

Nov. 14, 1944.

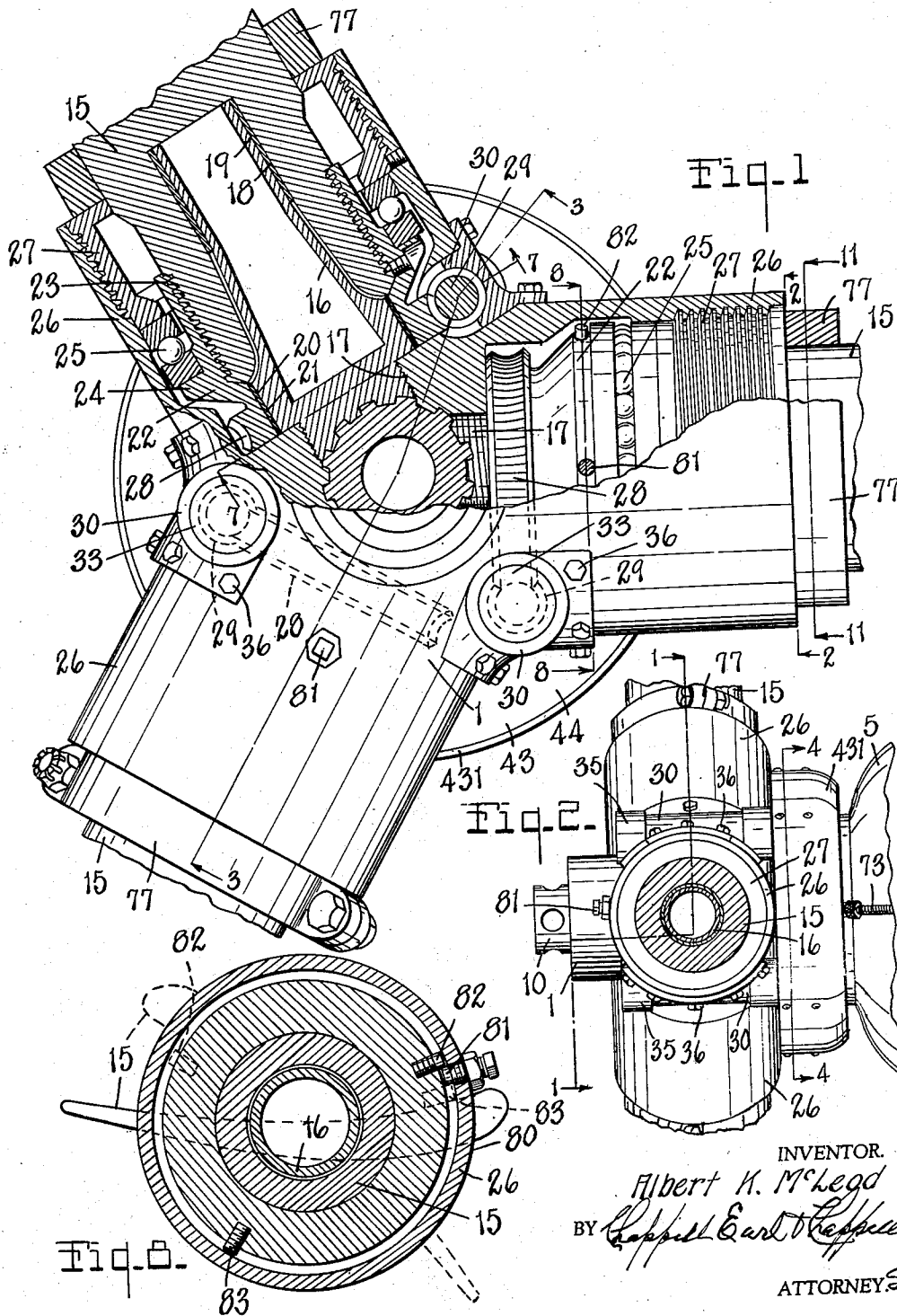
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2,362,914

ADJUSTABLE PITCH PROPELLER MECHANISM FOR AIRPLANES

Original Filed Jan. 6, 1936

6 Sheets-Sheet 1



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Nov. 14, 1944.

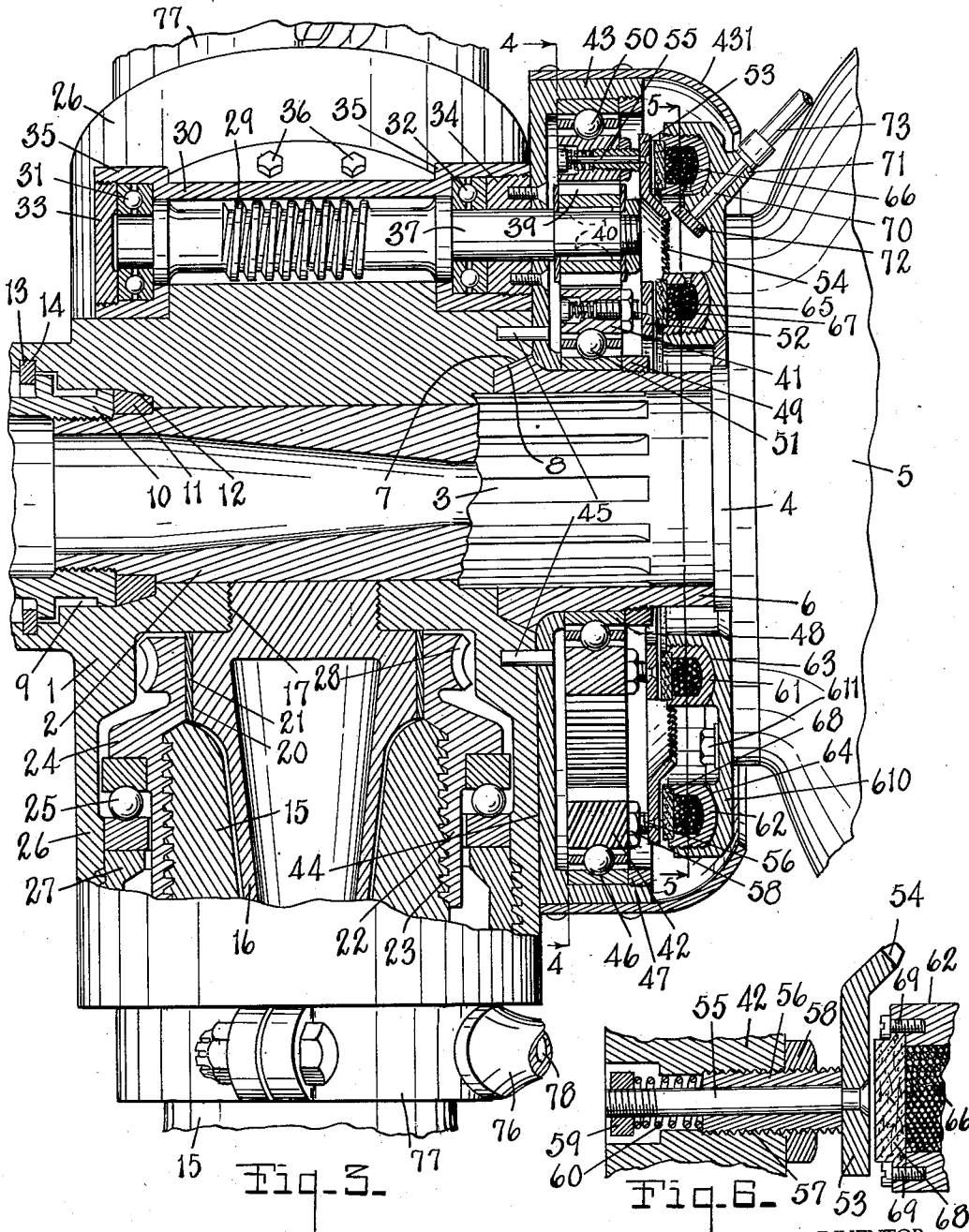
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ADJUSTABLE PITCH PROPELLER MECHANISM FOR AIRPLANES

