March 28, 1939. H. H. PLATT 2,152,419

VARIABLE PITCH PROPELLER

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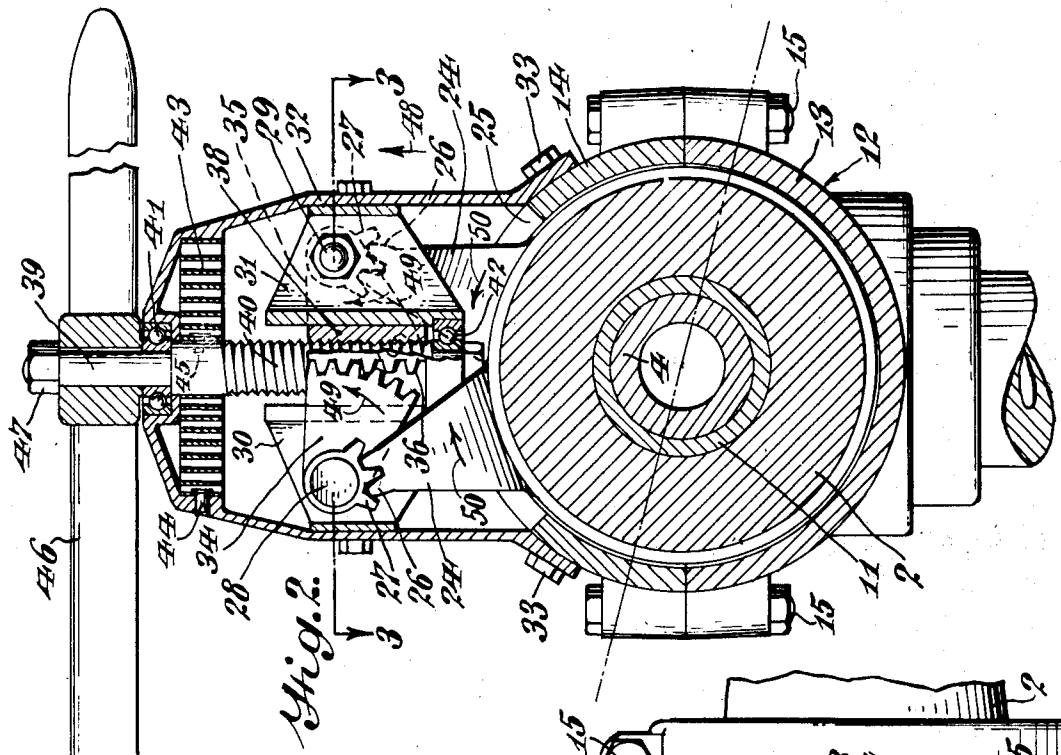


Fig. 2.

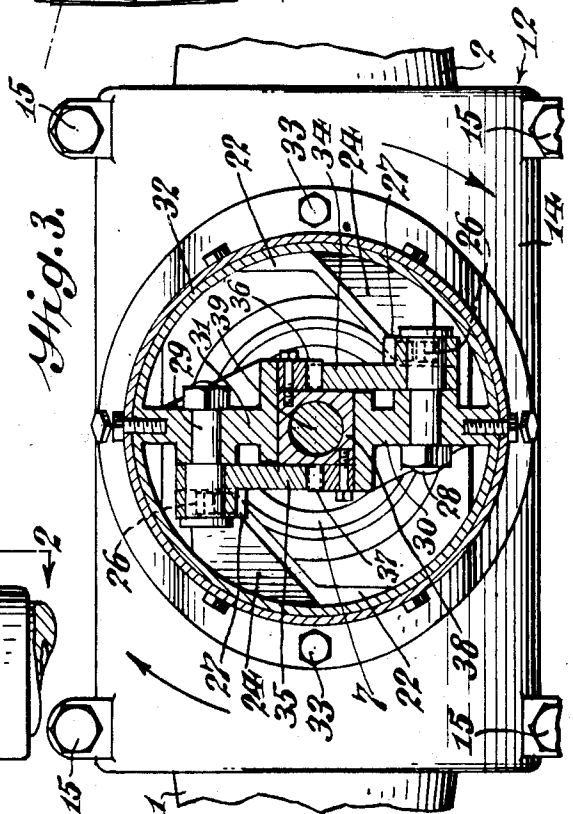


Fig. 3.

