Feb. 25, 1947. W. W. EVERTS 2,416,516

VARIABLE PITCH PROPELLER

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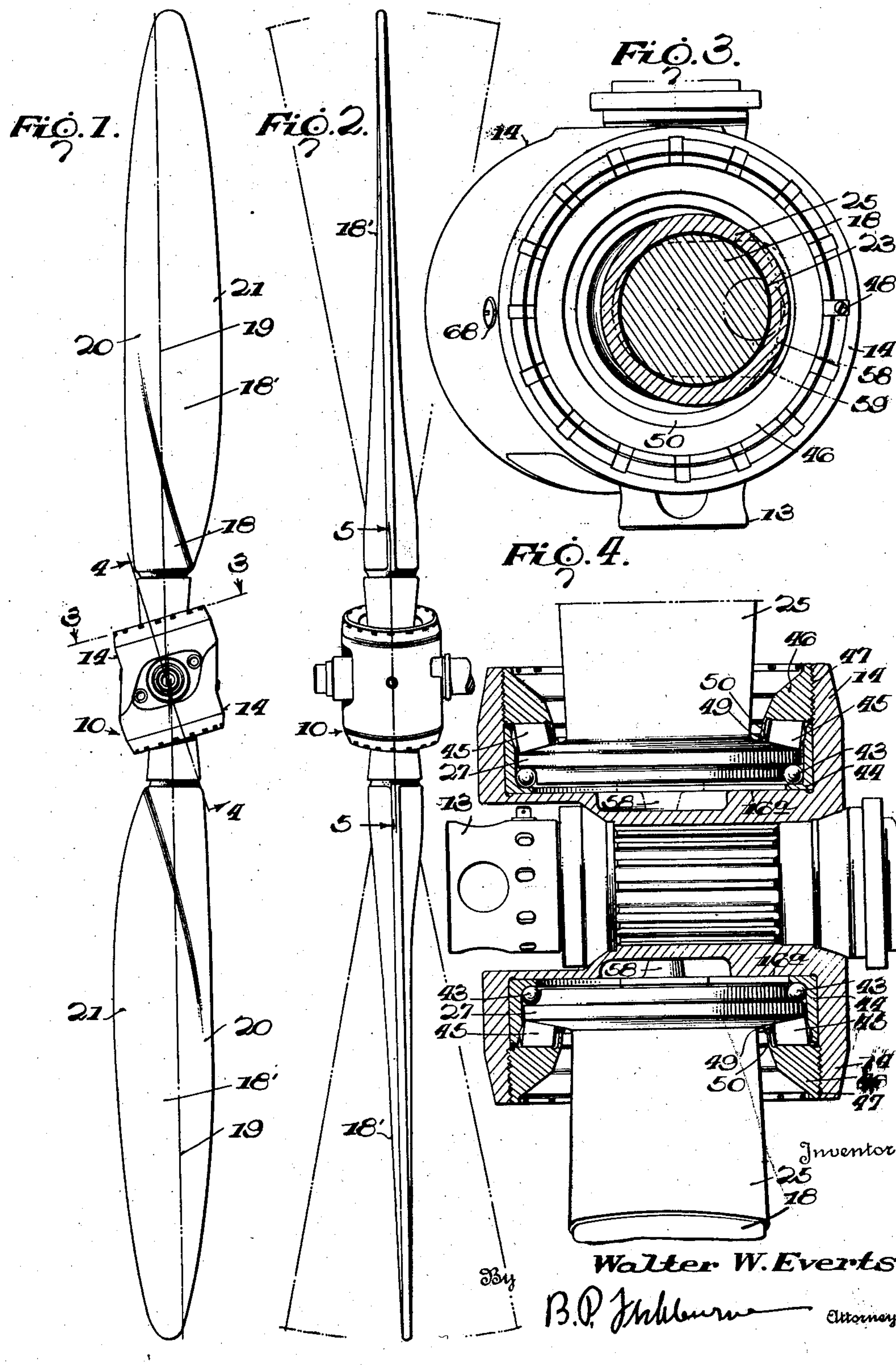

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VARIABLE PITCH PROPELLER

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Fig. 5.