Original Filed Jan. 6, 1936

6 Sheets-Sheet 2



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ADJUSTABLE PITCH PROPELLER MECHANISM FOR AIRPLANES

Original Filed Jan. 6, 1936

6 Sheets-Sheet 3

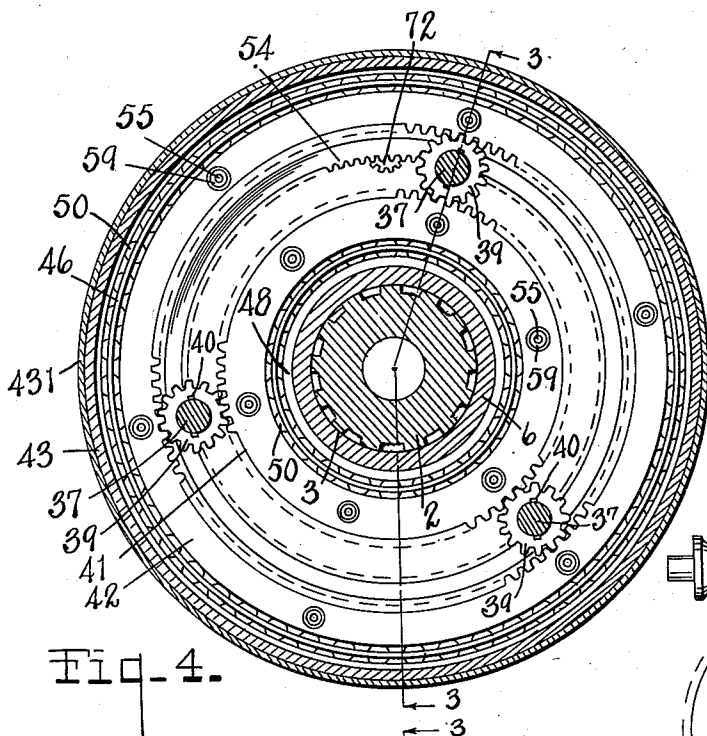


Fig. 4.

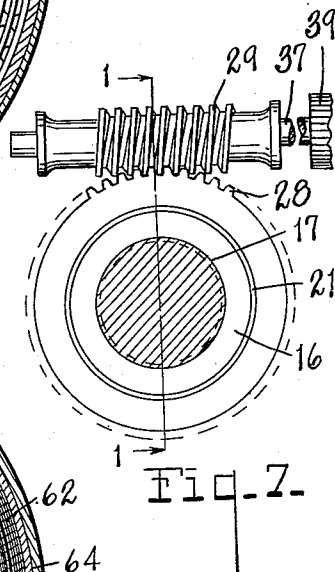


Fig. 7.

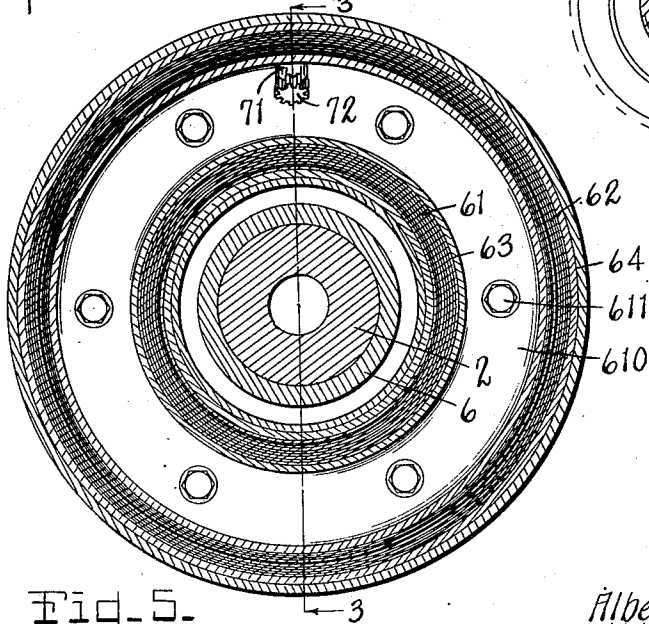


Fig. 5.

