Feb. 14, 1933. W. F. STIMPSON ET AL 1,897,445

CONTROLLABLE PITCH PROPELLER

Filed June 19, 1930 3 Sheets-Sheet 1

Fig. 2.

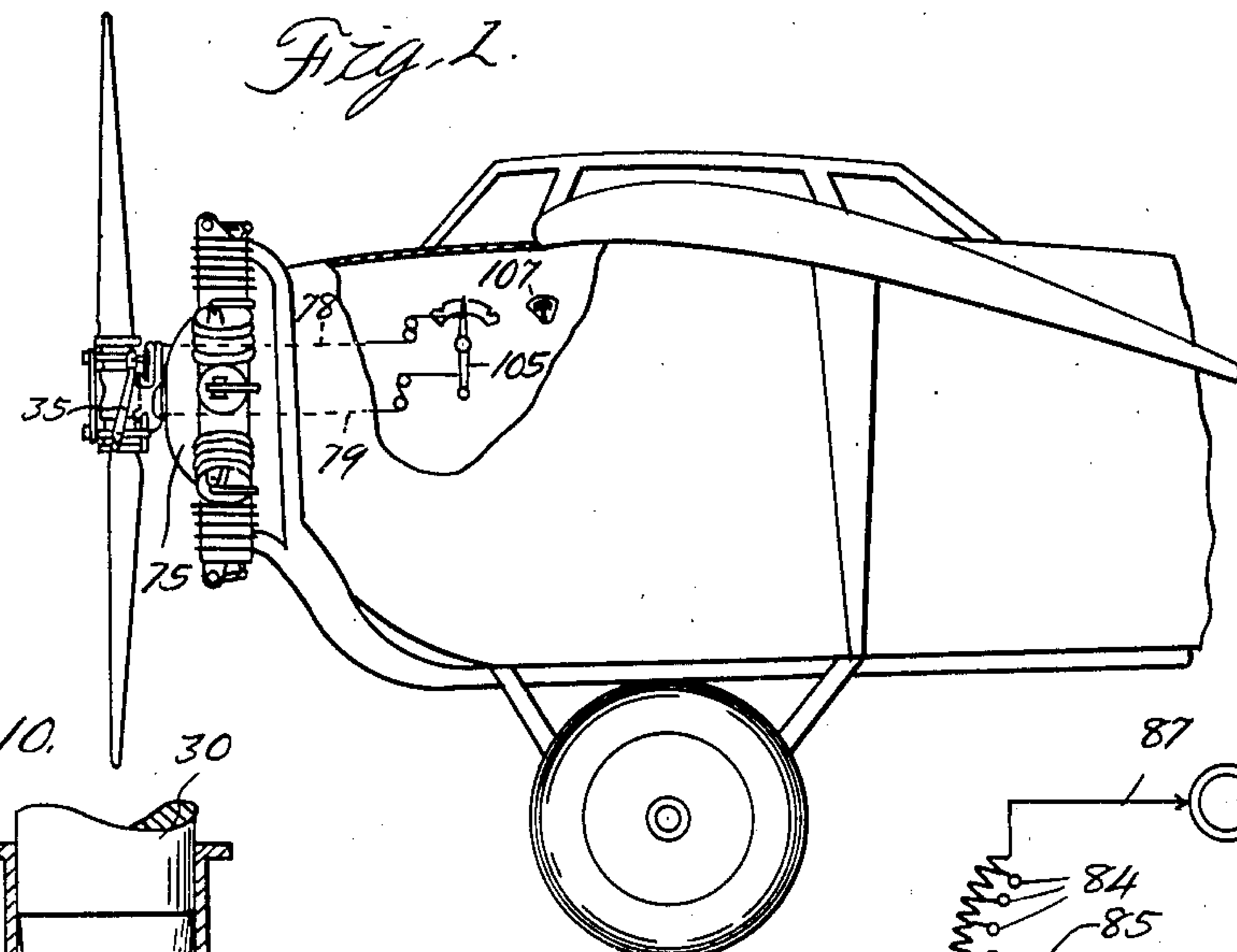
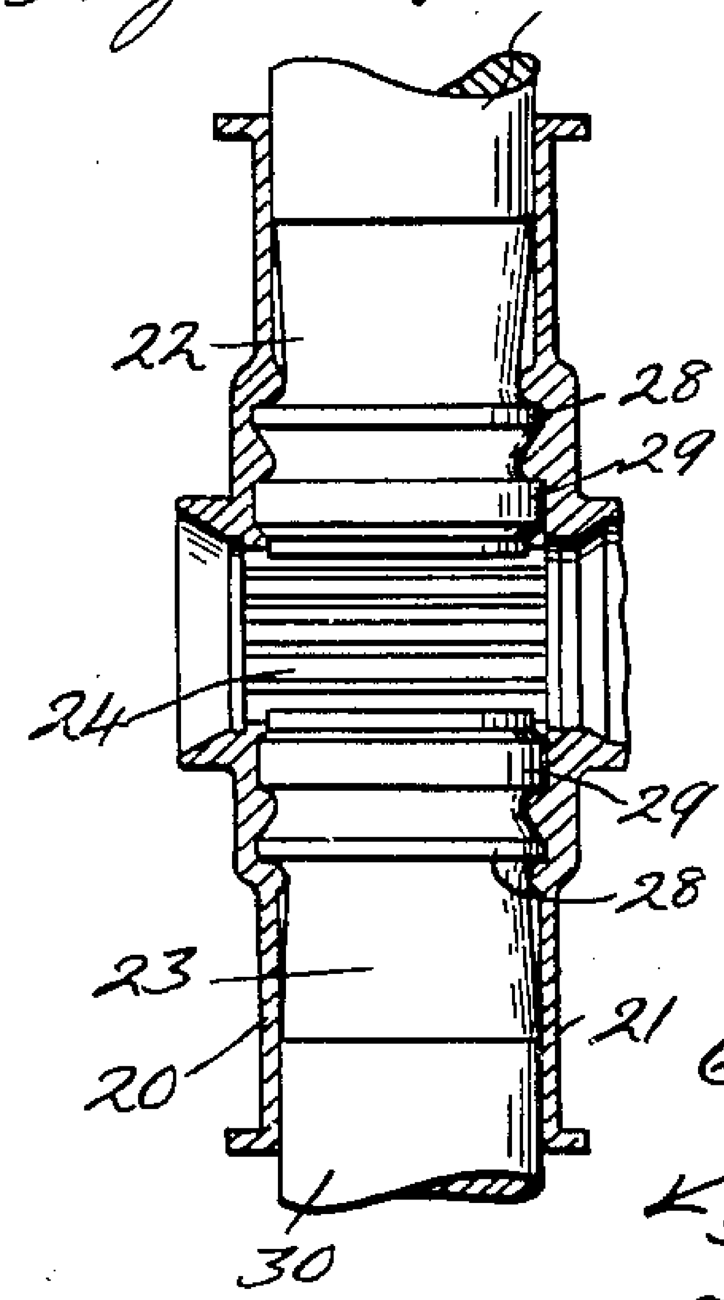


Fig. 10.



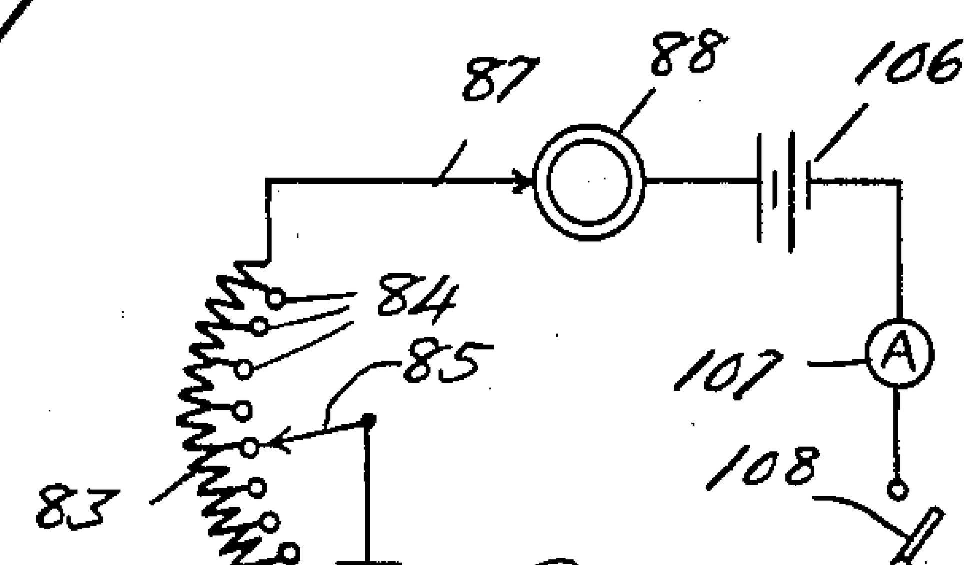


Fig. 12.