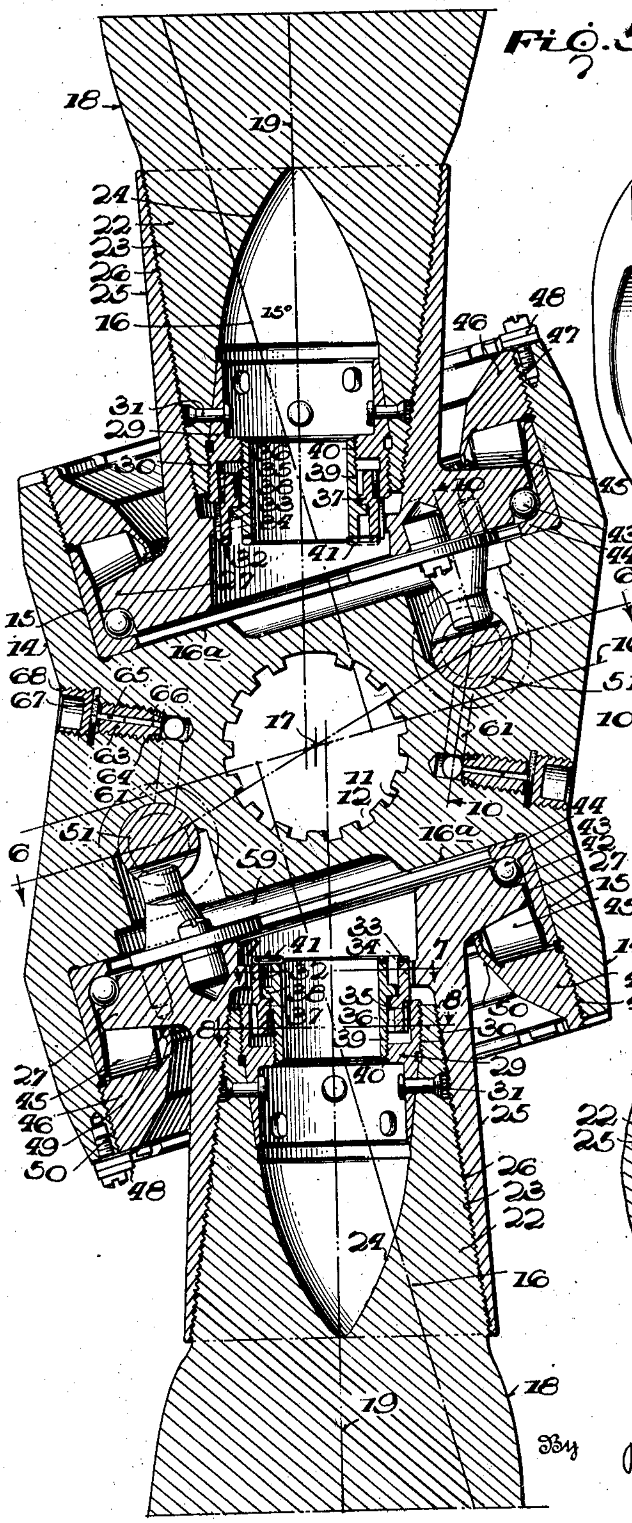


Fig. 6

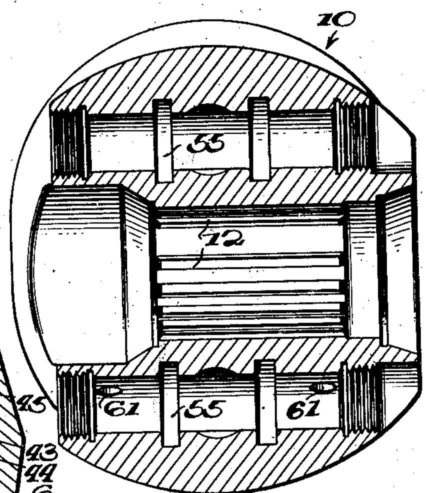


Fig. 7.

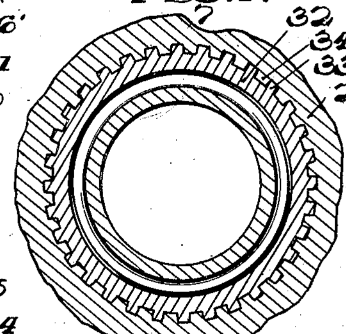
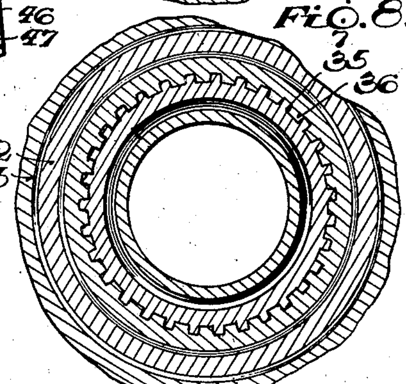


Fig. 8.



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VARIABLE PITCH PROPELLER

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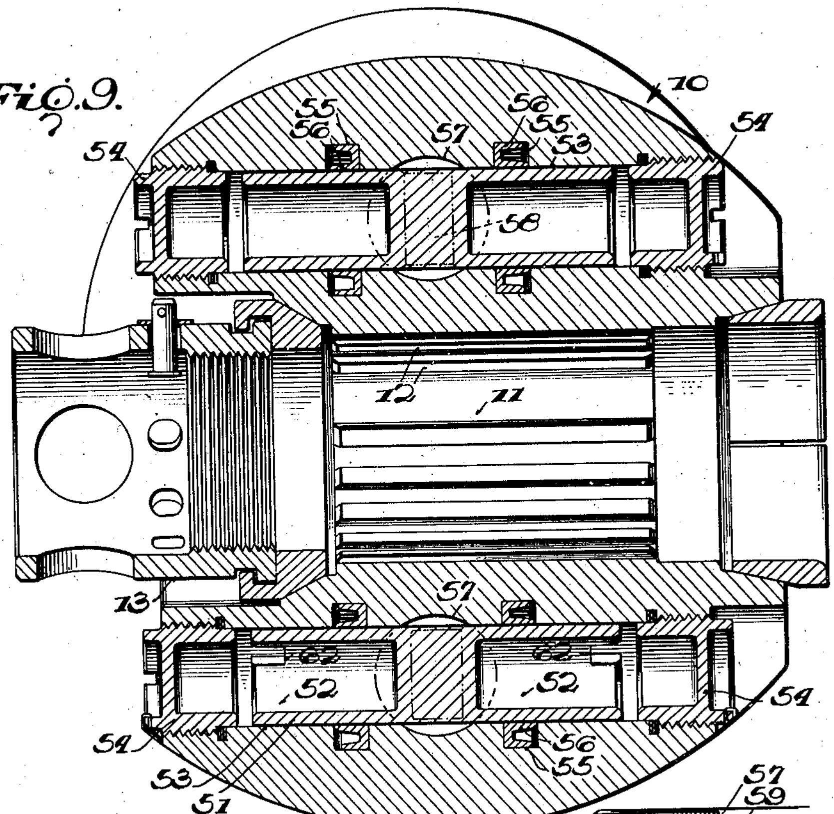
Fig. 9.