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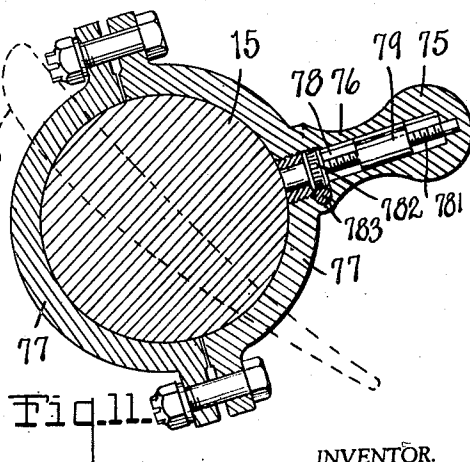
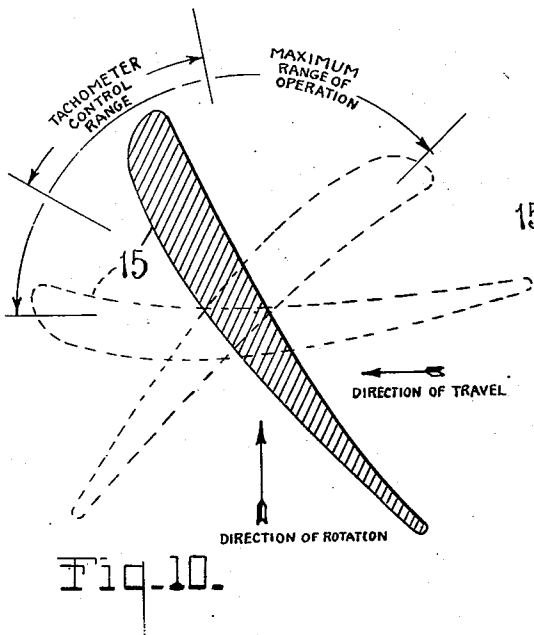
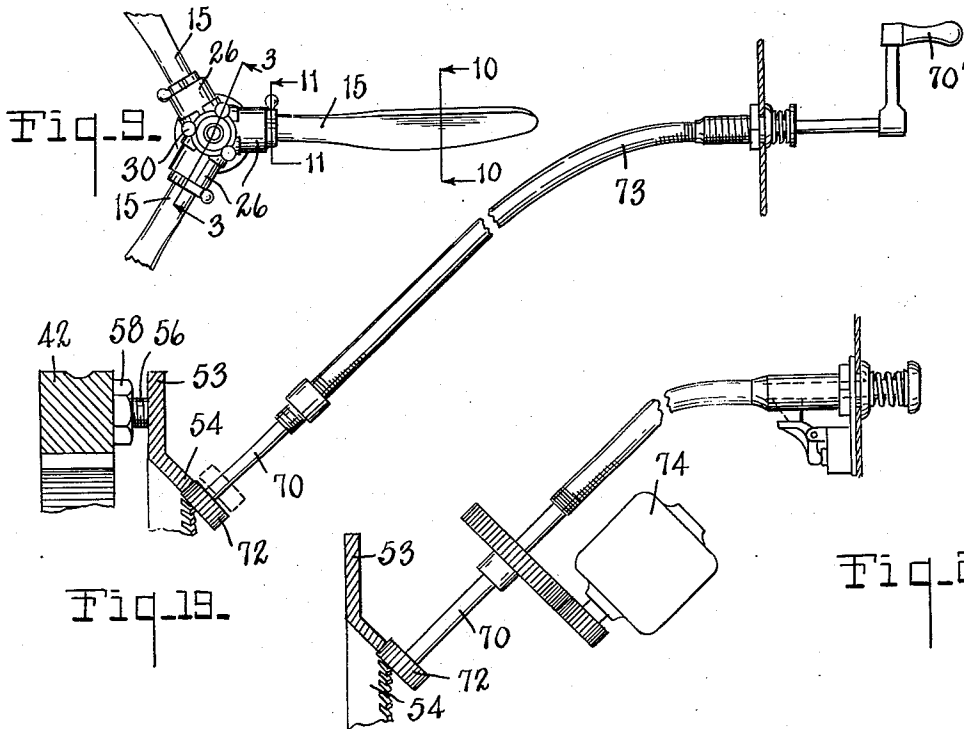
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ADJUSTABLE PITCH PROPELLER MECHANISM FOR AIRPLANES

Original Filed Jan. 6, 1936 6 Sheets-Sheet 4



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ADJUSTABLE PITCH PROPELLER MECHANISM FOR AIRPLANES

Original Filed Jan. 6, 1936 6 Sheets-Sheet 5

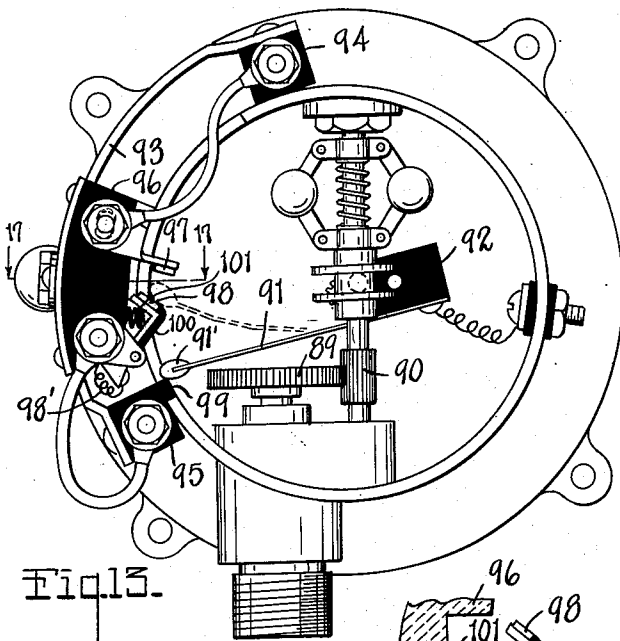


Fig. 13.

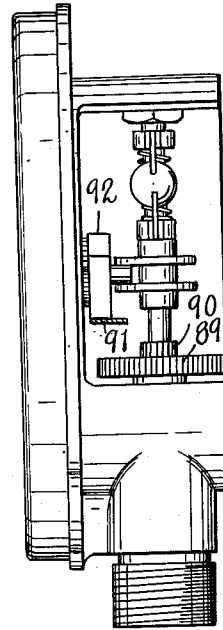


Fig. 14.

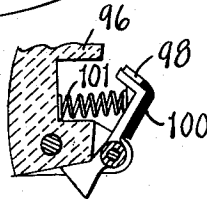


Fig. 15.

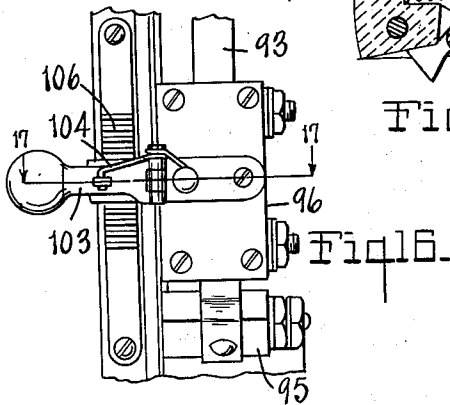


Fig. 16.

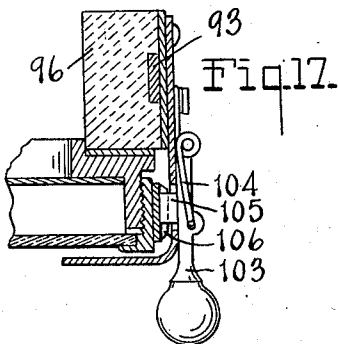


Fig. 17.

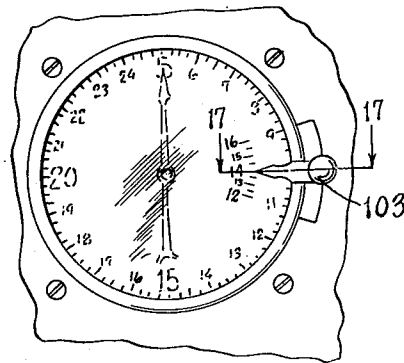


Fig. 12.