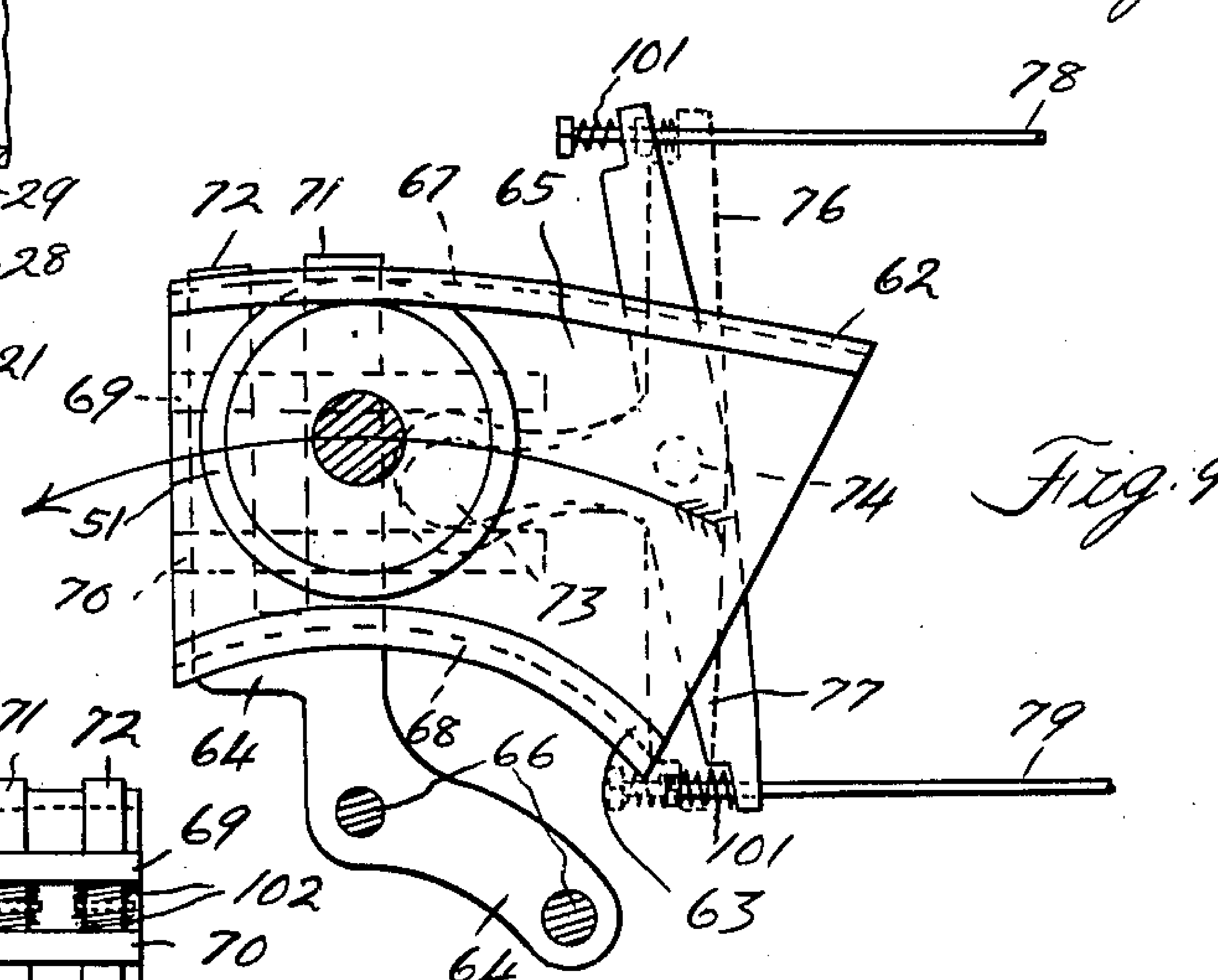


Fig. 9.

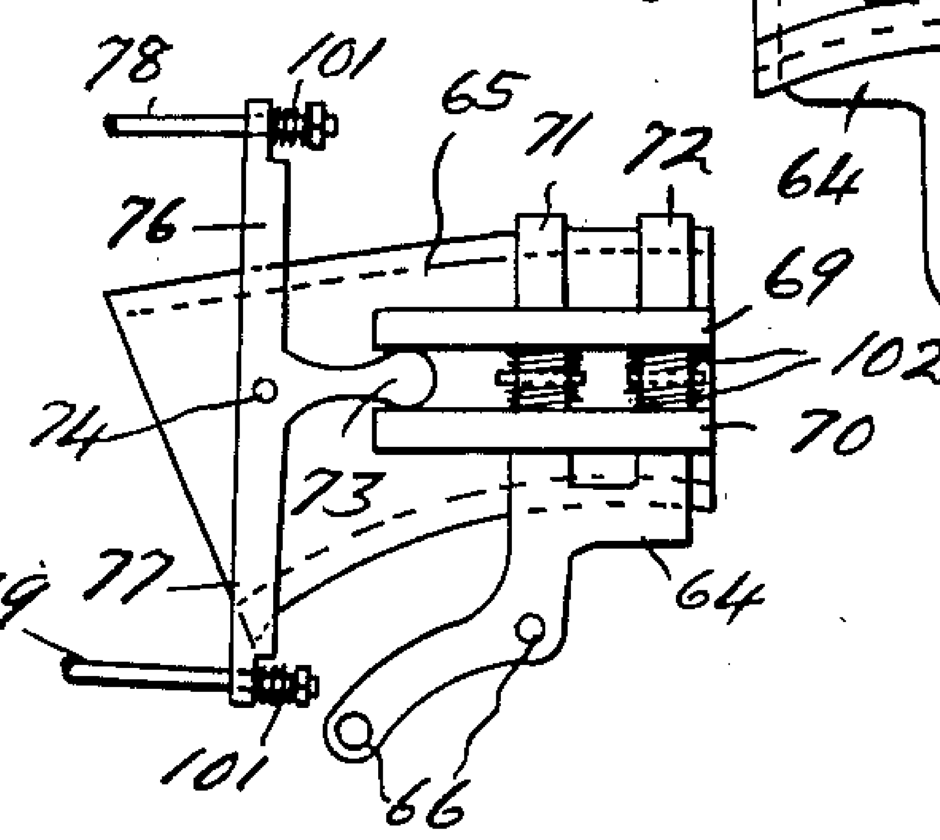


Fig. 11.

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CONTROLLABLE PITCH PROPELLER