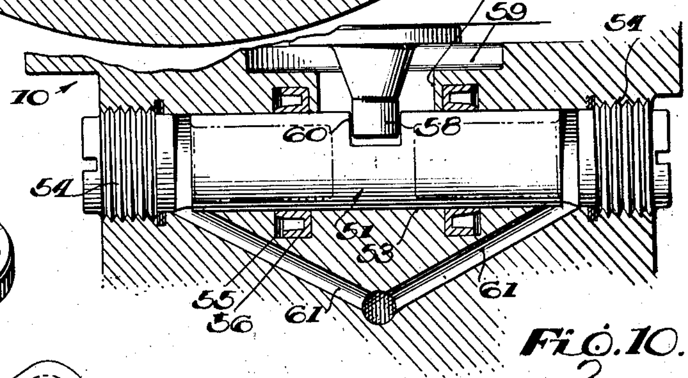
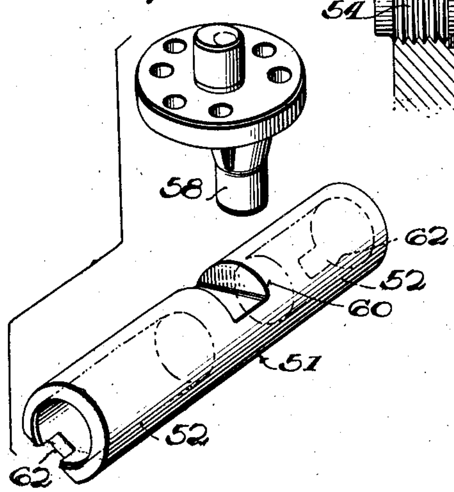


Fig. 10.

Fig. 11.



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VARIABLE PITCH PROPELLER

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Fig. 12.

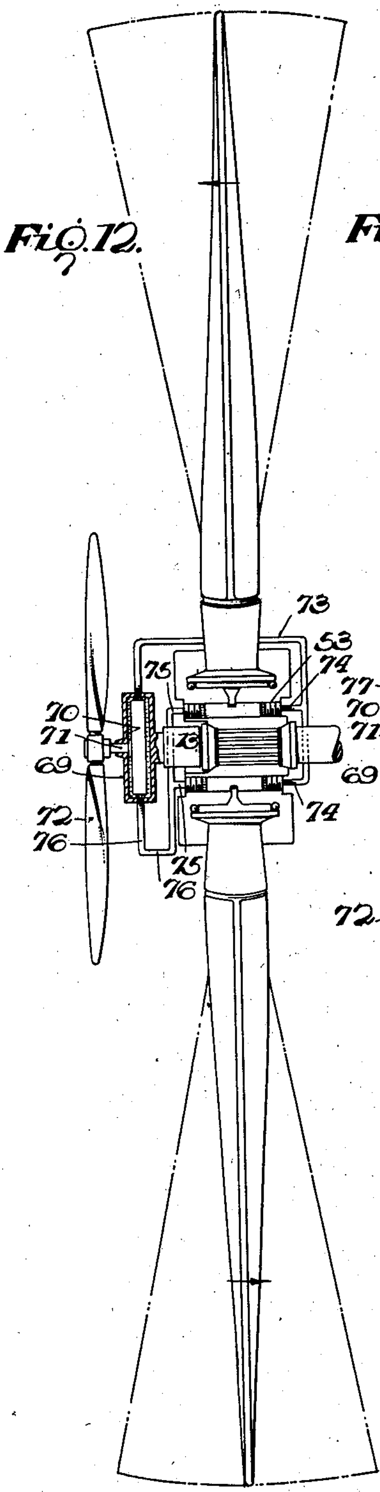


Fig. 13.

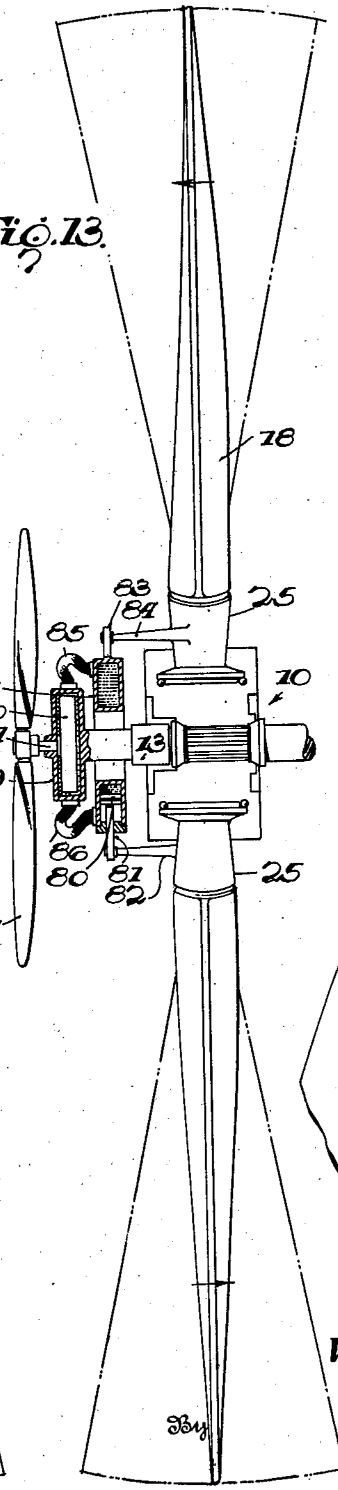
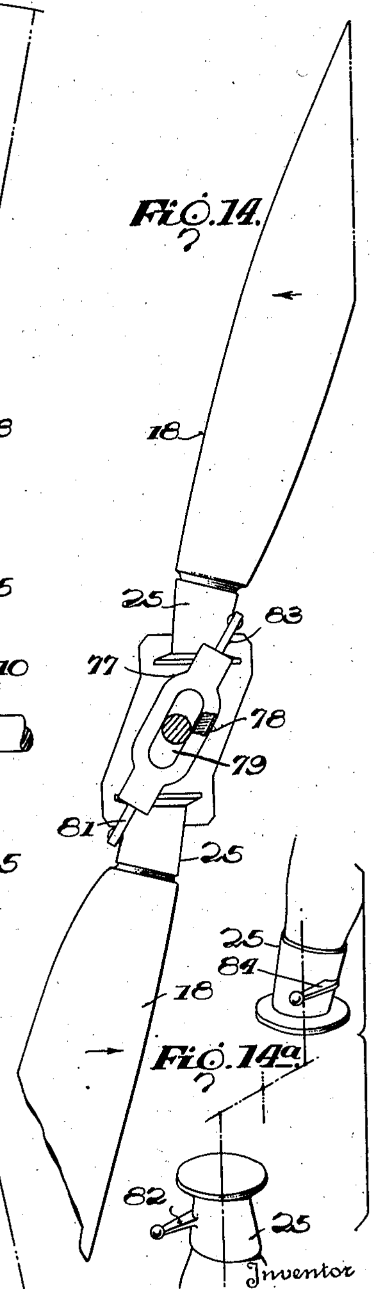