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ADJUSTABLE PITCH PROPELLER MECHANISM FOR AIRPLANES

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6 Sheets-Sheet 6

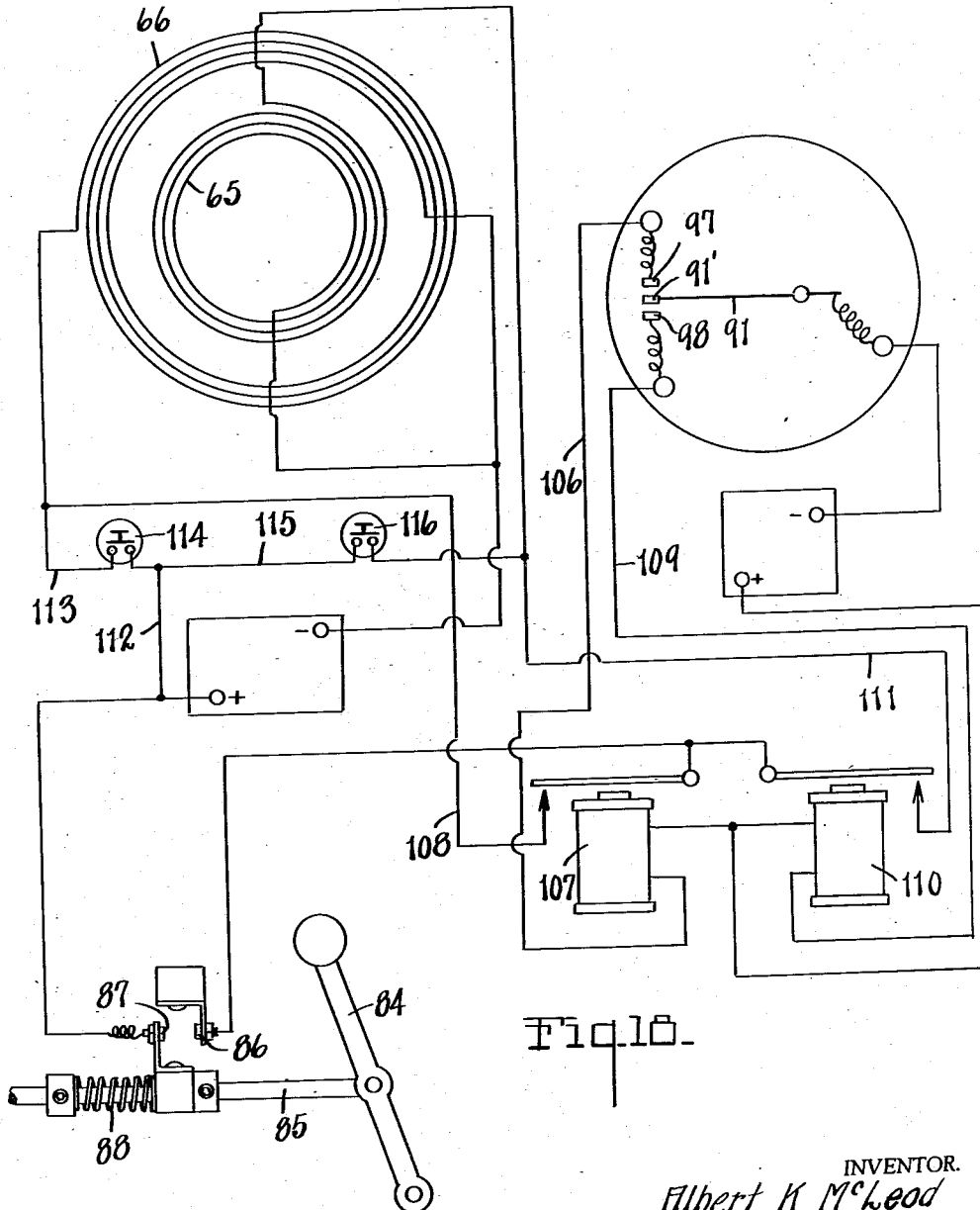


Fig. 10.

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UNITED STATES PATENT OFFICE

2,362,914

ADJUSTABLE PITCH PROPELLER MECHANISM FOR AIRPLANES

Albert Kenneth McLeod, Los Angeles, Calif., assignor to Aviation Patents, Inc., Los Angeles, Calif., a corporation of California

Continuation of application Serial No. 57,739, January 6, 1936. This application July 27, 1939, Serial No. 286,940

18 Claims. (Cl. 170-163)

This invention relates to improvements in an adjustable pitch propeller mechanism for airplanes.

The objects of this invention are:

First, to provide an improved adjusting means for the propeller blades.

Second, to provide improved control for such propeller blades when in action.

Third, to provide effective automatic constant speed electric controls.

Fourth, to provide in such a combination an improved counterbalance means for the adjustable blades of the propeller.

Fifth, to provide an improved tachometer means for such a combination and control.

Sixth, to provide an improved means for manual control of the whole or any of the parts, including the manual adjustment of the propeller blades.

Further objects pertaining to economies and details will appear from the description to follow. I describe a preferred embodiment of my invention in the following specification and the attached drawings, in which:

Fig. 1 is a fragmentary front elevation of the hub of a three-blade propeller, with the blades broken off, partially in section on the irregular section line 1-1 of Figs. 2 and 7.

Fig. 2 is a reduced sectional side elevation view of the same parts partly in section through the propeller blade shank on line 2-2 of Fig. 1.

Fig. 3 is an enlarged detail composite sectional view on the planes of lines 3-3 of Figs. 1, 4, 5, and 9, a part of the view showing the worm gear and the hub parts being on line 3-3 of Figs. 1, 4, and 9, while the magnet and the manual driving pinion are on the plane of line 3-3 of Fig. 5.

Fig. 4 is a detail sectional view somewhat reduced in size on line 4-4 of Fig. 3, showing the details of the adjusting ring gear means.

Fig. 5 is a somewhat reduced sectional elevation on lines 5-5 of Fig. 3 through the electromagnets, their coils and the electromagnet casing.

Fig. 6 is an enlarged detail of one of the yielding support pin means for the braking armature of the electromagnet, which armature ring is also provided with flange and gear teeth for manual or independent auxiliary control.

Fig. 7 is a conventional detail section on line 7-7 of Fig. 1 of the worm and worm gear for adjusting the angle of pitch of one of the adjustable pitch propeller blades, the same structure being provided for each blade.

Fig. 8 is an enlarged detail cross section on

line 8-8 of Fig. 1 showing the limiting stops for the control of the propeller for bringing the same to the feathering, or edge, or neutral position, or for reversing the propeller as emergency requires.

Fig. 9 is a reduced front elevation view of the three-blade propeller, part of two of the blades being broken away.

Fig. 10 is an enlarged detail sectional view on line 10-10 of Fig. 9 through one of the propeller blades, there being added in dotted lines and diagram the different positions which the blade assumes in operation and other details.

Fig. 11 is an enlarged detail sectional view on line 11-11 of Fig. 9 showing details of the propeller counterweight and its divided attaching ring, the relation and angle of the propeller blade being shown by dotted lines.

Fig. 12 is a detail front elevation view of the tachometer with my attachments.

Fig. 13 is an enlarged detail elevation of the rear face of the tachometer with my attachments.

Fig. 14 is an elevation view from the left hand of Fig. 13 showing the tachometer with my adjusting stops omitted and the cutaway wall and an end view of the flexible brush member.

Fig. 15 is an enlarged detail elevation view of the depressible switch member which permits the flexible indicating switch member to automatically move to position.

Fig. 16 is an enlarged elevation view of my adjusting means for adjusting the range of the tachometer control taken from the right hand of Fig. 12 and the left hand of Fig. 13.

Fig. 17 is an enlarged detail sectional elevation view taken centrally through the adjusting means on line 17-17 of Figs. 12, 13, and 16.

Fig. 18 is a detail wiring diagram of the entire electric system showing conventional and simple relays and circuits therefor. The relays are available in many forms, I show two batteries as the simplest.