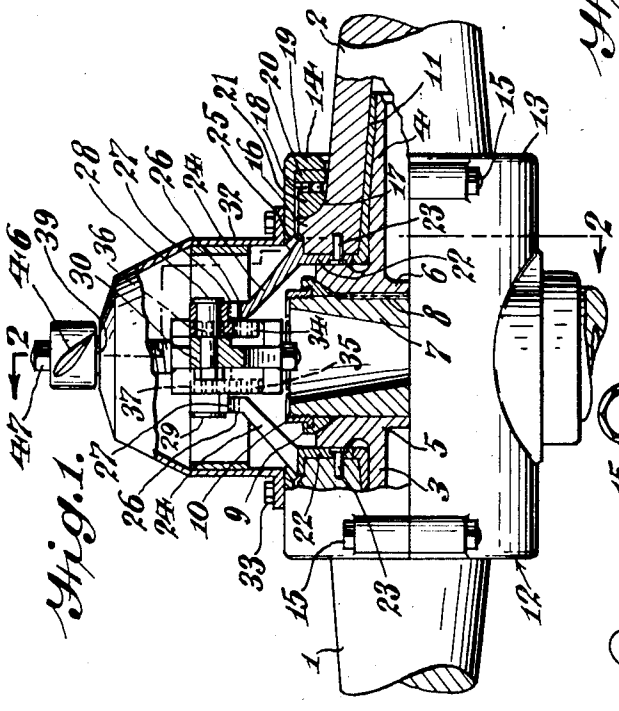


Fig. 1.

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Fig. 5.

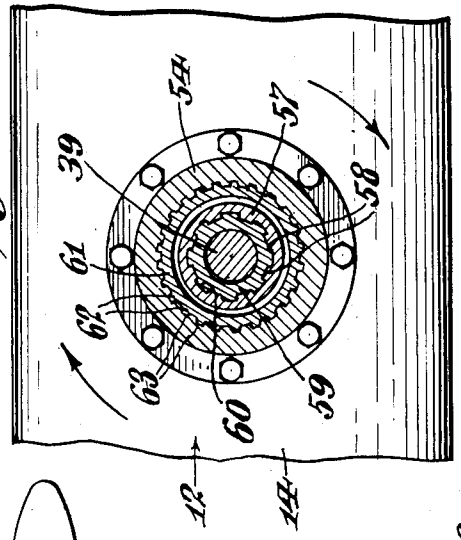


Fig. 6.

