing fluid under pressure into said section.

18. A combination as claimed in claim 17 in which said means for moving said sections as a unit comprises an expansible enclosure formed partially by a portion of one section and means for conducting pressure fluid into said enclosure, and said means for introducing fluid into said chamber comprises a bleed orifice connecting said enclosure chamber.

19. A combination as claimed in claim 17 including a drain for said chamber and valve means controlled by the position of one section relative to said hub for controlling draining of said chamber.

20. A combination as claimed in claim 19 in which said means for controlling draining includes valve mechanism blocking said drain during a selected portion of the travel of said one section and connecting said drain with said chamber during the remainder of the travel of said one section.

21. A combination as claimed in claim 20 in which said one blade part is located in said hub forward of said other blade part, and said valve mechanism blocks said drain from approximately 8 degrees pitch to approximately 25 degrees pitch of said one blade part.

22. A combination as claimed in claim 16 in which mechanism responsive to a selected pitch angle of one set of blades controls said relatively moving means.

23. A combination as claimed in claim 16 in which a governor responsive to the speed of the propeller controls said means for moving said sections as a unit to control the pitch of both sets of blades and control the propeller speed.

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JULIUS E. WEST, *Primary Examiner.*