Fig. 19 is a detail view partly diagrammatic of the manual adjusting means comprising the adjustable flexible shaft and pinion with a crank for the manual control of the concentric outer ring gear and controlling pinions and adjusting worm gears for the propeller blades.

Fig. 20 is a similar diagrammatic view where a simple form of electric starting motor is made use of in this connection by merely pushing the button of the starter.

The parts will be identified by their numerals of reference which are the same in all the views.

A three-blade propeller is illustrated. 1 is the

hub of the propeller of barrel form. 2 is the engine shaft which is splined at 3 into the hub 1 and has a collar 4. The shaft 2 projects from the nose of the engine 5. A spacing sleeve 6 is on the inner end of the shaft having an enlarged conical inner end 7 which fits into a corresponding centering recess 8 on the inner end of the hub. The hub is counterbored at 9 to receive the hub nut 10 which forces conical centering ring 11 into a corresponding seat 12 in the hub. The nut 10, when screwed onto the outer end of the shaft 2, forces the conical members 7 and 11 into the hub and centers the same effectively on the shaft. A spring locking ring 13 is in the annular recess 14 in the projecting end of the hub and locks the hub nut 10 in place. This is good practice in use for attaching the propeller hub.

Each propeller blade 15 is revolvably supported upon a shank 16 (see Fig. 1) which is shouldered and screw threaded at 17 into the hub 1. The splines are machined into the shank 16 and hub 1 at the same operation. The propeller blade 15 is provided with a journal bearing 18 for the journaled outer end of the shank 16, the bearing 18 being provided with a bushing 19. The inner end of the shank 16 is a journal and is provided with a journal bearing 20 with a bushing 21 inserted into the adjusting thrust collar 22. The adjusting thrust collar 22 is secured to the inner end of the propeller by the buttress type of screw thread at 23. The adjusting collar is provided with a shoulder 24 and receives the thrust ball bearings 25 which are within the propeller socket 26 integral with hub 1 and held by the screw thimble 27 threaded into the outer end of the propeller blade socket 26.

28 is the worm gear adjusting means on the end adjusting collar 22. 29 is the worm which controls gear 28. It is retained by the housing 30 which contains thrust bearings 31, 32 at each end, which are kept in place by the plugs 33, 34, screw threaded into the bearing housing enlargements 35, 35 at the ends of the housing that embrace the ball bearings. The housing 30 is retained in place by a series of cap screws 36, see Figs. 1, 2, and 3 for the details.

The worms 29 are provided with bearing shafts 37 to each of which is secured a pinion 39 by suitable keys 40, indicated by dotted lines in Fig. 3. These pinions 39 are disposed between the inner spur gear ring 41 and the outer internal threaded gear ring 42, see Fig. 4. The adjusting ring gears 41 and 42 are supported within the annular housing 43, the inner face 44 of which is located by dowel pins 45 on the end of the hub 1 and is secured by screws to the screw plugs 34 which retain the thrust bearing of the worm 29 in place. The ball bearing ring 46 is fitted securely within the periphery of the housing 43 and is retained by a screw threaded ring nut 47. An inner ball bearing ring 48 for the ring 41 is carried by the spacing sleeve 6 and is clamped in place by the screw threaded ring 49 which clamps the bearing ring 48 against the inner edge of the housing 43 and assists in clamping and holding the same in place. The outer ring gear 42 is tempered and hardened at its periphery to form the outer member or race of the ball bearing therefor and cooperates with the balls 50 which are retained in a suitable ball ring within the bearing ring 46 and the peripheral bearing surface of the ring bearing so that the outer ring gear is freely rotatable and adjustable within the casing for the pur-

pose of controlling the pinions above-mentioned. A shield 431 is provided for protecting the parts from the elements.

The inner or spur gear 41 is hardened on its inner bearing surface and cooperates with the balls 51 which run in the race within the bearing ring 48 whereby this inner spur gear readily rotates and is adjustable and in mesh with the aforesaid pinions 39. These pinions, ring gears, and parts all revolve with the hub. It is clear that, if the outer ring gear 42 is retarded or stopped in its relative movement to the ring 41, this will cause the pinions 39 to rotate and, by their rotation, they cause the operation of the worms 29 and adjust the pitch of the propellers. On the other hand, if the ring spur gear 41 is retarded, it will also have the effect of rotating the aforesaid pinions but in the opposite direction, causing the corresponding adjustment of the pitch of the propellers. I preferably do the retarding with magnetic brake means, but other means are available. The worms 29 have a low helix angle and are adjusted only by the action shown.

I provide armature rings of steel corresponding to each of the ring gears and support them on pins which are parallel to the axes of said ring gears and are yieldingly held inwardly by coil spring construction. The internal gear ring 41 is provided with armature ring 52 and the external internally-toothed gear ring 42 is provided with an armature ring 53. The armature ring 53 is provided with an internal oblique flange 54 toothed on its edge for the purpose of hand or independent manipulation, hereafter to be described. The armature rings are each supported by a set of spring pins which are all the same, one of them being detailed in Fig. 6. The pin 55 is carried in a screw sleeve 56 which is screw-threaded into a socket bore 57, which sleeve is held adjustably in place by the lock nut 58. The inner end of the pin 55 is screw-threaded and provided with an adjusting screw nut 59. A coiled spring 60 is on the axle, the tension of which is varied by the nut 59 which reacts upon the outer end of the spring. The inner end of the spring is bottomed against the screw-threaded sleeve 56.

Corresponding to the armature rings are annular electromagnets 61 for the inner ring 41 and 62 for the outer ring 42. The housing of each of these magnets is a U-shaped annular ring having grooves 63, 64, made of pure iron or high grade cast iron or whatever is found to be most effective as magnets. These magnets are carried by supports 610 secured to the motor housing by cap screws 611. The same are provided with annular coils of wire, the inner 65 and outer 66, constituting the coils of each of said magnets. The cores of the magnet are external to the coils. These coils 65 and 66 are, according to the official aircraft requirements, closed coils extending from one side to the other of the battery or source of electric current used. Supported opposite the core of each magnet and within the magnet casing are brake rings 67 of non-magnetic material for the inside and brake rings 68 for the outer magnet. These are rigidly secured to the shells of the magnets by suitable screws 69 (see Fig. 6) and are very accurately spaced from the armature, whereby a very slight excitation of the coils causes the armatures to contact with the brake with a slight pressure, causing retardation in proportion to the current and to the coefficient of friction. This structure

illustrated is engineered for direct electric current. The same invention can be utilized with alternating current but would be engineered and designed accordingly.

On the outer armature ring 53, I form an extension oblique flange 54 and provide fine gear teeth on the inner edge thereof. This is for the purpose of hand or supplemental manipulation of the external ring gear.

A small shaft 70 (see Figs. 3, 19, and 20) is disposed in a suitable bearing 71 carrying a pinion 72 adapted to mesh with the gear teeth on the flange 54. The shaft 70 is driven by a crank 70' connected by a flexible shaft 73 (Fig. 19), the crank projecting at a convenient place on the instrument board or within reach of the pilot in the cockpit. If the engine has gone dead and the propellers are not rotating, this enables the pilot, by pushing the pinion 72 into engagement, to crank the same and turn the outer gear ring sufficiently to adjust the propeller blades to the edge or feathering position so that the propeller will not offer resistance and will not windmill, thus enabling, in the event of a single propeller machine, the gliding to ground in a much larger radius, and, in the event the engine is one in a multiple-engine plane, the same can be put effectively out of operation so that flying may be continued efficiently with a part of the propellers in use. This means is entirely independent of the magnetic electric apparatus.