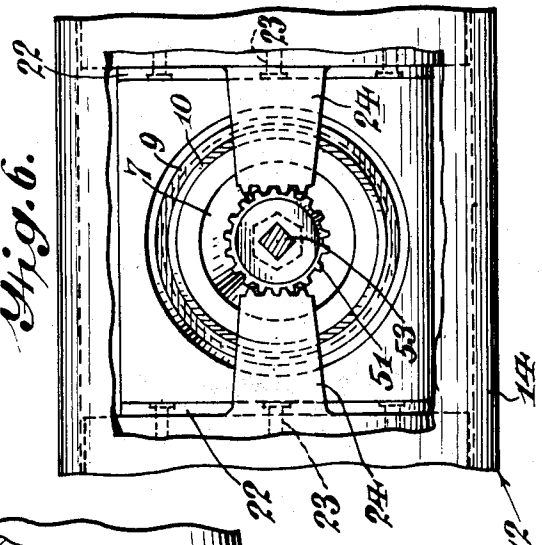
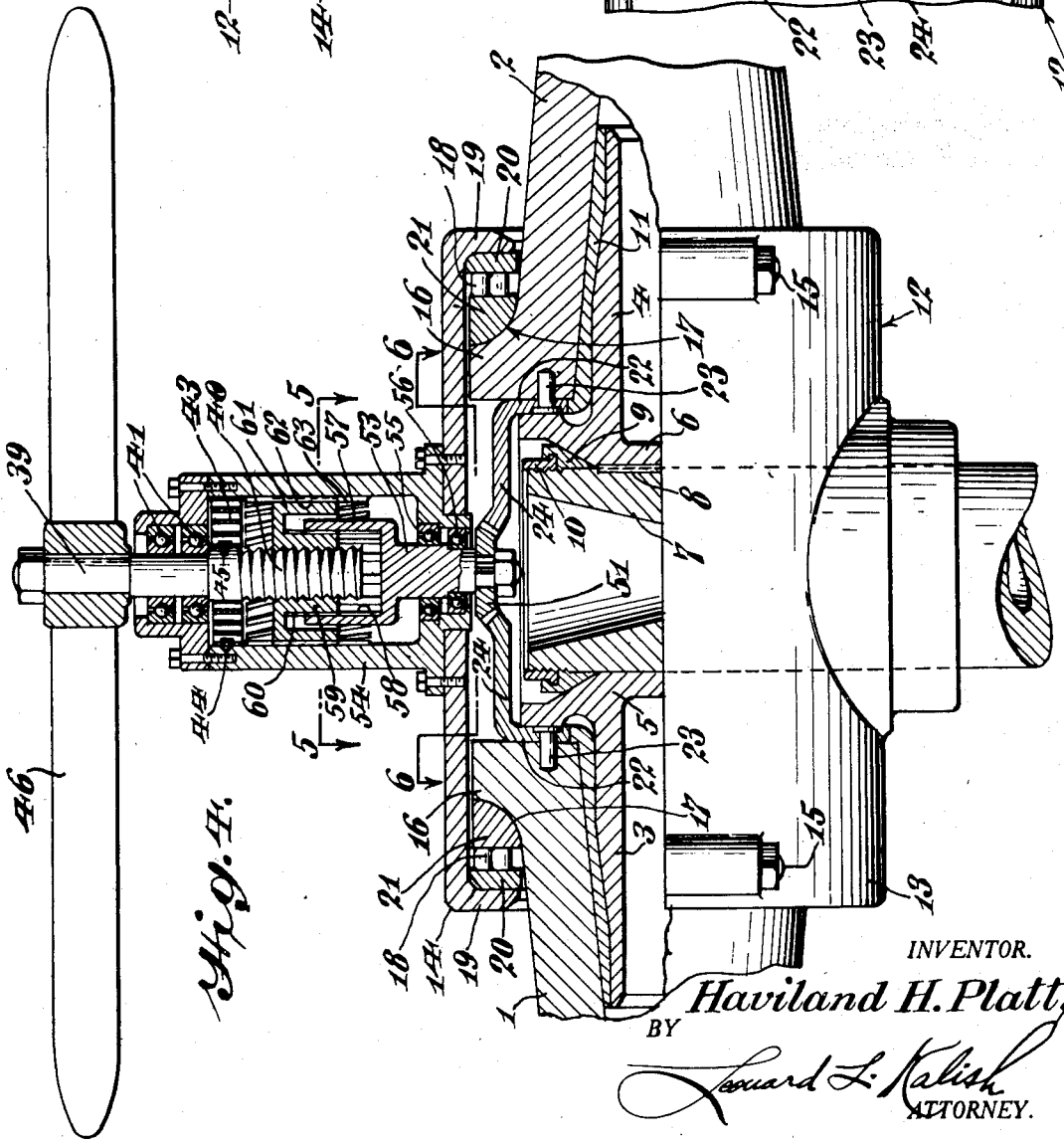


Fig. 4.



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UNITED STATES PATENT OFFICE

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VARIABLE PITCH PROPELLER

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Application January 18, 1935, Serial No. 2,349

13 Claims. (Cl. 170—162)

My invention relates to a new and useful variable pitch propeller adapted for an automatic change of propeller pitch, wherein the propeller pitch change would be influenced by the relationship between the rotary speed of the propeller and the air velocity of the craft.

It is an object of my invention automatically to vary the pitch of the propeller to the most efficient or to the most desirable blade angle under varying conditions of operation, in an automatic manner, that is, without any attendance, so as to permit a combination of efficient take-off, that is, a relatively low-speed take-off with load, and an efficient or high top-speed.