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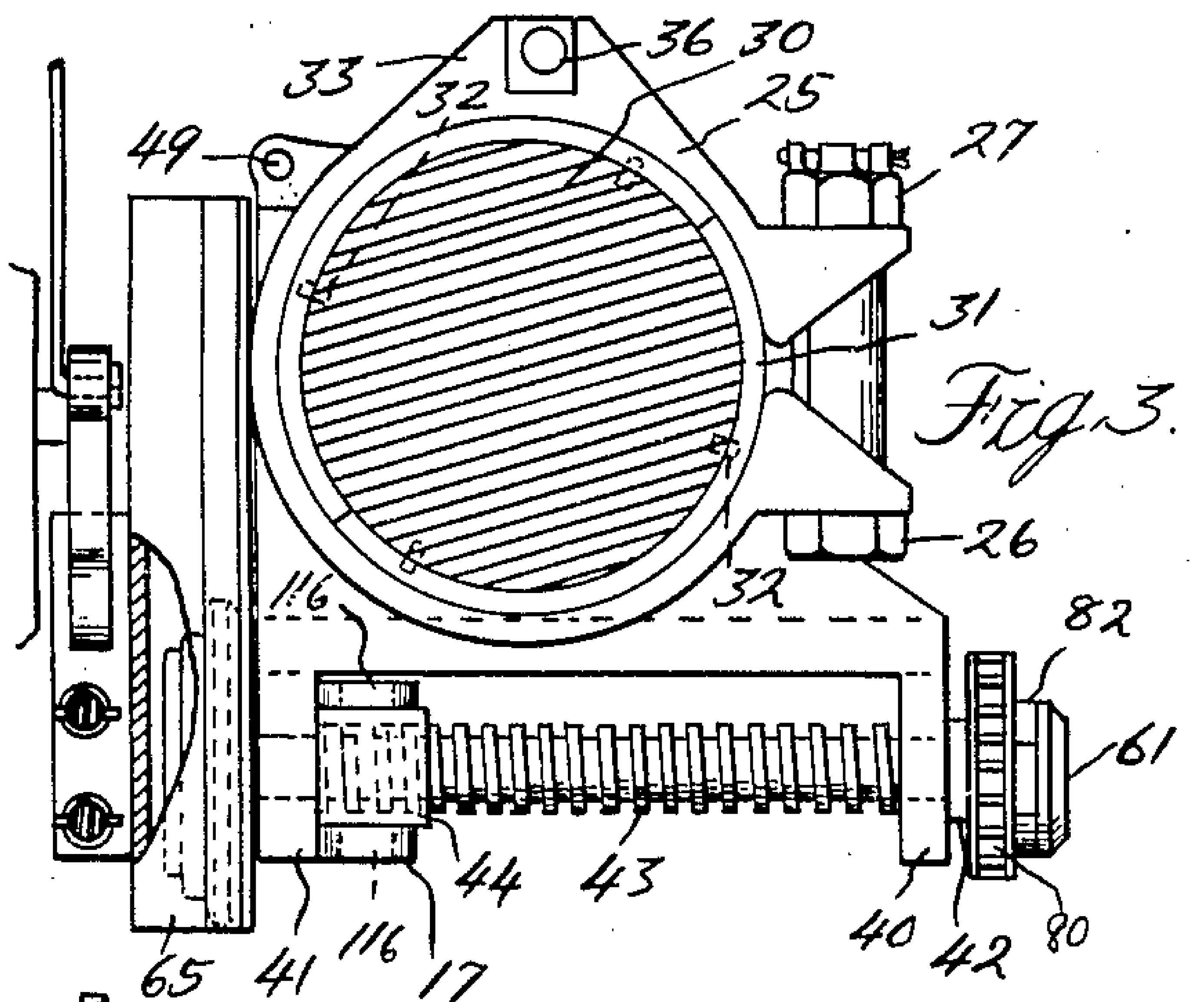


Fig. 3.

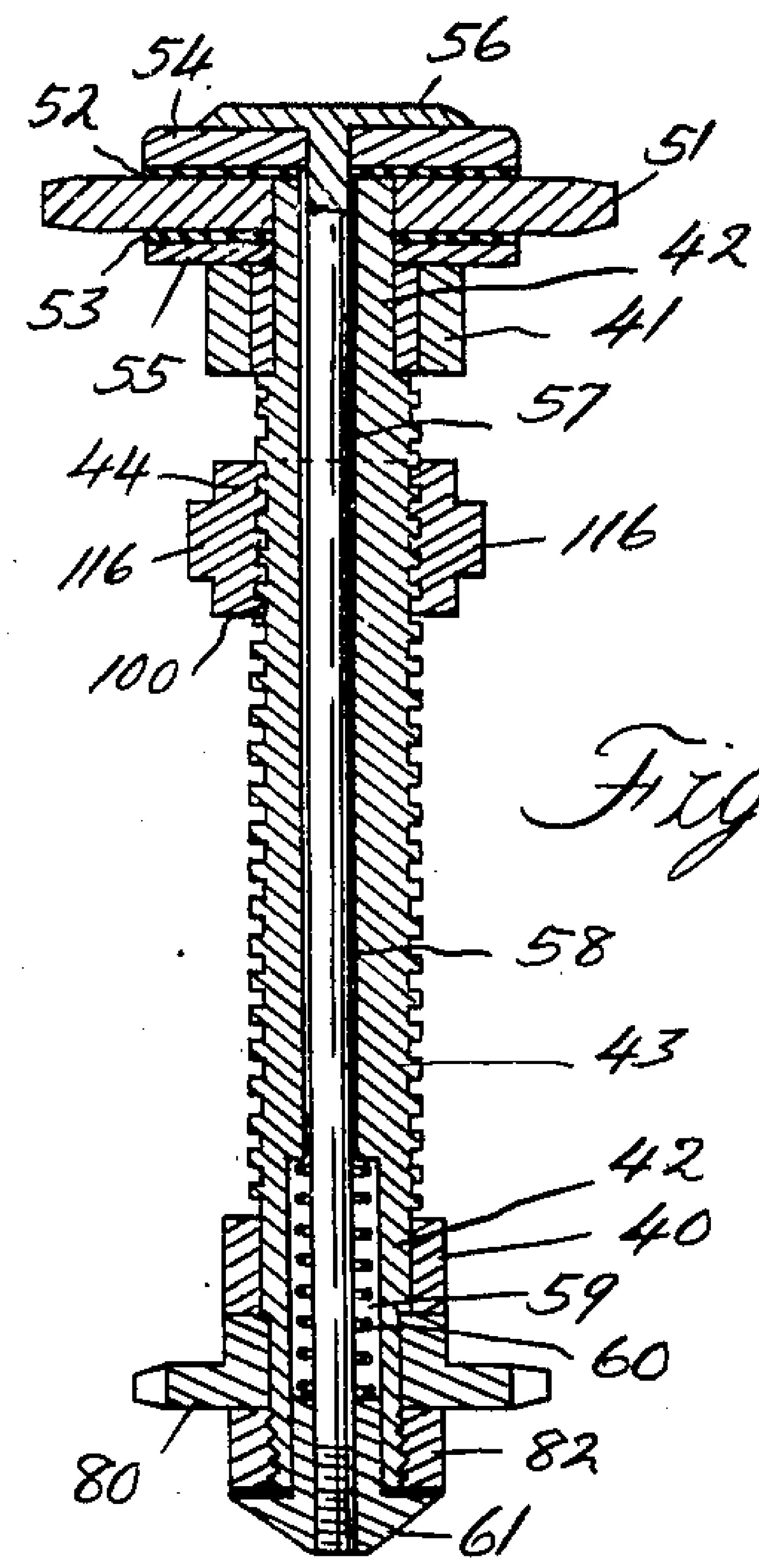


Fig. 7.