In Fig. 20, I have shown, installed for driving the shaft 70 and the pinion 72, a small electric starter motor 74 controlled by the usual starter button. This is largely indicated diagrammatically and is not detailed because the details for such starting motor are well known and well understood. By proper energization, this motor can be made to move the outer ring gear relative to the housing and thus vary the pitch of the blades.

In an adjustable pitch propeller, the pitch of the propeller is varied by the adjustment and this induces a different action upon the propeller, particularly in view of the fact that it is rapidly rotating as well as advancing in the air. It is a requirement that the propeller be very nicely regulated and balanced by counterweight in order to avoid undue strains. Clearly, to calculate this definitely would call for careful consideration of the material of the propeller and its form, and I, therefore, work out this balancing by "rule of thumb." I illustrate and describe the preferred procedure under such circumstances.

In Fig. 11, I show the counterbalance weight 75 secured on a shank 76 by a divided collar 77 to the round part of the propeller blade, the same being suitably clamped thereto, one part carrying the counterweight 75. This is here shown conventionally as a ball but, as a matter of fact, it is of irregular shape to avoid accumulation of ice. The shank 76 is provided with a radial bore 78. From the center out is a suitably screw-threaded shaft 781 cooperating with the screw-threaded weight 79. A gear 782 is fixed to the end of the shaft 781 and meshes with a driving screw 783. This weight is adjustable only by special tool or screw driver operating the screw 783. This internal support and adjustment is provided to prevent dislocation of the parts which are supported on the propeller arm and subjected to rapid motion and severe strains. A slight adjustment of the weight has a very marked effect on the propeller blade. The weight 79 might be otherwise adjusted with the

loss of the special advantages. In securing this result, it is preferred to make a master blade by making parts readily adjustable and then making the integral completed master blade from the adjusted structure as a pattern. To this the screw-threaded weight is added. The slight adjustment possible by the screw-threaded weight 79 makes it possible to adjust and accurately counterbalance each individual propeller blade by the means here illustrated. The blade is made substantially correct by a master blade and this slight variation by the screw adjustment takes care of the complete adjustment of the same.

Very slight adjustment of the pitch of the blade makes a great difference in its action. In Fig. 10, I have indicated this range by showing the blade in cross section, the full lines showing it about midway of the controlled range. The direction of travel of the entire airplane structure is indicated by the arrow at the right of this figure, and the direction of rotation is indicated by the vertical arrow at the bottom. I provide the stop ring 80 with a screw top 81 which cooperates with a pair of stops 82, 83 (see Fig. 8).

In the event of an emergency, the operator may open sealed switches to one or the other of the circuits to one or another of the magnets, as required, and close the proper opposite circuit, and thereby cause the propeller to be adjusted against the stop, which throws the propeller to the reverse position. This is done in an emergency where the pilot is required to make a forced landing. By reversing the pitch of the propellers, the pilot can check the speed of the plane and land in a much smaller area or field. Also, the circuit may be thus closed to feather the propellers. In the event the engine goes dead, the control circuits are thrown out completely and it is possible for the pilot, by the adjusting crank 70', to edge or feather the blades of the propeller, thereby overcoming their resistance to the advance of the airplane and permitting much wider radius and area of operation in coasting to ground. If the plane is a multiple propeller one, this adjustment can be made so far as required when any engine unit fails.

I will now discuss the circuits and means by which the automatic control or tachometer control is accomplished. The usual construction of tachometer is made use of along with attachments added thereto. The circuit is closed by a circuit breaker used in connection with the throttle of the engine. In Fig. 18 (see lower left of Fig. 18), I show the throttle lever 84 operating the throttle control rod 85. I provide a fixed contact 86 and a sliding contact 87 insulated from the throttle control rod 85. A coil spring 88 on the rod causes the same to be held yieldingly in place. These contacts close the circuit when the throttle lever is moved half or two-thirds over and, consequently, the circuit is closed for regulation only when the throttle is halfway open or open to the extent determined upon, and for all the lower speeds represented by movement of the throttle before this contact is made, the tachometer control is cut out.

I make additions to the usual construction of tachometer on an airplane so that the same can be adjusted for the control of the electric current to the magnets through the speed ranges which are appropriate to the particular service required. I provide such adjustment that may be set to control the propeller blades at the most efficient angle for operation at 1400 R. P. M. I can also set the same for the most efficient angle of the

blades at 2200 R. P. M. for instance. The angle of the blades will be varied to work effectively at the rate selected. I, therefore, add an adjustable segment to the regular tachometer to be regularly brought into use at or above the range of the rate indicated up to the high speed limit of the engine. Incidentally, the device should never be set beyond the limit of the high speed of the engine.

I provide controls associated with the moving part of the tachometer. The tachometer is of usual construction with the drive (not illustrated) operating a gear 89 to drive the pinion 90 of the tachometer, thereby operating its centrifugal governor weights and parts that are connected to control the indicator hand on the dial and show the speed. I cut out a segment of the wall of the case and secure the flexible contact arm 91 to the hand-carrying part 92 of the tachometer, allowing the end of the arm 91 with contact head 91' to project through this opening. I provide a curved segment slideway 93, suitably insulated by blocks 94, 95 to carry the adjustable slide block 96 and cooperating contacts 97 and 98 (see Fig. 13).

The contact 97 is secured adjustably on the insulated slide block 96 in position to contact with the contact head 91' on the flexible arm 91. Contact 98 is pivoted to swing up to permit the flexible arm 91 with head 92 to pass up past it. The arm 91 is adapted to swing down and pass the pivoted contact 98 against the insulated block 99 below. The pivoted contact 98 is provided with insulation 100 on its face and is pivoted within the circuit and held yieldingly out by spring 101 (see details particularly in Figs. 13 to 15). The contact 98 is connected by a flexible conducting wire 98' so that it does not depend upon the pivotal contact for its electric circuit. It will be seen that the contact head 91' will swing up past the yielding contact 98 without closing the circuit, but on its return will contact by a wiping contact of the head 91' with the pivoted contact 98 and, on the further bending of the flexible arm 91, it will pass the pivoted contact 98 and automatically go out of commission and come in engagement with the insulated stop 99.

The insulated sliding block 96 can be set to any position required on the tachometer, the position which it takes being indicated and calibrated in R. P. M. With the structure illustrated, it can be set from about 1400 R. P. M. to 2500 R. P. M. or more, within the capacity of the highest speed of the engine. The block 96 (see Figs. 13 and 14) is adjustable by means of the lever 103 held yieldingly in place by spring 104. The lever 103 is provided with a tooth 105 to engage the notched segment 106 on the outside along the periphery of the dial face of the tachometer casing. By taking hold of the end of the lever 103 which is in the form of a knob, the slide is released, the pointer swung to the position required, and the spring lever carries the tooth 105 into engagement with the notched segment 106, holding the same securely in place. The binding posts on the insulated slide block 96 are connected by very flexible cables into the circuit so that the slide is adjusted freely back and forth without interfering with the circuit that is connected to the binding post.