With the above and other objects in view which will appear more fully from the following detailed description, my invention consists of a propeller, which may be a two-bladed or a three or more bladed propeller, wherein the blades are mounted for more or less limited angular adjustment about their respective axes, and in which the blade angle setting is governed or controlled by two opposite forces or sets of forces acting upon any suitable power-transmission mechanism, one of which forces has an aerodynamic origin and is responsive to or influenced by the air speed of the craft as well as by the rotary speed of the propeller and the other of which forces is arranged to balance the first-mentioned force in such a way that the balance of forces will be determinative of the blade angle setting at any time.

My invention further consists of other novel features as well as certain novel details of construction, all of which will appear from the following detailed description.

For the purpose of illustrating my invention, I have shown in the accompanying drawings forms thereof which are at present preferred by me, although it is to be understood that the various instrumentalities of which my invention consists can be variously arranged and organized and that my invention is not limited to the precise arrangement and organization of the instrumentalities as herein shown and described.

Referring to the drawings in which like reference characters indicate like parts:

Figure 1 represents an elevational view of a propeller showing one embodiment of my invention, with parts broken away and shown in section.

Figure 2 represents a sectional view taken at a right angle to the view shown in Figure 1 and generally on line 2—2 of Figure 1.

Figure 3 represents a section on line 3—3 of Figure 2.

Figure 4 represents an elevational view of a propeller showing another embodiment of my invention, with parts broken away and shown in section.

Figure 5 represents a section on line 5—5 of Figure 4.

Figure 6 represents a section on line 6—6 of Figure 4.

The propeller blades 1 and 2 (although three or more blades may also be provided) are carried upon or centered upon, (and also journalled upon) the radially projecting ends 3 and 4 of the spider unit 5, the hub 6 of which is splined or keyed onto the free end of the propeller shaft 7 (the splining being indicated generally by the numeral 8). The spider 5 is locked in position by means of the jam-collar or gland 9 and the lock-nut 10 or by any other conventional means. Intermediate the inner hollow ends of the propeller blades 1 and 2 and the projecting ends 3 and 4 of the spider 5, any suitable bearing or journalled bushing 11 may be provided of bronze or the like.

The propeller blades 1 and 2 are further centered and retained against the centrifugal forces by means of an outer housing or shell designated generally by the numeral 12, preferably formed of two halves 13 and 14 respectively, which are held together by suitable bolts or other fastening means 15.

Each of the propeller blades is provided with a radially projecting flange 16 with suitable fillet 17, and a suitable roller type or other anti-friction thrust bearing 18, as for instance, the dual roller type indicated in the drawings, is then interposed between the inwardly extending retainer flanges 19 of the housing and the outwardly projecting flanges 16 of the propeller blades;—the thrust bearing also including suitable race-ways or race collars 20 and 21.

To each propeller blade 1 and 2 an annular ring 22 is also fixedly connected by suitable pins 23 and it is this ring or other suitable means which carries the actuating arm 24 through which the angular adjustment of the blade is directly effected.

In the modification of the invention illustrated particularly in Figures 1 to 3 inclusive, the arms 24 project out through a suitable opening 25 in the outer half 14 of the shell 12, and are provided at their free ends with similar small gear segments 26 which mesh with and at all times remain in mesh with corresponding pinion segments 27 of suitable extent, idly carried by suitable pivot pins 28 and 29, respectively. The pivot pins