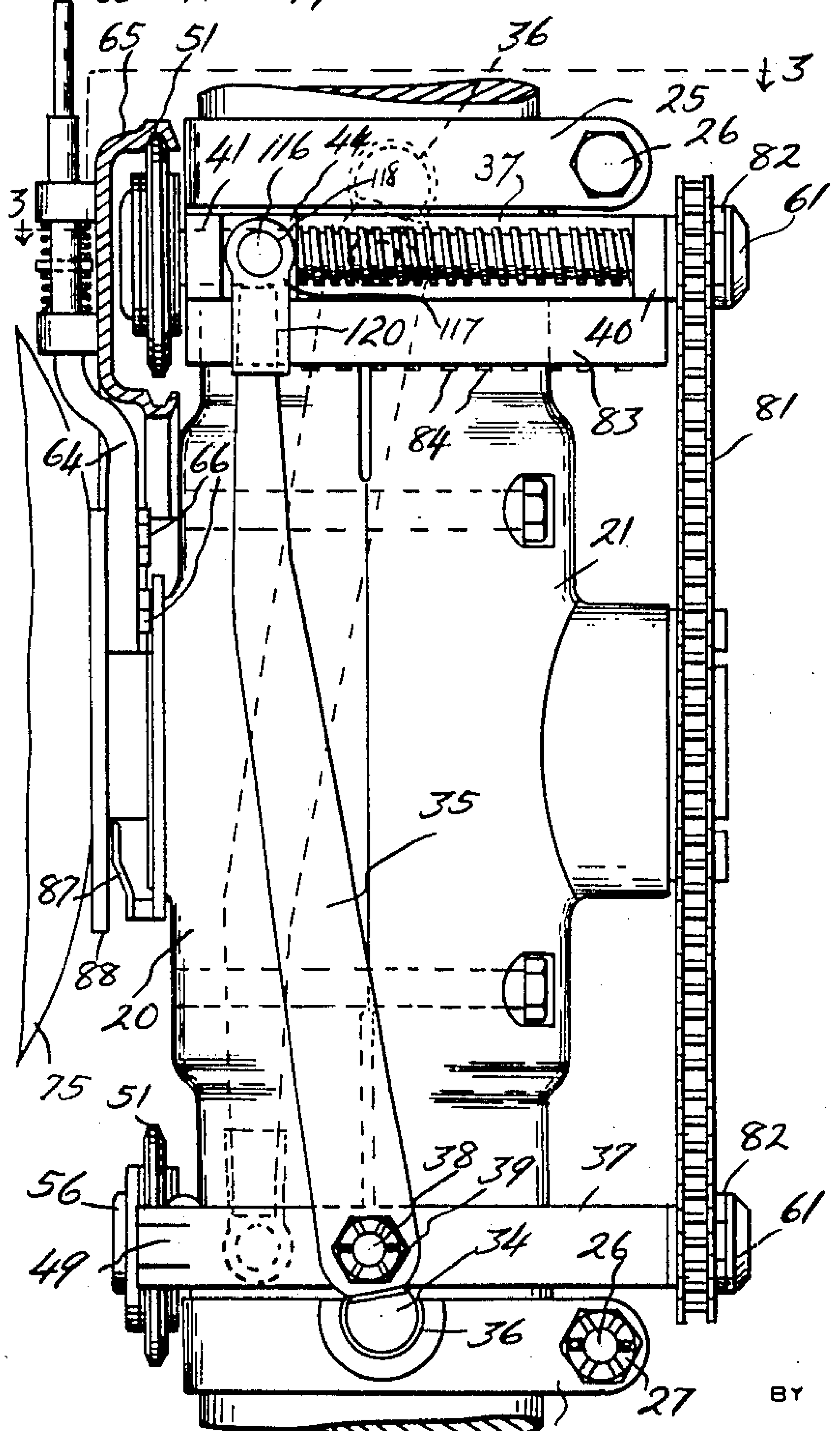
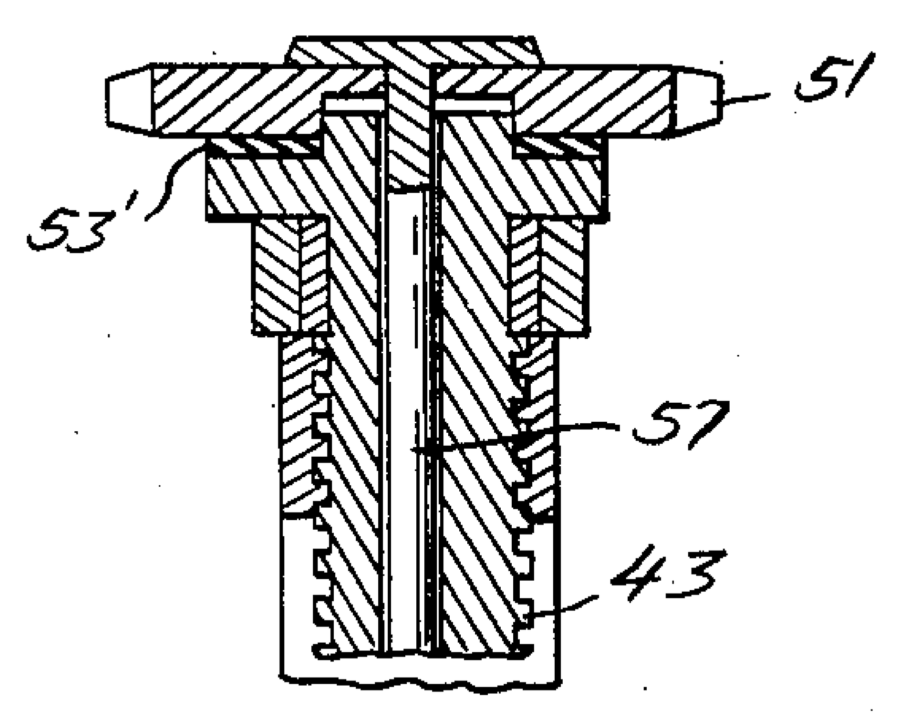


Fig. 2.

Fig. 8.



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CONTROLLABLE PITCH PROPELLER

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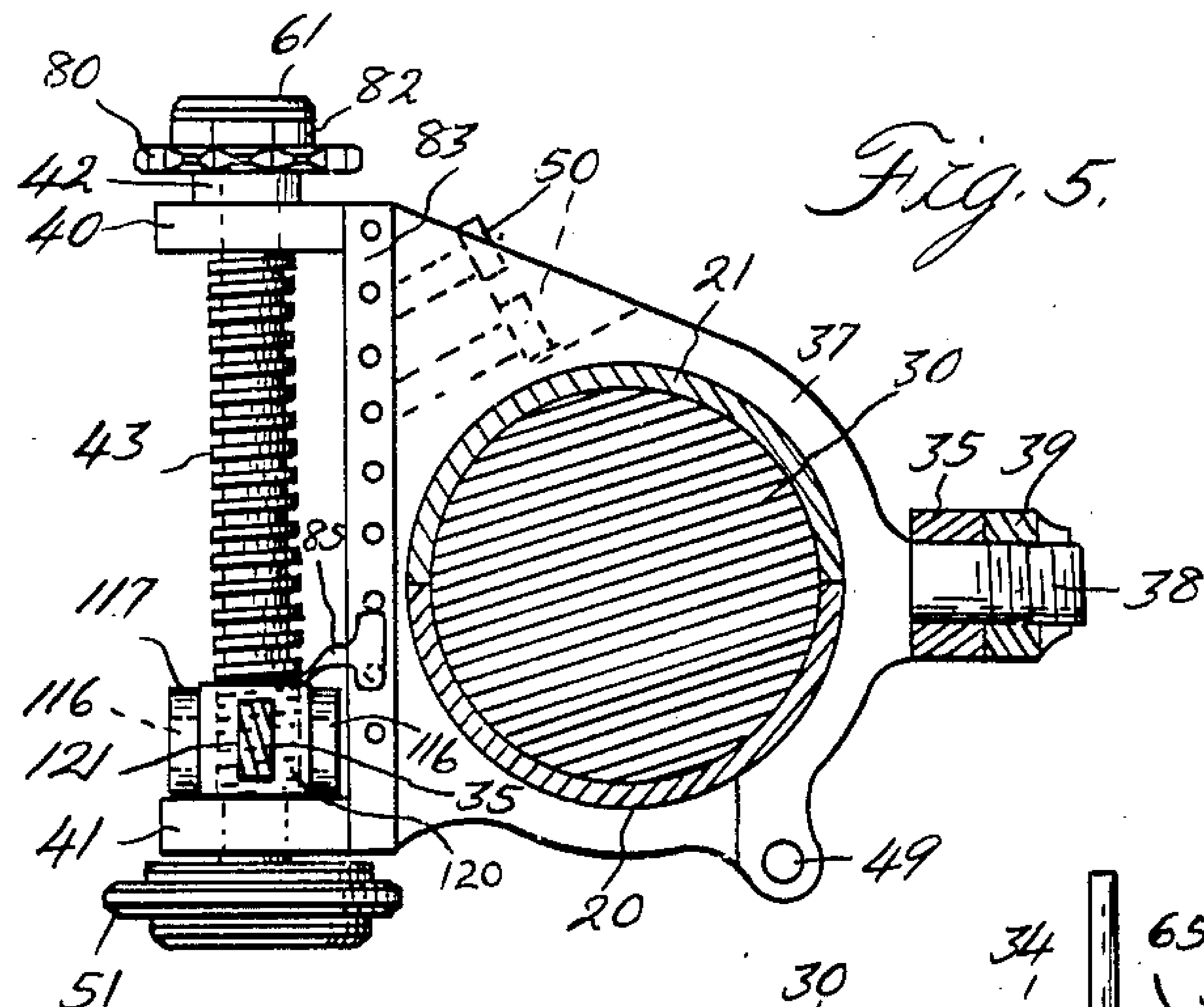
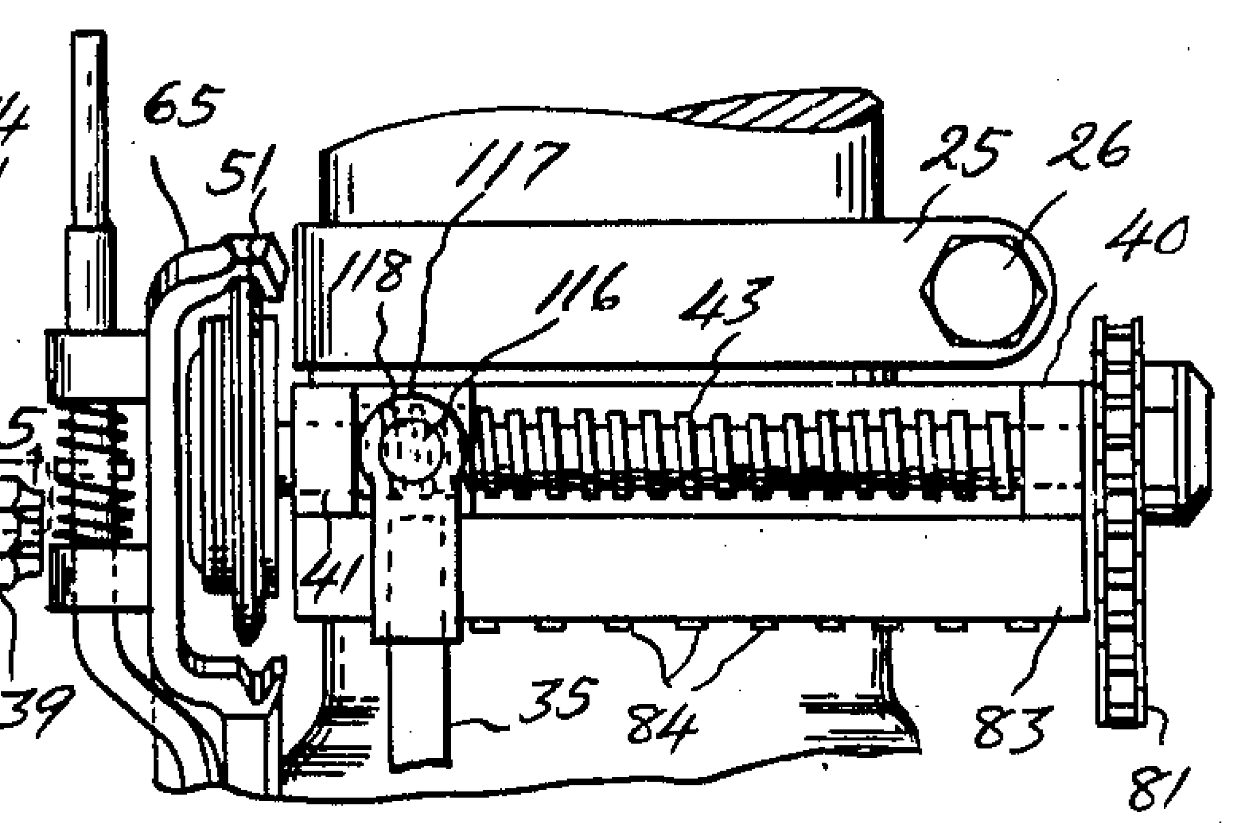