Fig. 14.

Fig. 14a.



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VARIABLE PITCH PROPELLER

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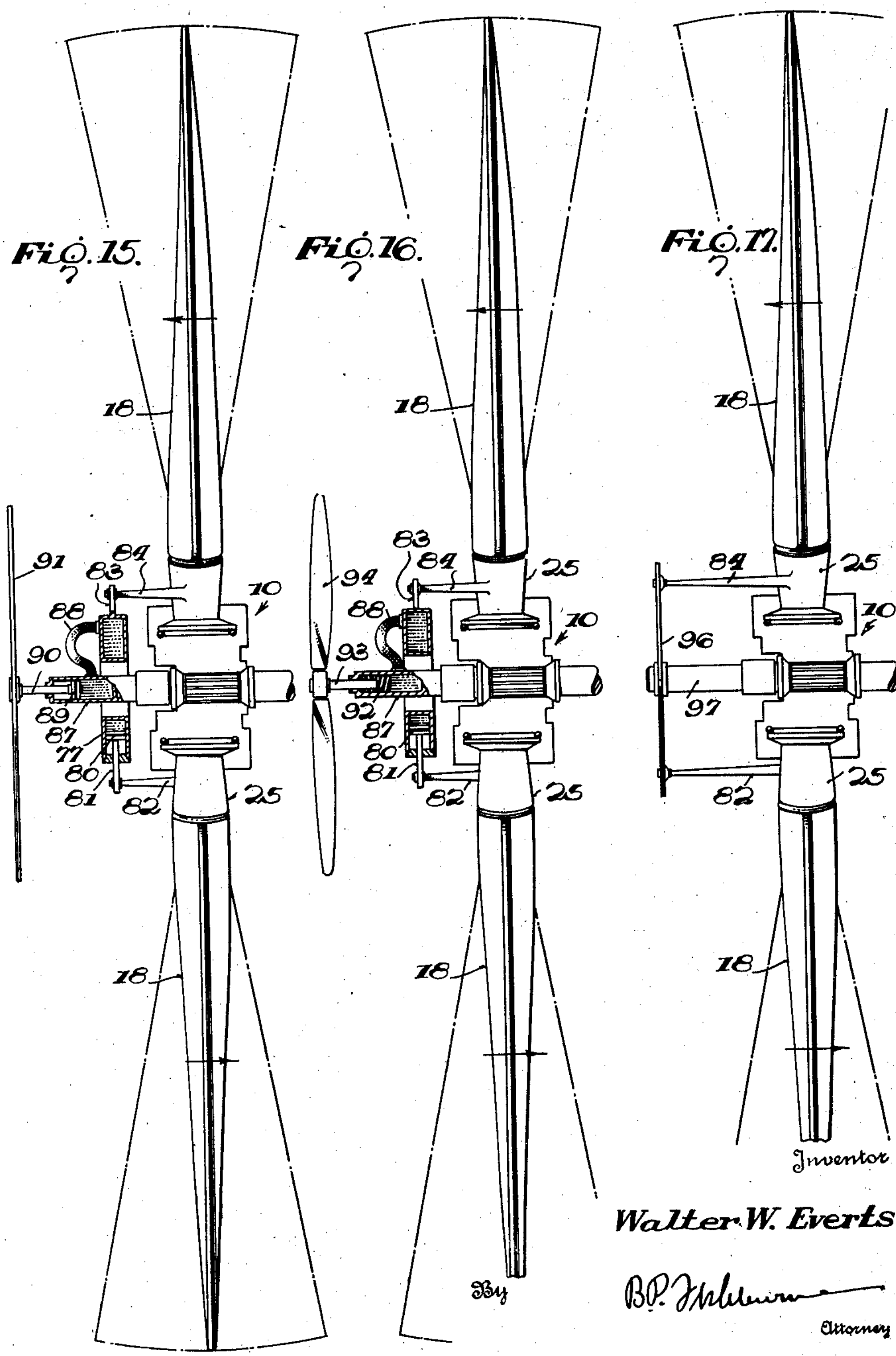

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Patented Feb. 25, 1947 **2,416,516**

UNITED STATES PATENT OFFICE

2,416,516

VARIABLE PITCH PROPELLER

Walter W. Everts, Baltimore, Md., assignor to Everel Propeller Corporation, Baltimore, Md., a corporation of Maryland

Application August 26, 1939, Serial No. 292,148

7 Claims. (Cl. 170—162)

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My invention relates to propellers for air craft, boats, submarines or the like and fans for displacing fluids.

An important object of the invention is to provide a propeller having means to automatically vary the pitch of the blades as the elevation of the vehicle changes.

A further object of the invention is to provide means to automatically increase the pitch of the blades as the applied power increases, at any given elevation.

A further object of the invention is to provide means to automatically increase the pitch of the blades as the speed of travel of the vehicle increases.

A further object of the invention is to provide strong and compact means to pivotally mount the blades upon the hub of the propeller.

A further object of the invention is to arrange the means for mounting the blades within the hub to provide an enclosed structure.