28 and 29 in turn may be suitably supported, as for instance, in the guide brackets or guide blocks 30 and 31;—the latter in turn being carried by a suitable housing or other supporting structure 32 fastened or otherwise secured to the outer half 14 of the retainer shell 13, as for instance, by means of the bolts 33. The pinion segments 27 are either formed integrally with or are suitably keyed or pinned to corresponding gear segments 34 and 35, which in turn are in mesh with corresponding rectilinear toothed racks 36 and 37 carried by a screw-operated nut-like slide member 38 which is guided longitudinally but retained against rotation by and between the guide blocks or brackets 30 and 31. An impeller shaft or control shaft 39, having a suitable portion thereof screw-threaded as at 40, is extended through and is maintained in screw-threaded engagement with the nut-like slide member 38, and is suitably journalled in ball-bearings or other suitable antifriction bearings 41 and 42, being suitably retained against axial displacement by interlocking shoulders, retainer collars, flanges, thrust bearings or the like. A flat coil spring 43 is operatively interposed between the control shaft or impeller shaft 39 and the stationary housing or supporting structure 32, tending to resist, with increasing force, the rotation of the impeller shaft relative to the propeller itself in the direction of the normal rotary direction of the propeller. Any suitable spring anchorages 44 and 45 may serve to connect the two ends of the spring to the housing 32 and the shaft 39, respectively. Upon the outer free end of the impeller shaft 39, an impeller unit 46 (which may be provided with any suitable number of blades or which may be otherwise formed), is fixedly secured, that is, suitably splined or keyed, and held thereon by nut or other locking means 47. The pitch of the impeller unit 46 is in such a direction that the air-flow past the impeller unit in an axial direction will tend to rotate the impeller in the same direction as the normal rotary direction of the propeller. The angular magnitude of the pitch of the impeller unit however, is such that the resultant air-flow, compounded of the air-flow axially induced by the propeller (as for instance, when the craft is stationary), and the air speed of the impeller, will be generally parallel to the effective surfaces of the impeller or parallel to the cord of the impeller blade. By this means the impeller unit will tend to rotate generally at the same speed as the propeller when the air-flow past the propeller is merely the air-flow induced by the propeller, that is, when the aircraft has no actual air speed, as for instance, when stationary on the ground with the engine running. Thus, the direction and the magnitude of the pitch of the impeller unit is such as to tend to create no relative rotation between the impeller unit and the propeller when the propeller is rotating without any forward speed of the craft. When, however, additional air-flow passes through the impeller unit by virtue of forward speed of the craft or forward air speed of the craft, such additional airflow will tend to rotate the impeller unit relative to the propeller and in the direction of the propeller rotation. This tendency to rotate the impeller unit is resisted by the spring 43, the resistance of which increases as the relative rotation of the impeller increases. Thus, as the air speed of the craft increases, the impeller will rotate and the screw 40 will also rotate relative to the propeller and will cause the nut-like slide member 38 to be advanced in the direction of the arrow 48, thereby causing a rotation of the segments 34 and 35 in the direction of the arrows 49 and a rotation of the arms 24 in the direction of the arrows 50, thereby turning the opposite propeller blades correspondingly to increase the pitch of such blades to the extent of such angular displacement of the arms 24. As the air speed of the craft is reduced again, the spring rotates the shaft or screw 40 in the opposite direction, tending to reduce the pitch of the blades.

The amount of angular variation in the pitch is generally relatively little for most practical purposes, although this angular variation may be increased or decreased, and may be anything from two, three or five degrees to ten or fifteen degrees or even more, although generally the amount of angular variation is relatively small for most purposes.

Between the position of smallest pitch and greatest pitch the device may assume any intermediate position which is determined by the balance of the aerodynamic forces upon the impeller and the counterforce of the spring or other similar means. Likewise, the limiting positions for both the lowest pitch angle as well as the greatest pitch angle may be either determined by means of positive stops, as for instance, running the nut-like member 38 against suitable limiting collars or limiting members, as for instance, the raceway of the lower ball bearing and the spring 43, or against a suitable flange or collar carried by the screw shaft 40 in advance of the spring, or by any suitable stops placed on opposite sides of the segments 34 and 35, or at segments 24, or stops provided directly on the blades. If desired, however, the high and low limits of angular pitch variation or blade deflection may be determined without positive stops, but merely by the appropriate balance of the aerodynamic forces and counter forces (spring or the like), acting upon the impeller shaft.

In Figures 4, 5 and 6 a modified embodiment of the present invention is shown wherein the gear segment arms 24 are bent closer or formed closer as shown in Figure 4 and mesh with a single or common pinion 51 coaxially disposed with respect to the propeller shaft 7 and carried by a shaft 53, journalled in the housing 54 by means of ball bearings 55 and 56. The shaft 53 carries a generally cylindrical housing shell 57 having one or more rectilinear splines or keyways 58 formed on its inner surface which are generally parallel to its axis. Within the cylindrical shell 57 a generally cylindrical nut-like member 59 is disposed, having similar splines or key-ways 60 meshing with the splines or keyways 58, thereby maintaining it against rotational movement with respect to the shaft 53 but permitting axial displacement relative thereto. The nut-like member 59 is provided with a screw-threaded aperture therethrough, through which the screw-threaded impeller shaft 39 extends in screw-threaded relation thereto. The nut-like member 59 carries an outer member 61, which may also be of a generally cylindrical character or which may be of any other suitable shape, having one or more outer inclined keyways or splines 62, which mesh with or interlock with corresponding and similarly inclined keyways or splines 63 formed on the inner surface of the cylindrical housing 54. Thus, the axial movement of the nut-like member 59 and the outer member 61 carried thereby (as may be occasioned by the relative rotation of the impeller and propeller shafts) causes a slight rotational