Fig. 5.

Fig. 6.



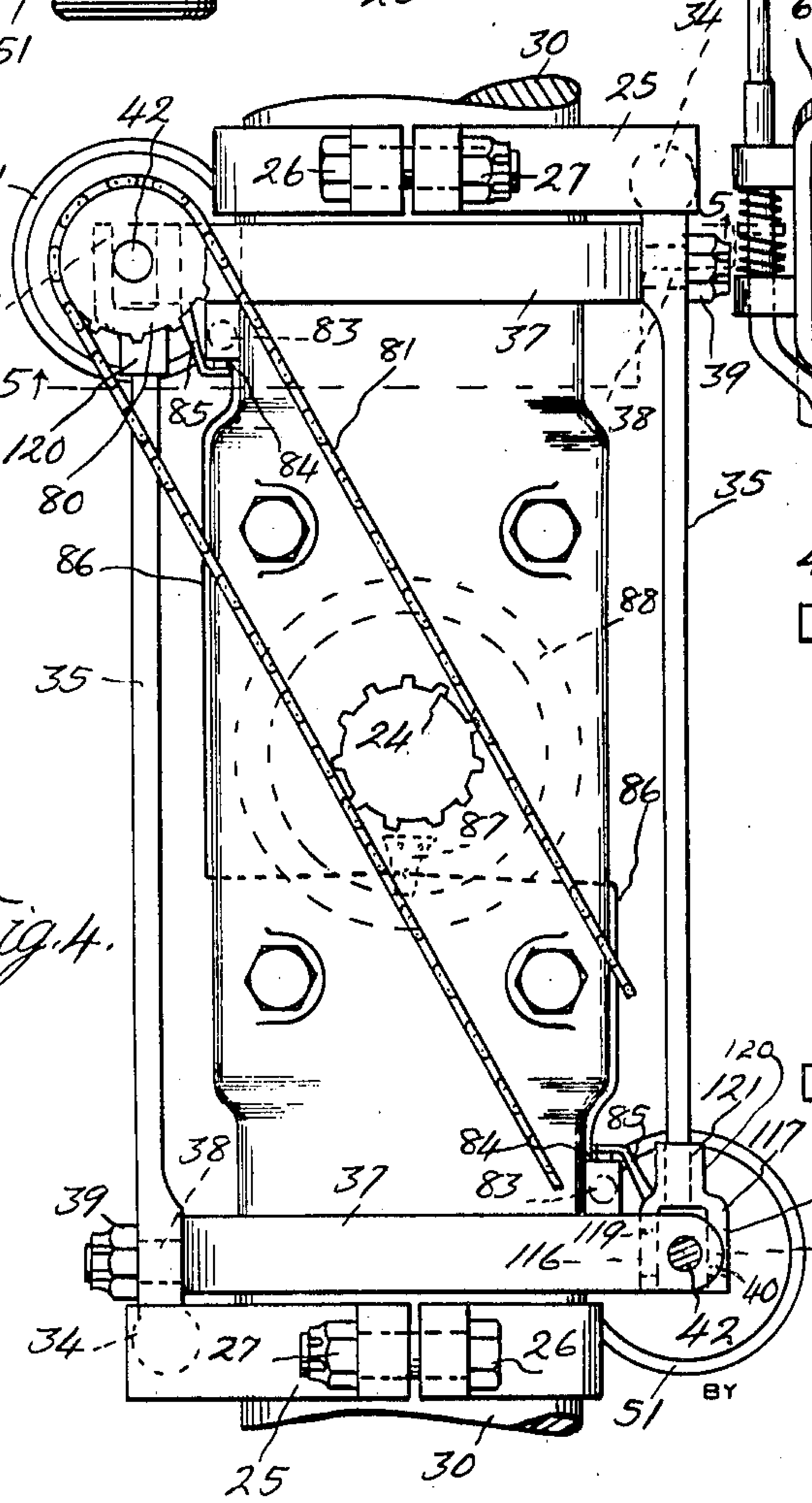


Fig. 4.