By referring to the wiring diagram, particularly Fig. 18, it will be seen that, when the flexible contact arm 91 passes up to the control position and the upper contact 97, the current will be delivered to the relay through circuit 108 to

the relay magnet 107 which closes the same and relays to the main circuit 108 which is controlled by the throttle lever, as described, and that this will excite the outer coil 66 which will operate the magnetic brake in that behalf and retard the outer ring 42, thereby controlling the pitch of the propeller blades and increasing the pitch of the propeller by the advancing edge of the same to secure the stronger action thereof. If the tachometer flexible contact arm 91 swings down, the head 91' contacts at 98 and excites the relay circuit 109 going to the corresponding relay magnet 110, and relays to the main circuit 111 which leads to the inner magnet coil 65 which serves to rotate the actuating worms in the opposite direction, resulting in decreasing the pitch of the propeller blades. These circuits are connected and both returned to the negative posts of the battery.

I also provide a hot wire connection 112 branched at 113 to the outer coil 66 controlled by sealed push button switch 114 and branched at 115 to the inner magnet coil 65 controlled by sealed push button switch 116. These push button switches are sealed switches and are to be used only in event of emergency. The breaking of the seal requires the pilot to make explanation and report.

The outer ring gear 42 is capable of being manipulated manually, as I have explained. It is possible thus to completely control the pitch of the blades by such manipulation. The propeller blades may be feathered to prevent windmilling and to reduce the resistance to permit greater ease of cruising with less than all of the engines in a multiple-engine plane or increasing the radius for coasting down in event of an accident and the stopping of the engine.

As to the tachometer, I have shown a special construction. The flexible arm 91 insures a rubbing action for the contact and, consequently, insures most effective action. Likewise, it vibrates and, when nearing one or the other of the contacts, its circuit-closing engagement therewith is momentary so as to deliver impulses to the corresponding relay and electromagnet. I have shown one of the stops adjustable and the other stop pivotal, cooperating with the flexible arm, for the special purpose indicated. However, it is clear that the stops being properly placed, the flexible arm would function without the special construction which facilitates the same. The contacts might be made with any moving part of the tachometer which synchronizes with the indicator part.

The use of the flexible switch arm is of importance because the wiping and vibratory action assures an immediate response and eliminates the possibility of welding at the switch due to the passing of current from the flexible arm to the contact. This switch is particularly adapted for use in the relay circuit because it is possible with this switch to handle a very small amount of current and to provide an effective contact to actuate the magnetic brakes quickly and positively to produce the desired braking effect. The switch, due to the lack of welding, will release quickly and effectively in response to very slight movement of the tachometer. In combination with the tilting contact 98, this switch is particularly effective because the automatic control is not put into operation until the engine of the airplane is up to nearly the desired speed. The flexible switch arm can easily pass over the contact without putting the automatic control

into operation when the throttle is opened and, when the throttle is at the position for operating speed, the contacts and switch are positioned for most effective cooperative action. When the throttle is retarded, the spring arm permits the switch blade to slide over the contact and the automatic controls are effectively put out of operation for slow or idling speeds.

The ring gears for adjusting the propellers I have provided with a special ball bearing with hardened parts which I consider desirable in this behalf. It is clear that, with proper fitting of the pinions to the external and internal gears, the rings would not need to be provided with such accurate bearings as they will be carried by the pinions themselves. In this behalf also, one ring alone might be made use of by, for instance, connecting the starting motor shown in Fig. 20 to return the same to initial position. By taking time for the manipulation of the gear rings, it might be accomplished by the crank illustrated in Fig. 19, when, of course, one ring would be sufficient as the pilot could turn the crank in either direction and make complete adjustments for all purposes, control, feathering, or reversing.

As to the electromagnetic brake, I find it desirable to provide the braking surface with the brake lining material interposed to secure this braking action. However, it might be accomplished with a strong enough current without the necessity for contact between the parts. Again, I have shown a special armature ring carried by the ring gears. The ring gears themselves might be made of magnetic metal and dispense with these intervening parts without, however, securing the advantages accomplished thereby.

The invention comprehends employment of means for momentarily retarding the inner and outer gears selectively while the rotatable structure is rotating to move the gears relative to the rotatable structure, while avoiding locking or stopping of that gear which is momentarily retarded, this being accomplished by the two electromagnetic means respectively including a pair of normally-open circuits, and a control means for momentarily closing either of the circuits selectively for a period of time insufficient to stop either of the gears but sufficient to momentarily decelerate the braked gear with respect to the prevailing speed of the rotatable structure. The invention also comprehends an annular electromagnetic element, such as the annular electromagnet 62, providing a winding and a braking surface, with a means for energizing the winding at intervals and a means for applying a retarding force to the gear means for a shorter period of time than the period of time during which the electromagnetic element is energized, this last-named means including an armature operatively connected to the gear means and spring means resiliently holding the armature away from the electromagnetic element but exerting a resilient force which is overcome by energization of the electromagnetic element and corresponding attraction of the armature to retard the armature by light frictional contact with the electromagnetic element. The first portion of the period of energization of the electromagnetic element is used up in an advancing movement of the armature toward the electromagnetic element so that short periods of retardation can be obtained with longer periods of energization of the electromagnetic element.

As to the relays for the current, the result could be effectively accomplished without the interposition of relays. The advantages of the relays would, of course, be omitted in such a structure.

I have shown the wiring in each instance for direct current. The same could be engineered for alternating current as well, as previously mentioned.

I desire to claim the invention specifically as well as broadly.

This application is a continuation of my application Serial No. 57,739, filed January 6, 1936.

I claim as my invention:

1. In an adjustable pitch propeller adapted to be coupled with the shaft of an engine, the combination of: a rotatable member including a hub; a blade extending outward from said hub; means for pivotally securing said blade to said hub to turn about an axis of said blade; a pinion shaft extending parallel to the rotational axis of said hub; means for journalling said pinion shaft relative to said rotatable member; means for operatively connecting said pinion shaft and said blade to translate rotation of said pinion shaft into a turning of said blade to vary the pitch thereof; a pinion on said pinion shaft; an outer gear comprising a ring gear providing internal teeth meshing with said pinion; an inner gear providing external teeth meshing with said pinion; bearing means for said outer and inner gears; a pair of brake means for respectively retarding said inner and outer gears while said hub is rotating and including a pair of ring armatures, means for yieldably attaching same respectively to said gears and a pair of electromagnetic means disposed respectively adjacent said ring armatures, said electromagnetic means including a ring of magnetic material of U-shape in cross section adjacent each ring armature and providing an annular winding space and a winding therein, each ring of magnetic material providing a braking surface contactable with the corresponding yieldably-secured armature when said winding is energized thereby applying a braking force to the corresponding gear to rotate said pinion; relay means providing sets of contacts; main circuits for respectively connecting said sets of contacts in circuit with said windings to energize same individually; a tachometer providing means movable in response to the rotational speed of said hub and a flexible switch blade driven thereby, said tachometer providing a movable part; a pair of contacts mounted on said movable part to be moved together relative to said flexible switch blade and disposed in the normal path of movement of said blade, said flexible switch blade flexing to pass one of said contacts in moving into and from an intermediate position therebetween in which it can electrically contact each of said contacts individually in response respectively to an increase and decrease in the rotational speed of said hub; circuits connecting said contacts and said flexible blade to said relay means to energize one of said windings when said flexible switch blade electrically engages one of said contacts and to energize the other of said windings when said flexible switch blade engages the other one of said contacts; and insulating means on that one of said contacts first reached by said flexible switch blade when the speed of said hub increases for preventing electrical contact therebetween until said switch blade assumes said intermediate position.