movement of the nut-like member 59 due to the inclination of the splines or key-ways 62 and 63 and this slight rotation is transmitted to the shaft 53 through the splines or key-ways 58, which, in turn, causes a slight rotation of the pinion 51, sufficient to produce the required rotation of the propeller blades for the desired pitch variation.

In this embodiment of the present invention the transmission mechanism between the impeller shaft and the propeller blades may be made more compact.

The inclined line (dot and dash) shown in Figure 2, is indicative of the pitch angle of the propeller blade (the one nearest) because the propeller blades have been actually broken away in Figures 1, 3 and 4, as well as in Figures 5 and 6, so as to permit the illustration of the operating mechanisms on a larger scale. It will be understood naturally that the blades projecting outwardly are oppositely inclined at suitable angles, and variable between suitable limits of angular variation, the general direction of inclination being the same as the direction of inclination indicated by the line in Figure 2 and the same as the angle of inclination of the impeller member shown in end view in Figure 1, although the views in the drawings are not intended to show the exact magnitude of the angles, as this is a matter which varies with different constructions of installations.

The invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof, and it is therefore desired that the present embodiments be considered in all respects as illustrative and not restrictive, reference being had to the appended claims rather than to the foregoing description to indicate the scope of the invention.

Having thus described my invention, what I hereby claim as new and desire to secure by Letters Patent, is:

1. In a fluid-borne craft, the combination of a multi-bladed variable pitch propulsive screw and a shaft therefor, a flow responsive air screw connected to the shaft of said propulsive screw but mounted for limited rotational movement relative thereto and means adapted to cause the rotational movement of said air screw relative to said shaft to vary the pitch of said propulsive screw, said means including a threaded shaft upon which is mounted said air screw, a nut on said last mentioned shaft and mounted for movement axially thereof upon rotation of such shaft, and means operatively interposed between said nut and the blades of the propulsive screw for transforming axial movements of said nut into pitch variations of the blades of said propulsive screw, said latter means including gearing.

2. In an air-borne craft, the combination of a variable pitch propulsive screw, an air screw mounted upon a threaded shaft, counter-balancing means for progressively resisting the rotation of said air screw, a nut screw threadedly mounted on the threaded shaft adapted to move axially with respect thereto, and mechanical means operatively interposed between said nut and said variable pitch propulsive screw for transmitting the axial movements of said nut into corresponding pitch variations of the propulsive screw.

3. In combination, a variable pitch propeller, an air screw mounted on a threaded shaft, counter-balancing means for progressively resisting the rotation of said air screw, a nut screw threadedly mounted on the threaded shaft, and means operatively interposed between said nut and said variable pitch propeller for converting axial displacements of said nut relative to said shaft into corresponding pitch variations of the propeller.

4. In an air-borne craft, the combination of a variable pitch propulsive screw, an air screw, counter-balancing means for progressively resisting the rotation of said air screw, a threaded shaft driven by said air screw, a nut screw threadedly engaging said shaft and adapted to move axially with respect thereto, and means operatively interposed between said nut and said variable pitch propulsive screw for transforming the axial movements of said nut into corresponding pitch variations of the propulsive screw.

5. In an air-borne craft, the combination of a variable pitch propulsive screw, an air screw mounted upon a threaded shaft, counter-balancing means for progressively resisting the rotation of said air screw, a complementary threaded member in operative engagement with said threaded shaft and adapted for rectilinear motion with respect thereto, and mechanical means operatively interposed between said complementary threaded member and said variable pitch propulsive screw for transforming the axial movements of said complementary threaded member into corresponding pitch variations of the propulsive screw.