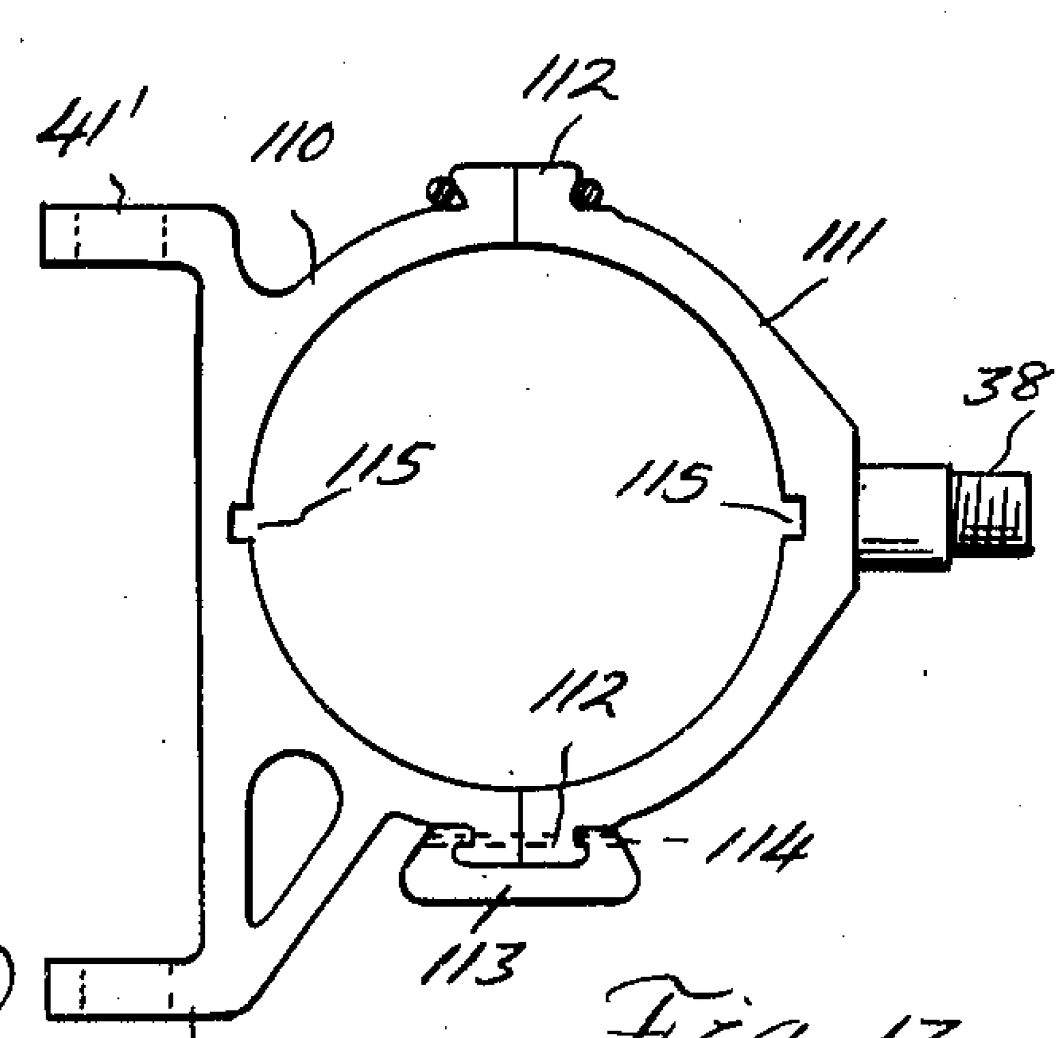


Fig. 13.

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1,897,445

UNITED STATES PATENT OFFICE

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CONTROLLABLE PITCH PROPELLER

Application filed June 19, 1930. Serial No. 462,353.

This invention relates to air propellers, such as are in common use for propelling various forms of aircraft, and for propelling some forms of land and water craft, relating more particularly to propellers of controllable pitch, that is; propellers having blades which may be turned about their longitudinal axis to any desired pitch or angle of incidence while the propeller is rotating.

The advantages of a propeller of light, simple and practical design which would attain these results and yet be sturdy enough to stand up under actual service conditions has long been recognized in the field of aviation, and many attempts have been made to supply such a propeller having its pitch controllable at will by the pilot from his seat.

One object of this invention is the production of such a propeller which will occupy no more space than is available for the installation of such a device upon airplanes as at present constructed, and which will be of relatively light weight and capable of perfect balance.

Another object of this invention is the production of such a pitch-varying means which may be readily installed on a propeller of standard design without requiring material alteration thereof, and having all of the pitch-varying mechanism centered within the area swept by the hub and boss portions of the propeller, so that it causes little if any interference with the slip stream.

Another object of our invention is the production of a propeller embodying such pitch-varying means in which the actuating parts will be out of engagement with each other and at rest except during those times when they are actually engaged in turning the blades about their longitudinal axes, and in which, when the working parts are so engaged, their movement in respect to each other will be relatively slow, in order that friction and consequent wear may be materially reduced, and the extent of pitch variation more readily controlled by the pilot. It may be said in that connection that we have found therein to lie one of the principal difficulties in the construction of a successful propeller of this nature, forasmuch as the parts must operate under great strain when in actual service due to wind resistance, centrifugal force, etc., and if in addition they must move rapidly relatively to each other, the great friction thereby produced causes their premature wearing out, and renders such a device short lived even though it may operate successfully for a time. As a result of the relatively slow-moving operation we have attained in the present invention, accurate adjustment of the blades within close limits to the precise angle desired by the pilot is made possible. Furthermore the present arrangement makes available relatively great force to do the actual work of turning the blades, so that they may be firmly held in their hub against vibration at various angular positions.

Another object of this invention is the production of such a propeller in which the blades may be moved in absolute synchronism, but in which the synchronizing means will be under very little strain.

Another object of this invention is the provision of electrical indicating means enabling the pilot to determine accurately at any time, without leaving his seat, the pitch angle of the blades.

Other objects and advantages will be apparent from the following description, wherein reference is made to the accompanying drawings illustrating a preferred embodiment of our invention and wherein similar reference numerals designate similar parts throughout the several views.

In the drawings:

Figure 1 is a simplified fragmentary side elevation of the front end of an airplane equipped with our improved propeller, and having a portion of the fuselage broken away to show the positioning of the control and indicating members.

Figure 2 is a side elevation of our pitch-varying mechanism installed on a propeller hub of standard split-hub construction, the blades being fragmentarily shown.

Figure 3 is an end view, partly in section, taken substantially on the line 3—3 of Figure 2, and looking in the direction of the arrows there shown.

Figure 4 is a front elevation of a standard hub equipped with our invention, also showing the blade-hubs fragmentarily, and bringing out the synchronizing chain.

Figure 5 is a sectional view taken substantially on the line 5—5 of Figure 4, and looking in the direction of the arrows there shown.

Figure 6 is a fragmentary detail view of a portion of the hub of a propeller equipped with our invention, and showing the construction of the friction-drive mechanism, which is shown in side elevation.

Figure 7 is an enlarged longitudinal section of one of the worm or screw-threaded driving members and the integral shaft upon which is is formed, together with the sprocket wheel and friction driving wheel, in their assembled relation as mounted in their supporting clamp.

Figure 8 is a fragmentary view similar to a portion of Figure 7 but showing a somewhat modified form of construction.

Figure 9 is a front elevational view of the friction-drive mechanism, showing my preferred means for supporting and controlling the same.

Figure 10 is a longitudinal section of a standard two blade propeller split hub, with portions of the blades shown clamped therein.

Figure 11 is a rear elevation of the friction-drive mechanism shown in Figure 9.

Figure 12 is a schematic diagram of the electrical circuit used in my preferred indicating means, and

Figure 13 is a plan view of an alternative form of clamp construction for use on the propeller hub, the purpose of which will subsequently be apparent.

Referring to the drawings:

Reference numerals 20 and 21 indicate the two halves of a standard steel propeller hub of the form commonly used upon modern aircraft for supporting two metal propeller blades, although it will be apparent that the invention might be applied to propellers having three or more blades. The butts of the blades are fragmentarily shown in Figure 10, and indicated by reference numerals 22 and 23. Normally such an assembly renders the blades adjustable when the propeller is at rest, as the two halves of the hub housing may be loosened relatively to each other, and the blades turned to the desired angle; whereupon the hub is again tightened firmly about them. In order to accomplish the controlled turning of the blades while rotating about the engine shaft, we use the disclosed structure; and in order to enable such turning, the two halves of the hub, which are of the form shown in Figure 10, are not clamped about the butts of the blades as tightly as when in use without our mechanism being attached. The fit may be described as a tight slip fit, the blades being held tightly enough to prevent vibration, but capable of being turned if a considerable force is applied. The hub, and consequently the blades, are driven by the engine in any suitable manner, either directly or through gearing, being here shown splined directly to the engine shaft, as at 24.

Tightly clamped about the boss of each blade directly outside the hub is a clamp 25, actuation of which serves to rotate the blade in the hub. The clamp may be held thereon in any suitable manner, as by means of the bolt 26 and castellated nut 27. Since the buttresses 28 and 29 on the stub ends of the blades (Figure 10) are of greater diameter than the adjacent boss portions 30 about which the clamps are to be engaged, a split ring, as 31, may be introduced between them to enable passage of the clamp over the projecting buttresses, which may if desired be keyed or pinned to the blade boss for additional security, as by the pins 32, (Figure 3). An integral projection 33 is formed by widening one side of the clamp 25, which portion is apertured to form a ball socket 36 for reception of the rounded extremity 34 of the lever 35, which actuates the clamp, and consequently the blade. Each lever 35 is carried by and fulcrumed on a clamp 37 fastened on the hub in any suitable manner, as by being hinged at 49 and bolted together, at its extremities by bolts 50, one clamp being fastened at each end of the hub. Figure 13 shows an alternative method of constructing the clamp and securing it to the hub, wherein it is made in two sections, 110 and 111, the meeting edges of which are dovetailed as at 112, and secured together by cooperating clamps 113 which are driven on from the end, and which may be additionally secured in place by means of pins, as 114. If this construction is used it may be well to key or spline the clamp on the hub to guard against its turning; keyways 115 being shown in Figure 13 for that purpose. A pivot pin 38, (38′ Figure 13) which may be formed integral with the clamp, serves as the axis of the lever, which may be secured thereon in any suitable manner, as by the nut 39. Each clamp 37 also carries the projecting bearing arms 40 and 41, (40′ and 41′ Figure 13) in which a shaft 42, having a worm or screw-threaded central portion 43 is journaled (Figures 3 and 5). Upon the threaded portion rides the cooperatively threaded traveller or nut 44, which is free to move longitudinally on but not to rotate with the driving worm 43, so that rotation of the shaft causes its longitudinal movement therealong, the direction in which it is driven depending upon the direction in which the worm is rotated. Our preferred manner of constructing the traveller 44 is clearly shown in Figures 2, 3, 5, and 7; the central or body portion, which may be of any suitable shape is here shown as cylindrical and equipped with trunnions 116, by means of which the traveller is connected with the long arm of the lever which is fulcrumed on the opposite clamp, and by means of which the traveller is simultaneously prevented from rotating. The connection between the traveller and lever, which may be made in a number of ways, we prefer to make by means of the yoke 117, equipped with trunnion bearings 118 and 119 (Figures 2, 3, 4, and 5), and having the elongated central portion 120 which is suitably apertured as at 121 for slidable reception of the end of the lever arm 35 therein as shown in Figures 4 and 5. As the lever 35 turns on its pivot pin 38 its farther end will obviously have a slight longitudinal movement with respect to the traveller, for which reason the provision is made for it to slide freely through the yoke member 117 as above described. The internal threading of the traveller is indicated by reference numeral 100. It will now be apparent that if the shaft 42 be rotated, the traveller 44 will actuate the lever 35, the shorter arm of which, 34, will move the clamp 25 and consequently the blade, through a much lesser distance than the traveller moves; but a sufficient distance to rock it through the desired angles. It will also be apparent that greatly increased force will be made available at the knuckle 36, depending on the ratio of the long and short arms of the lever.