Other objects and advantages of the invention will be apparent during the course of the following description.

In the accompanying drawings forming a part of this application and in which like numerals are employed to designate like parts throughout the same,

Figure 1 is a front elevation of a propeller embodying my invention,

Figure 2 is an edge elevation of the same,

Figure 3 is a transverse section taken on line 3—3 of Figure 1,

Figure 4 is a transverse section taken on line 4—4 of Figure 1,

Figure 5 is a vertical section taken in the plane of rotation of the propeller on line 5—5 of Figure 2,

Figure 6 is a transverse section taken on line 6—6 of Figure 5, parts omitted,

Figure 7 is a transverse section taken on line 7—7 of Figure 5,

Figure 8 is a similar view taken on line 8—8 of Figure 5,

Figure 9 is a transverse section taken on line 6—6 of Figure 5, the parts being assembled,

Figure 10 is a section taken on line 10—10 of Figure 5,

Figure 11 is an exploded perspective view of the plunger and associated lug,

Figure 12 is an edge elevation of a propeller embodying a modified form of the invention,

Figure 13 is an edge elevation of a propeller embodying a further modified form of the invention,

Figure 14 is a front elevation of the propeller shown in Figure 13,

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Figure 14ᵃ is a perspective view of the operating arms and sockets carrying them,

Figure 15 is an edge elevation of a propeller embodying a further modification of the invention,

Figure 16 is an edge elevation of a propeller embodying a still further modification of the invention, and,

Figure 17 is an edge elevation of a propeller embodying a further modification of the invention.

In the drawings, wherein for the purpose of illustration are shown preferred embodiments of my invention, the numeral **10** designates a hub, having a centrally arranged opening **11**, to receive the crank shaft of the engine of an airplane or the like. The hub is provided with splines or ribs **12**, to interlock with splines or ribs formed upon the crank shaft. The hub is held against longitudinal displacement upon the crank shaft by any suitable means. As an illustration, I have shown a nut **13**, having screw-threaded engagement with the crank shaft. The hub comprises end portions **14**, which are off-set laterally in opposite directions, in the plane of rotation of the hub, with relation to the center **17** of the hub. These end portions **14** have cylindrical recesses **15**. The central longitudinal axes **16** of the recesses **15** are off-set laterally in opposite directions, in the plane of rotation of the hub, and the axes **16** are equidistantly spaced from the center. The central longitudinal axes **16** of the recesses **15** are also disposed at a right angle to a line **16'**, passing through the center **17**, and arranged between the recesses **15**, and equidistantly spaced from the bottoms **16ᵃ** of the recesses, which bottoms are parallel with the line **16'**. The axes or center lines **16** are in a transverse plane, disposed at a right angle both vertically and horizontally with relation to the axis of rotation or center line **17**.

The numeral **18** designates propeller blades which are generally radial with respect to the opening **11**. Two of these blades are shown in opposed relation, for the purpose of illustration. The number may be increased. I also contemplate using only one blade, when a single-blade propeller is desired. The blades **18** are of the conventional construction and design and have the twist to produce the desired pitch. The lifting faces **18'** of the blades are convex or cambered. The blades have longitudinal axes **19**, which are generally radial with relation to the opening **11**. The blades have leading and trailing surfaces **20** and **21**, which are unbalanced, with the trailing surface **21** being the larger.

Each blade **18**, Figure 5, has a shank **22**, tapering inwardly, and screw-threaded, as shown at 23. The shank has a recess 24 formed therein, and this recess extends through the inner end of the shank, as shown, for a reason to be explained. The numeral 25 designates a socket, having a screw-threaded bore 26, which tapers inwardly, as shown. The tapered shank is adapted to have screw-threaded engagement within the tapered bore of the socket 25. Preferably formed integral with the inner end of each socket 25 is a circular attaching flange or disc 27. The socket 25 is circular in cross-section and is concentric with respect to the circular flange or disc 27, at the union of these parts, but the socket 25 becomes increasingly more eccentric with respect to the disc or flange 27 in a direction toward the outer end of the socket. The circular or cylindrical disc or flange 27 has as a center line or turning axis the line 16. The center line or longitudinal axis of each shank 22 of each blade is the line 19. The central longitudinal axis 19 of the blade and shank is therefore at an inclined or oblique angle with respect to the center line or turning axis 16 of the disc or flange 27. When the disc or flange 27 turns upon its axis 16, the propeller blade will travel about the circumference of a truncated cone having the line 16 as its center and this movement will vary the pitch of the blade.

Means are provided to lock the threaded shank 22 within the socket 25 against turning movement so that it cannot unscrew therefrom. This means comprises a coupling-sleeve 29 which is inserted into the recess 24 and has screw-threaded engagement with the shank 22, as shown at 30. This coupling-sleeve is further secured to the shank by rivets 31, so that the coupling-sleeve cannot turn with respect to the shank. The numeral 32 designates a lock-sleeve, provided upon its outer surface and near its inner end with an annular set of splines or teeth 33, to interlock or interfit with an annular set of splines or teeth 34 formed upon the inner end of the socket 25. The lock-sleeve is further provided upon its outer surface and near its outer end with an annular set of splines or teeth 35 to interfit or interlock with teeth 36, formed upon the inner surface of the coupling-sleeve 29. It is thus seen that when the lock-sleeve 32 is in position, it will prevent the coupling-sleeve 29 and shank 22 from turning with relation to the socket 25. The lock-sleeve 32 is provided with an internal flange or shoulder 37, to be engaged by an annular flange or shoulder 38, formed upon a tubular lock 39. This tubular lock has screw-threaded engagement with the coupling-sleeve 29, as shown at 40. The tubular lock 39 may be held against accidental rotation by any suitable means, such as a safety wire 41, passing through apertures in the parts 32 and 39, although a cotter pin or the like may be used. From the foregoing description it will be seen that the shank 22 is securely locked against improper rotation with respect to the socket 25, whereby these parts will remain rigidly connected in use.