6. In combination, a variable pitch propeller, an air screw mounted upon a threaded shaft, counter-balancing means for progressively resisting the rotation of said air screw, a complementary threaded member in operative engagement with said threaded shaft and adapted for rectilinear motion with respect thereto, and means operatively interposed between said complementary threaded member and said variable pitch propeller for converting axial displacements of said complementary threaded member relative to said threading shaft into corresponding pitch variations of the propeller.

7. In an air-borne craft, the combination of a variable pitch propulsive screw, an air screw, counter-balancing means for progressively resisting the rotation of said air screw, a threaded shaft driven by said air screws, a complementary threaded member in operative engagement with said threaded shaft and adapted for rectilinear motion with respect thereto and means operatively interposed between said complementary threaded member and said variable pitch propulsive screw for transforming the axial movements of said complementary threaded member into corresponding pitch variations of the propulsive screw.

8. In an air-borne craft, the combination of a variable pitch propeller and means adapted to vary the pitch thereof, said means deriving its entire power from a stream of air flowing past it, and comprising an air screw, counter-balancing means for progressively resisting the rotation of said air screw and means operatively interposed between said air screw and said variable pitch propeller for transforming the rotary movements of said air screw into corresponding pitch variations of the propeller, said means including a helically grooved rotatable shaft and a complementary member in operative engagement with said helical groove and adapted for rectilinear motion relative to said shaft.

9. In an air-borne craft, the combination of a multi-bladed variable pitch propeller and means

adapted to vary the pitch thereof, said means deriving its entire power from a stream of air flowing past it, and comprising an air screw, counter-balancing means for progressively resisting the rotation of said air screw and means operatively interposed between said air screw and said variable pitch propeller for transforming the rotary movements of said air screw into corresponding pitch variations of the propeller, said means including a single helically grooved rotary shaft driven by said air screw, a complementary member in operative engagement with said helical groove and adapted for rectilinear motion relative to said shaft, and mechanical gearing operatively and directly interposed between said complementary member and the blade roots of the multi-bladed variable pitch propeller blades, said mechanical gearing being so arranged that the rectilinear movement of said complementary member may directly and simultaneously vary the pitch of all the propeller blades.

10. In an aerodynamically responsive servo mechanism adapted to operatively control an adjustable aircraft member, an air screw mounted upon a threaded shaft, counter-balancing means for progressively resisting the rotation of said air screw, a complementary non-tiltable threaded member in operative engagement with said threaded shaft and adapted for non-tilting rectilinear motion with respect thereto, and means positively connected to said adjustable aircraft member in operative engagement with said complementary threaded member and having a rotary motion responsive to the rectilinear motion of said complementary threaded member.

11. In an aerodynamically responsive servo mechanism adapted to operatively control an adjustable aircraft member an air screw mounted upon a threaded shaft, counter-balancing means for progressively resisting the rotation of said air screw, a complementary non-tiltable threaded member in operative engagement with said threaded shaft and adapted for non-tilting rectilinear motion with respect thereto, and means operatively connected to said adjustable aircraft member in operative engagement with said complementary threaded member and deriving therefrom a motion responsive to the rectilinear motion of said complementary threaded member and capable of transmitting force from said complementary threaded member to said adjustable aircraft member at a substantial mechanical ratio.

12. In an aerodynamically responsive servo mechanism adapted to operatively control an adjustable aircraft member, an air screw mounted upon a threaded shaft, counter-balancing means for progressively resisting the rotation of said air screw, a complementary non-tiltable threaded member in operative engagement with said threaded shaft and adapted for non-tilting rectilinear motion with respect thereto, and a train of toothed transmitting members operatively connected between said adjustable aircraft member and said complementary threaded member and responsive to the rectilinear motion of the latter.

13. In an aerodynamically responsive servo mechanism adapted to operatively control an adjustable aircraft chamber, said servo mechanism deriving its sole source of power from a stream of air flowing past said servo mechanism, an air screw adapted to be rotated by said stream of air, counter-balancing means for progressively resisting the rotation of said air screw, and means in operative engagement with said air screw comprising a helically grooved shaft driven by said air screw, a complementary non-tiltable member in operative engagement with said helical groove and adapted for non-tilting rectilinear motion relative to said shaft, and a train of toothed transmitting members capable of transmitting force from said complementary member to said adjustable aircraft member at a substantial mechanical ratio.

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