The desired rotation of the worm shafts 42 may be secured in a number of ways, but we prefer to use the friction-drive mechanism shown, wherein a drive wheel 51 is secured to one end of the shaft 42. Obviously one drive wheel may be mounted on the end of each worm shaft 42, or only one drive wheel may be used, the other shaft being driven by the chain 81, which also synchronizes them, and the functions of which will subsequently be described more particularly. By reason of the great reduction made possible by the arrangement here shown, very little power is required to turn the drive wheel, even when the propeller is rotating at a high rate of speed, for which reason the wheel may be made of relatively soft rubber, or equipped with a rubber tire, although some other suitable material, such as one of the phenolic-condensation or impregnated materials sold under various trade names might also be used.

In Figure 2, the reference numeral 75 designates the crank case of a radial aviation engine, shown in its entirety in Figure 1, being mounted in the customary manner on the nose of the airplane. It will accordingly be seen that the friction-drive wheel or wheels 51 just described, project back toward the engine and revolve with the propeller in a common orbit perpendicular to the engine shaft, and the mechanism for driving them is fixedly secured to the engine crankcase, although it might obviously be secured to any fixed portion of the engine or fuselage if a different 'plane construction were in use.

The driving means comprises one or more segmental wheel contacting members disposed to be movable into and out of the annular path swept by the driving wheel or wheels 51 when the propeller is rotating. If two driving wheels are used as here shown, they must obviously be positioned equidistant from the engine or drive shaft. In the disclosed structure one segmental wheel contact member is used, the roughly sector-like shape of which is best shown in Figure 9. It will be seen that there are two tracks, an outer and an inner one, carried by the same member, which is selectively movable in such manner that either of the tracks as desired may be thrown into engagement with the planetary friction-drive wheels 51, the consequent direction of rotation of which on their own axes will of course depend upon the track with which they are intermittently engaged. It will be seen that the approach of the drive wheel to the track is rendered gradual by shaping each track outward and away from a true circumferential path at its approach end, as at 62 and 63, Figure 9. This results in the somewhat funnel-shaped contouring of the two tracks there shown, and minimizes jar and vibration as the drive wheels come into contact with the track when the propeller is rotating and the pitch-varying mechanism is in use. At their narrowest point, however, the distance separating the two tracks is greater than the diameter of the drive wheels 51. It will be seen that a simple vertical movement of the track-carrying member (designated 65) will suffice to bring one of the tracks into intermittent engagement with the drive wheels if the propeller is in revolution, while if the track-carrying member is maintained in the middle or central position, the friction-drive wheels will not touch either track to be actuated thereby. The track member is supported by and vertically slidable on the yoke-shaped supporting bracket 64, which is secured to a fixed portion of the motor or fuselage in any suitable manner, here being shown fastened to the crank case by the bolts 66. The upper track in member 65 is designated 67, the lower, 68. The bearing members or blocks 69 and 70 which are secured to or integral with the track carrying member, on the opposite side from that carrying the tracks (see Figure 11) are laterally apertured for free passage therethrough of the two arms 71 and 72 of the supporting bracket 64, and members 69 and 70 are extended longitudinally as shown in Figure 11, a channel being thereby formed between them within which fits the rounded end of the lever 73 formed integral with the crank member 76—77, as shown in Figures 9 and 11. The crank arms 76 and 77 may be formed in a straight line as shown, pivotally supported at their approximate center upon a fixed portion of the engine or fuselage, as at 74. The projecting knuckle or lever 73 maintains the track-carrying member in the desired position, and is controlled through the levers 76 and 77, to the extremities of which are attached cables 78 and 79, which run to the cabin or cockpit as shown in Figure 1, and are controlled by the pilot. Springs may be inserted in the cables or affixed directly to the levers 76 and 77, as shown at 101 in Figure 9, in order that the tension exerted by the cables may be yieldable, and that the track may give slightly under too great an impact from the planetary friction-drive wheels 51, thus also tending to reduce vibration caused by such regular impact, while this effect is still further minimized if rubber or rubber tired drive wheels are used as above described. Centering springs 102 may also be provided.

We consider a relatively short sector as described preferable to a continuous annular track, in order that the speed of operation of the pitch-varying device may be further reduced, and if only one drive wheel 51 is used, as mentioned above, the speed of operation will obviously be even more greatly reduced.

A suitable control lever 105, for the cables, is placed in a position accessible to the pilot, as shown in Figure 1, enabling the track-member to be elevated so that the lower track will be engaged by the friction wheels when revolving in their common orbit to thereby rotate them; or to be depressed so that the upper track will be thus engaged, thereby rotating the wheels in the opposite direction. It will thus be seen that in this manner the worms 43 may be turned in either direction at the will of the operator, thus turning the blades in the manner described above.

To insure absolute synchronism between them, each worm shaft 42 carries at its forward end a sprocket wheel 80, and a single chain 81 engages and is driven by them. The sprocket wheels 80 may be splined on the worm shaft, and secured thereon by the nut 82, which also serves as a check nut to lock in position the plug 61. If only one driving wheel 51 is used, the chain also serves to drive the other worm shaft 42, which imposes no harmful strain in the chain, since very little power is required to drive the worm shafts; which is one of the advantageous features of our construction.

In order to allow slippage in event the traveller reaches the end of the worm and rotation of the shaft in the same direction is continued, which otherwise would jam the threads or destroy the traveller, the drive-wheel 51 is not rigidly secured to the shaft, but is freely mounted thereover and held relatively tightly between one or more clutch faces, as shown in Figures 7 and 8. In Figure 7 two clutch faces, 52 and 53 are shown, which may be in the form of discs of fiber or other friction material clamped tightly against each side of the wheel between metallic discs 54 and 55. The required yieldable pressure is secured by means of the elongated mushroom-headed bolt 56, the stem 57 of which extends through the length of the shaft 42, which is axially apertured as at 58 to receive it. An enlarged recess 59 is formed at the farther end of the shaft from the drive wheel as an enlargement of the aperture 58. within which is housed the relatively stiff compression spring 60, which urges the stem outward and consequently the outer clutch face toward the inner, by bearing outwardly against the internally threaded sleeve-like plug 61, which simultaneously seals the aperture, secures the stem 57, and renders the tension of the spring adjustable, as will be apparent from Figure 7. Figure 8 illustrates a somewhat modified construction wherein only one clutch face, 53′ is used, and the operation of which will be apparent upon an examination of that view, being in principle substantially the same as the form shown in Figure 7.