The attaching flange or disc 27 is mounted concentrically within the cylindrical recess 15 and is provided upon its inner side with a raceway 42, to receive bearing-balls 43 operating within a ball race 44. Bearing elements, such as roller bearings 45, engage the outer side of the attaching disc or flange 27 and are held in place by a ring 46 or the like, having screw-threaded engagement with the end portion 14, as shown at 47. Any suitable form of lock means 48 may be employed to prevent the accidental unscrewing of the ring 46. There is a packing ring or grease seal 49, carried by a lip 50 of the ring 46, to prevent the escape of the lubricant from about the roller bearings.

The longitudinal axis 19 of each blade 18 is at an inclined or oblique angle with respect to the turning axis 16 of its disc or flange 27. This angle is shown as about 15°, but the invention is not restricted to this precise angular arrangement, as the same may be varied as found advantageous. It is probable that this angle could vary within 10° to 40°. The longitudinal axes 19 of the blades 18 do not extend through the center 17 of the hub, but are arranged upon opposite sides of this center and are spaced from the same for equal distances. This is the preferred arrangement, as it acts as a torque counterbalance, neutralizing the tendency that the blade would have to twist bodily in the plane of rotation within the recess 15. By virtue of the arrangement of the axes 19, the pressure upon the roller bearings 45 is neutralized throughout the entire circumferences of the disc or flanges. The arrangement of the axes 19 also causes the blades to balance each other.

Means are provided to dampen or retard the movement of each blade about the surface of the truncated cone. This means comprises a cylindrical plunger 51, having recesses 52 in its opposite ends. The plunger is mounted to reciprocate within a cylindrical bore 53 formed in the hub 10. There are two of these cylindrical bores, which are equidistantly spaced from the center 17 and circumferentially arranged so that the hub remains balanced. The ends of the bores 53 are covered by screw-threaded plugs 54. The bore 53 has annular grooves 55, receiving packing rings 56, contacting with the plunger 51 and preventing the escape of the brake fluid between the plunger and the packing rings. The hub 10 is provided with a passage 57, arranged between the packing rings 56, and this recess receives a stud or finger 58, which is carried by and rigidly secured to the inner face of the disc or flange 27. The hub has a further recess 59. The stud 58 engages within a notch 60, formed in the intermediate portion of the plunger 51. It is thus seen that when the disc or flange 27 is turned upon its axis 16, the stud or finger 58 will shift the plunger 51 longitudinally. A port 61 leads into the opposite ends of the bore 53 adjacent to the plugs 54. The plunger 51 has notches 62 formed therein so that the ends of the port 61 remain permanently uncovered. When the plunger moves in one direction it will force the liquid, such as ordinary brake fluid, through the port 61, from one end of the bore 53 into the other end. The passage of the brake fluid through the port 61 is restricted or retarded, and the plunger 51 will serve to dampen or retard the movement of the blade in changing its pitch. This retarding action may be increased by further retarding the passage of the brake fluid through the port 61, which may be effected by screwing in a screw-threaded plug 63, engaging within a screw-threaded opening 64. This plug has a slot 65 for receiving a screw driver or like implement and also has a port 66, for the escape of a volume of brake fluid equal to the volume displaced by the plug. The opening 64 is covered by a lead washer 67, held in place by a plug 68. The two plungers 51 are not connected and operate separately.

Operation

The operation of the propeller is as follows:

The propeller is driven counter-clockwise, viewed from the front of the airplane, which is the practice in the United States. As soon as the propeller rotates, centrifugal force acts upon the blades 18 and tends to move these blades to a radial position. This action of centrifugal force is opposed by the air thrust, which tends to swing the blades forwardly so that the outer ends of the blades move forwardly from the radial position and inwardly of the maximum sweep. These two opposing forces act against each other and the blade will assume a normal operating position between the extreme forward position and the true radial position. When the blade is in the extreme forward position it is at the minimum pitch and when in the true radial position it has the maximum pitch due to centrifugal force. Assuming that the airplane is now flying at substantially sea level, the air thrust is then at the maximum and the blade has moved forwardly about the surface of a truncated cone, to assume the forwardmost position which will impart to the blade the minimum pitch. The action of centrifugal force tends to move the blade rearwardly about the surface of the truncated cone toward the true radial position, thereby increasing the pitch of the blade. As the speed of the airplane increases, the air pressure acting upon the forward face of the blade tends to move the blade rearwardly about the surface of the truncated cone for increasing the pitch of the blade. Assuming that the propeller is being driven at 2,000 R. P. M., at sea level, the propeller will then have the minimum pitch for this elevation. If the airplane now rises to a considerably higher elevation, the air thrust acting upon the propeller will be reduced, while the action of centrifugal force remains the same and hence the action of centrifugal force will overcome the air thrust upon the propeller blades, and the propeller blades would be moved rearwardly about the surface of a truncated cone, and thereby increasing the pitch of the propeller blades. This increased pitch of the propeller blades will cause the propeller to drive the airplane at an increased speed but the speed of rotation of the propeller will remain substantially constant.

When the air pressure upon the front faces of the blades 18 is sufficient to overcome the action of centrifugal force, as when the airplane is making a nose dive, the blades are shifted rearwardly beyond the radial position, and the pitch of the blades is increased over the maximum pitch which can be imparted to them due to the action of centrifugal force, which would occur when the blades are shifted by centrifugal force into a true radial position.

The blades 18 are free to be shifted about the surfaces of the truncated cones, within limits, to vary their pitch, as explained, and this shifting movement is dampened by the action of the plungers 51 and associated elements, and these plungers also serve as means to stop the shifting movement of the blades within the desired limits.