To enable the pilot to ascertain at any time the pitch angle of the blades, we provide electrical indicating means comprising essentially a circuit containing a source of current, a variable resistance controlled by the pitch-varying mechanism, and a current-indicator mounted within the cock-pit so as to be easily observable by the pilot. More specifically, our preferred indicator consists of a resistance coil 83, shown enclosed in a housing, affixed to the clamp 37, preferably adjacent the jaws 40 and 41 thereof, having taps 84, or an actual portion of the winding itself in such position that they or it may be wiped by a contact arm 85 carried by the traveller 44 as it moves over the worm 43. The contact arm or brush 85 is of course grounded, being connected through metal parts to the metal propeller, which is carried by the metallic engine shaft. The coil and the taps 84, however, are insulated from their mounting, and the free end of the coil is connected by means of an insulated conductor 86 to a brush 87 also carried by and nearer the axis of rotation of the propeller, as shown in Figures 2 and 4. A collecting ring 88 is carried by but insulated from a fixed portion of the frame or engine, here shown as the crank case 75, and from the collecting ring an insulated conductor runs to a source of current 106, and an ammeter or milliameter 107, in series, and then to a grounded connection, which may be to a portion of the fuselage if metal, or the engine. The source of current may be either a battery or wind actuated generator. A schematic diagram of the circuit employed is shown in Figure 12, although obviously variations might be made. The resistance of the coil is of course entirely optional, depending on the capacity of the ammeter or milliameter to be used and the voltage supplied by the battery or generator. The scale of the ammeter may be calibrated to read in degrees of mean or geometric pitch instead of amperes or milliamperes if desired, in order that direct and readable indication may be had. A switch 108 may of course be inserted in the circuit, to be controlled either by hand or automatically by the control lever or cables, or another part of the actuating mechanism. When the switch is closed, the amount of resistance in the circuit thus formed will be proportionately varied by the brush 85 as the traveller moves along the worm or screw threads 43. Since the position of the traveller always conforms to a certain definite blade angle, the amount of resistance in the circuit will thus also be made to vary proportionately thereto, and the variations will be indicated by the ammeter within the field of observation of the pilot.

It will thus be seen that the pilot may continually observe, while changing and controlling, the pitch angle of the blades, and may accurately ascertain their pitch angle at any time.

The substantially perfect propeller balance made possible by virtue of this construction will also be appreciated. Corresponding parts are oppositely disposed in respect to the driving shaft, and are not only identical and therefore of equal weight, but are spaced equal radial distances from the center of the shaft. They are also oppositely disposed in respect to the longitudinal axis of the propeller, as will be seen upon studying the drawings, corresponding parts being on opposite sides of the longitudinal axis and equidistant therefrom; so that a straight line connecting any two corresponding oppositely disposed parts passes through the center of the engine shaft. This perfect lateral and longitudinal balance is maintained throughout all operation and any position assumed by the mechanism, for it will be observed that the relative movements of the corresponding parts are equal in extent when the pitch-varying mechanism is in use, thus making the changes in the positions of the parts self-compensating in respect to the balance of the propeller.

While it will be apparent that the illustrated embodiment of our invention herein disclosed is well calculated to adequately fulfill the objects and advantages primarily stated, it is to be understood that the invention is susceptible to variation, modification and change within the spirit and scope of the subjoined claims.

We claim:

1. In a propeller having a hub and a blade rotatable on its longitudinal axis in the hub, a worm gear, a traveller motivated by the worm gear, and a reducing lever pivotally connected to both the traveller and blade for turning said blade.

2. In a propeller having a hub and a blade rotatable on its longitudinal axis in the hub, a friction-driven worm gear, a traveller motivated by the worm gear, and a reducing lever connecting the traveller and blade for turning said blade.

3. In a propeller having a hub and a blade rotatable on its longitudinal axis in the hub, a friction-driven worm gear, a traveller carried upon and motivated by the worm gear, and a lever fulcrumed on the hub and connecting the traveller and blade for turning said blade.

4. In a propeller having a hub and a blade rotatable on its longitudinal axis in the hub, a friction-driven worm gear, a traveller carried upon and motivated by the worm gear for longitudinal movement therealong, and a reducing lever connecting said traveller and blade, whereby the latter may be turned about its longitudinal axis upon rotation of said worm.

5. In a propeller having a hub and a blade rotatable on its longitudinal axis relatively to the hub, a worm gear carried by the hub, a traveller carried upon and motivated by the worm gear for longitudinal movement therealong, a lever pivotally supported by said hub having one arm thereof connected to said traveller and another arm connected to said blade, whereby rotation of said worm causes rotation of said blade about its longitudinal axis.

6. In a propeller having a hub and a blade rotatable on its longitudinal axis relatively to the hub, a friction-driven worm gear carried by the hub, a traveller carried upon and motivated by the worm gear for longitudinal movement therealong, a clamp affixed to said blade, a lever pivotally supported by said hub having one arm thereof connected to said traveller and another arm connected to said clamp, whereby rotation of said worm causes actuation of said lever and consequent rotation of said blade about its longitudinal axis.

7. Means for turning a propeller blade about its longitudinal axis while in rotation, comprising a hub, a blade held thereby but turnable therein, a driving shaft for rotating said hub and blade about said shaft, a wheel carried by and projecting from said hub for planetary revolution about said driving shaft in an orbit substantially perpendicular to both the axis of said driving shaft and the axis of said wheel, a segmental track-carrying member movably mounted adjacent the orbit of said wheel, means for yieldably projecting said track member into the orbit described by the periphery of said wheel for intermittent engagement therewith, whereby engagement of said track member with the

periphery of said wheel rotates the latter about its own axis, and connecting means between said wheel and blade including a lever carried by said hub and actuated by rotation of said wheel to turn said blade within the hub.

8. Means for turning a propeller blade about its longitudinal axis while in rotation, comprising a hub, a blade held thereby but turnable therein, a driving shaft for rotating said hub and blade about said shaft, a wheel carried by and projecting from said hub for planetary revolution about said driving shaft in an orbit substantially perpendicular to both the axis of said driving shaft and the axis of said wheel, a worm gear carried by said hub and drivable by said wheel, a traveller carried upon and motivated by the worm gear for longitudinal movement therealong, a lever connected to said traveller for actuating said blade, whereby the latter may be turned about its longitudinal axis upon rotation of said worm, a track-carrying member movably mounted on a fixed member, and means for projecting said track member into the orbit described by the periphery of said wheel for engagement therewith, whereby engagement of said track member with the periphery of said wheel rotates the latter about its own axis and drives said worm, thereby turning said blade within the hub.

9. In a controllable pitch propeller a hub formed of a plurality of parts, clamping means securing the hub parts together, of a blade held by the hub but turnable on its longitudinal axis relatively thereto, a wheel carried by said clamping means and rotatable on its own axis by external friction-driving means, and blade actuating means also carried by said clamping means for turning said blade, said blade-actuating means being also frictionally drivable by said wheel.

10. Means for simultaneously turning a plurality of independently mounted propeller blades about their longitudinal axes while in rotation, comprising a hub, a plurality of blades held thereby but turnable relatively thereto, a driving shaft for rotating said hub and blades about said shaft, a plurality of wheels carried by said hub, projecting therefrom, and equidistant from said shaft, for planetary revolution about said driving shaft in a common orbit substantially perpendicular to both the axis of said driving shaft and the axes of said wheels, a plurality of worm gears each drivable by one of said wheels, carried by said hub and equidistant from the center thereof, a traveller carried upon and motivated by each worm gear for equal and simultaneous longitudinal movement therealong, levers connected to each of said travellers, carried by the hub and equally disposed relatively to the center thereof, for equal and simultaneous motivation by said travellers, and means equally disposed with respect to the center of the hub for connecting each of said levers to one of said blades, whereby rotation of said wheels causes equal and simultaneous turning of said blades relatively to the hub.

11. In a propeller having a hub and blades rotatable on their longitudinal axes relatively thereto, a plurality of friction-driven worm gears carried by the hub and equi-distant from the center thereof, travellers carried upon and motivated by the worm gears for equal and simultaneous movement therealong, clamps affixed to each of said blades and equidistant from the center of the hub, and levers pivotally supported by said hub and equally disposed about the center thereof each connected to one of said travellers and one of said clamps, whereby equal and simultaneous rotation of said worms causes corresponding actuation of said levers and concomitant turning of said blades about their longitudinal axes.

12. In an air screw propeller, a hub formed in a plurality of sections, clamps for holding the sections together, a plurality of blades having their butts held in the hub, and means for changing the pitch of the blades comprising driving mechanism for turning the blades carried by the clamps.

13. In an air screw propeller, a hub formed in a plurality of sections, clamps for holding the sections together, a plurality of blades having their butts held in the hub, and means for changing the pitch of the blades comprising driving mechanism for turning the blades partly carried by the clamps.

14. In an air screw propeller, a hub formed in a plurality of sections, clamps for holding the sections together, a plurality of blades having their butts held in the hub, and means for changing the pitch of the blades comprising friction driven mechanism for turning the blades carried by the clamps.

In testimony whereof we sign this specification:

WALTER F. STIMPSON.
MURRAY K. PATTEN.