Attention is now called to Figure 12 of the drawings, showing the first modification of the invention. In this form of the invention the same hub 10 and propeller blades 18 are employed and the blades are mounted upon the hub in the identical manner as described in connection with the first form of the invention. These blades turn about the surface of a truncated cone to vary their pitch, as explained in connection with the first form of the invention. In the form of the invention shown in Figure 12, a centrifugal pump is provided including a casing 69, which is rigidly mounted upon the nut 13, to rotate therewith. Arranged within the casing is a rotor 70, which is driven in an opposite direction to the direction of rotation of the casing 69. This rotor receives its rotation from a shaft 71, carrying a fan or propeller 72, which drives it. The main propeller including the blades 18 is rotated counter-clockwise when looking into the same from the front of the airplane while the fan 72 is rotated clockwise when viewed from the same direction. The outlet side of the casing 69 discharges into a pipe 73, which leads into the rear ends of the bores 53, the plugs 54 being removed and other plugs substituted therefor, which are adapted to serve as couplings between the branches 74 and the rear ends of the bores 53. In a similar manner the plugs 54 within the forward ends of the bores 53 are removed and other plugs substituted therefor, which are adapted to serve as couplings between the branches 75 and the forward ends of the bores 53. The branches 75 lead into a pipe 76, which is connected with the intake side of the casing 69. The plugs 63 may be now adjusted to permit of the maximum flow of the brake fluid through the port 61.

All other parts of the propeller remain identical with those shown and described in connection with the first form of the invention. The operation of the propeller shown in Figure 12 is as follows:

The propeller is rotated counter-clockwise when looking toward the same from the front of the airplane. The air thrust tends to shift the propeller blades forwardly about the surfaces of truncated cones to decrease their pitch, while centrifugal force tends to move them rearwardly about the surfaces of the truncated cones to increase their pitch. During the travel of the airplane, the fan or propeller 72 is rotated in an opposite direction to the direction of rotation of the casing 69 of the centrifugal pump. The centrifugal pump serves to force brake fluid into the rear ends of the bores 53 and to withdraw the same from the forward ends. This action increases with the increase of the speed of the airplane, and increased pressure is applied to the rear ends of the plungers 51. The forward movement of the plungers is transmitted to the propeller blades, and coacts with centrifugal force in shifting the blades rearwardly about the surfaces of the truncated cones to increase the pitch of the blades. The propeller 72 and the centrifugal pump therefore serve as means operated by the travel of the airplane, to increase the pitch of the blades in proportion to the increased speed of the airplane.

In Figure 13, I have shown a second modification of the propeller. The propeller shown in Figures 13, 14 and 14*a* has the same hub 10 and blades 18, and the blades are mounted on the hub to move about the surfaces of truncated cones, to vary their pitch as explained in connection with the first form of the invention. In this form of the invention, Figures 13 and 14, the plungers 51 are not employed in shifting the blades about the surfaces of the truncated cones, but plungers 51 and associated elements may be employed as dampening means, as described in connection with Figures 1 to 11. In Figures 13 and 14, the same centrifugal pump is used including the casing 69 and rotor 70. The rotor is driven by the shaft 71 and fan or propeller 72. This is the same arrangement as shown in Figure 12. In the form shown in Figure 13, I provide a pressure operated device including a cylinder 77, having an intermediate portion 78 which is hollow, with a passage 79 for the crank shaft of the engine or a continuation thereof. A plunger 80 is mounted within the lower portion of the cylinder 77. This plunger is connected with a plunger rod 81, having a universal connection with an arm 82 which is rigidly connected with the socket 25 of the blade. The opposite end of the cylinder 77 has a rod 83 rigidly secured thereto, having a universal connection with an arm 84 which is rigidly secured to the socket 25 of the other blade. The arm 82 is disposed on the trailing edge of its socket 25 and the arm 84 is disposed upon the trailing edge of its socket 25 so that when the rods 81 and 83 are shifted outwardly they move the arms 82 and 84 respectively, to depress the trailing edges of the blades and increase their pitch.

In the operation of this form of propeller, the centrifugal pump forces the brake fluid through a flexible hose 85 into one end of the cylinder 77 inwardly of the plunger 80 and withdraws the brake fluid from the opposite end of the cylinder through a flexible hose 86. This moves the cylinder and plunger in opposite directions longitudinally of each other and applies the force to the arms 82 and 84, and this force aids centrifugal force in shifting the blades about the surfaces of the truncated cones to increase the pitch of the blades. The force increases in proportion to the increase in speed of the airplane.

In Figure 15, the same cylinder 77 and plunger 80 are used, as described in connection with Figure 13, and these parts are connected with the sockets 25 in the identical manner as shown in Figure 13. However, the centrifugal pump is dispensed with and a cylinder 87 is substituted therefor and this cylinder has connection with a flexible hose 88, leading to one end of the cylinder 77. A plunger 89 is mounted within the cylinder 87 and is connected with a rod 90, carrying a flat disc 91. Due to the travel of the airplane, the air pressure will force the disc 91 rearwardly, moving plunger 89 rearwardly, which forces the brake fluid from the cylinder 87 into the cylinder 77. This causes the cylinder 77 and plunger 80 to apply force to the sockets 25 tending to increase the pitch of the propeller blades.

In the form of the invention shown in Figure 16, the same cylinder 87 and associated elements are employed, but a plunger 92 is mounted within the cylinder 87 and has screw-threaded engagement therewith. This plunger is rotated by a plunger rod 93, carrying a fan or propeller 94. During the travel of the airplane, the fan 94 rotates, turning the plunger 92, which in turn forces the brake fluid into one end of the cylinder 77, thus causing the cylinder and plunger 80 to coact for increasing the pitch of the blades.

In Figure 17, the sockets 25 are rigidly connected with the arms 84 and these arms have universal connections with a flat disc 96, slidable upon a guide 97. The pressure of the air upon the disc 96, due to the travel of the airplane, is transmitted to the arms 95, which aid in causing the blades to turn about the surfaces of the truncated cones to increase the pitch of the blades.

In all forms of the invention, Figures 1 to 17 inclusive, the same attaching discs 27 and associated elements are employed to mount the blades 18 upon the hub 10, in the same manner as described in connection with the first form of the invention. In all forms of the invention the discs 27 and blades 18 have the same mode of operation, in changing the pitch of the blades.

It is to be understood that the forms of my invention herewith shown and described are to be taken as preferred examples of the same and that various changes in the shape, size, and arrangement of parts may be resorted to without departing from the spirit of my invention or the scope of the subjoined claims.

Having thus described my invention, what I claim is:

1. A propeller comprising a hub having an axis of rotation and a plane of rotation normal thereto, blades to be carried by the hub, rotatable attaching means to secure each blade to the hub, the attaching means having a center turning line and lying in said plane, each blade having a longitudinal axis disposed diagonally with respect to the center line of its attaching means, whereby centrifugal force acting on the blades tends to move the blade axes into said plane of rotation and thereby rotate said attaching means about their turning line in a direction to increase the pitch of the blades, fluid pressure means applying a force in addition to centrifugal force to the blades for rotating the attaching means in said pitch increasing direction, and an element actuated by the air stream in response to the relative velocity thereof in the line of flight during the travel of the vehicle to operate the fluid pressure means.

2. A propeller comprising a hub having an axis of rotation and a plane of rotation normal thereto, blades to be carried by the hub, rotatable attaching means to secure each blade to the hub, the attaching means having a center turning line lying as said plane, each blade having a longitudinal axis disposed diagonally with respect to the center line of the attaching means, whereby centrifugal force acting on the blades tends to move the blade axes into said plane of rotation and thereby rotate said attaching means about their turning line in a direction to increase the pitch of the blades, fluid pressure devices connected with the attaching means to apply a force thereto in addition to centrifugal force on the blades to rotate the same in said pitch increasing direction, a rotary compressor to supply fluid pressure to the devices to operate them, and means independent of the propeller for driving the compressor including a rotary fan having blades at an angle of attack to the air stream and moved thereby in response to the relative velocity thereof.

3. A propeller comprising a hub having an axis of rotation and a plane of rotation normal thereto, blades to be carried by the hub, rotatable attaching means to secure each blade to the hub, the attaching means having a center turning line and lying in said plane, each blade having a longitudinal axis disposed diagonally with respect to the center line of the attaching means, whereby centrifugal force acting on the blades tends to move the blade axes into said plane of rotation and thereby rotate said attaching means about their turning line in a direction to increase the pitch of the blades, a fluid pressure device connected with the attaching means to apply a rotating force thereto in addition to centrifugal force to rotate the attaching means in said pitch increasing direction, a cylinder having communication with the fluid pressure device to supply

fluid pressure thereto, a plunger within the cylinder, and an element in the air stream and movable in response to the relative velocity thereof in the direction of flight, said element being connected with the plunger to actuate the same.

4. A propeller comprising a hub having an axis of rotation, blades to be carried by the hub, attaching means to secure each blade to the hub, the attaching means having a center turning line, each blade having a longitudinal axis disposed diagonally with respect to the center line of the attaching means, each blade being shiftable in one direction by centrifugal force to increase its pitch, a fluid pressure device connected with the blades to apply a force thereto in addition to centrifugal force to shift the blades for increasing their pitch, a cylinder having communication with the fluid pressure device to supply fluid pressure thereto, a plunger having screw-threaded engagement within the cylinder, and a fan connected with the plunger to turn the same.

5. A propeller comprising a hub having an axis of rotation and recesses, said hub also having bores, discs having center lines and mounted within the recesses to turn therein upon the center lines, the center lines of the discs, when extended, being perpendicular to a plane containing the axis of rotation and spaced on opposite sides of the axis of rotation, blades attached to the discs and having longitudinal axes arranged diagonally with respect to the center lines of the discs, a plunger arranged within each bore, each bore having a lateral opening intermediate its ends communicating with one of the recesses, means on each side of said lateral opening to seal the plunger within said bore, a stud secured to each disc and extending through the lateral opening in the bore to engage the adjacent plunger to move it, each bore being adapted to receive fluid between the ends thereof and the plunger, and means to regulate the flow of fluid in a retarded manner from one end of the bore to the opposite end.

6. A propeller comprising a hub having a recess therein, a disc mounted in said recess, a blade receiving socket internally threaded and carried by said disc, said socket and disc having registering openings therein providing access to the internally threaded portion of the socket, a blade having a screw threaded shank mounted within the internally screw threaded portion of the socket, said shank having an axial recess formed therein, a coupling sleeve fixedly mounted in the interior of said shank, an axially slidable tubular locking member inserted within the opening of said disc and extending into said sleeve and having external splines cooperating with said coupling sleeve and with said disc to secure said shank and coupling sleeve against rotational movement within said socket, and means extending through said locking member and having a screw threaded engagement with said coupling sleeve for retaining said locking member in locking position.

7. A propeller for aircraft comprising a hub having an axis of rotation *a*, blades to be carried by the hub *b*, attaching means to secure each blade to the hub, the attaching means having a center turning line *c*, each blade having a longitudinal axis disposed diagonally with respect to the center line of the attaching means *d*, each blade being so constructed and positioned as to be shiftable in one direction by centrifugal force to increase its pitch, a fluid pressure device connected with the attaching means to apply a rotating force therein in addition to centrifugal force to rotate the attaching means in said pitch increasing direction, a cylinder having communication with the fluid pressure device to supply fluid pressure thereto, a plunger within the cylinder, and an element presenting a surface normal to the air stream in the direction of flight and movable in response to the relative velocity thereof, said element being connected with the plunger to actuate the same.

WALTER W. EVERTS.

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