2. In combination: a variable-pitch propeller; pitch varying means for varying the pitch of said propeller while rotating and including two electric circuits and means responsive to the energization of one circuit to increase the pitch and means responsive to the energization of the other circuit to decrease the pitch; and means for selectively energizing said circuits, said means including first and second switch contacts respectively in said circuits and spaced slightly from each other, a circuit-energizing contact, a movable arm carrying said circuit-energizing contact from an end position which is to one side of both said switch contacts to an intermediate position between said switch contacts, means for moving said arm in response to a change in propeller speed, and means for automatically preventing energization of either of said circuits during movement of said circuit-energizing contact from said end position at one side of both the contacts to said intermediate position between the contacts whereby said circuit-energizing contact is inoperative to control the pitch of said propeller until it assumes said intermediate position.

3. In combination: a variable-pitch propeller; pitch varying means for varying the pitch of said propeller while rotating and including two electric circuits and means responsive to the energization of one circuit to increase the pitch and means responsive to the energization of the other circuit to decrease the pitch; and means for selectively energizing said circuits, said means including a tachometer providing a movable member which advances as the speed of said propeller increases, a flexible blade operatively connected to said movable member to advance from a low-speed position to a higher-speed position as said movable member advances, first and second contacts spaced from and insulated from each other and positioned in the path of travel of said flexible blade, means for electrically connecting said flexible blade and one of said contacts in one of said circuits and for electrically connecting said flexible blade and the other of said contacts in the other of said circuits to energize said circuits selectively in response to electrical contact between said flexible blade and said first and second contacts, and means for yieldably and movably mounting that one of said contacts which is first reached by said flexible blade in moving from said low-speed position to said higher-speed position to permit said flexible blade to displace said one of said contacts from its path of travel in moving into an intermediate position between said contacts, said blade flexing in moving from said intermediate position to permit passage thereof beyond said one of said contacts in returning to its said low-speed position.

4. A combination as defined in claim 3 in which the yieldably-mounted contact includes an insulating member contactable by said flexible blade in moving from said low-speed position toward its position intermediate said contacts whereby said contact is displaced from the path of travel of said flexible blade by contact between said blade and said insulating member thus preventing electrical contact between the flexible blade and the yieldably-mounted contact until said blade assumes its intermediate position between said contacts.

5. In combination with an engine: manually-adjustable means for changing the power output of said engine; and means for maintaining the

speed of said engine constant at a desired value within a few revolutions per minute irrespective of adjustment of said manually-adjustable means within a normal range of power outputs, this means including a variable-pitch propeller driven by said engine, pitch-varying mechanism rotating with said propeller, electric means for operating said pitch-varying mechanism and including a pair of control circuits adapted when selectively energized to increase and decrease respectively the pitch of said propeller, control means independent of adjustment of said manually-adjustable means within said normal range of power outputs for selectively energizing said control circuits in response to a deviation of engine speed from a desired value to increase the pitch of said propeller when the speed of said engine increases slightly and to decrease the pitch of said propeller when the speed of said engine decreases slightly thereby maintaining said speed constant within a few revolutions per minute, and automatic means for rendering said control means inoperative to actuate said electric means until the speed of said engine reaches said desired value.

6. A combination as defined in claim 5 including as an additional means a switch means electrically connected to said control circuits to render same inoperative when said switch means is in inoperative position and to render same operative when said switch means is in operative position, and means operatively connecting said switch means and said manually-adjustable means for maintaining said switch means in said inoperative position when said manually-adjustable means is positioned below said normal range and for moving said switch means to operative position when said manually-adjustable means is moved to a position within said normal range.

7. In an adjustable pitch propeller adapted to be coupled with the shaft of an engine, the combination of: a rotatable structure including a hub; a blade extending outward from said hub; means for pivotally securing said blade to said hub to turn about an axis of said blade; an outer gear comprising an internally-toothed gear ring concentric with the rotational axis of said hub; bearing means for journalling said outer gear for rotation about said rotational axis of said hub; an inner gear externally-toothed and concentric with the axis of rotation of said hub; bearing means for journalling said inner gear for rotation about said rotational axis of said hub; a pinion meshing with both said inner and outer gears; a pinion shaft carrying said pinion; means for journalling said pinion shaft relative to said rotatable structure to rotate about its own axis at a position spaced from the axis of rotation of said hub; means operatively connecting said pinion shaft to said propeller blade to turn same in proportion to the angular movement of said pinion; and an annular armature for each of said gears; means for respectively mounting said armatures relative to said gears and including resilient means for biasing said armatures toward their respective gears; a braking ring disposed adjacent each armature but spaced very slightly therefrom when said resilient means retract said armatures but being contactable by said armatures in an annular zone of contact upon overcoming the biasing force; and means for momentarily slapping either armature against its braking ring and for quickly releasing it thereby imparting a momentary retarding force to the gear asso-

ciated therewith without stopping thereof, said means including an annular electromagnetic means associated respectively with each braking ring and means for momentarily and selectively energizing said electromagnetic means for a period of time insufficient to stop the corresponding armature and gear but sufficient to momentarily decelerate this gear with respect to the rotatable structure through a momentary slapping contact between the corresponding armature and braking ring, this momentary retardation being sufficient to slightly change the pitch of the propeller, said last-named means including switch means providing two spaced contacts, a third contact adapted to be positioned between said two spaced contacts, means for operatively connecting said third contact and one of said spaced contacts to one of said electromagnetic means and for operatively connecting said third contact and the other of said spaced contacts to the other of said electromagnetic means, a flexible arm carrying said third contact at an outer end thereof, means for pivotally mounting the other end of said arm whereby said third contact may swing into contact with either of said spaced contacts, and means for moving said arm which is on said pivotally mounted means in response to deviations of rotational speed of said hub from a desired value.

8. In an adjustable pitch propeller adapted to be coupled with the shaft of an engine, the combination of: a rotatable structure including a hub; a blade extending outward from said hub; means for pivotally securing said blade to said hub to turn about an axis of said blade; an outer gear comprising an internally-toothed gear ring concentric with the rotational axis of said hub; bearing means for journalling said outer gear for rotation about said rotational axis of said hub; an inner gear externally-toothed and concentric with the rotational axis of said hub; bearing means for journalling said inner gear for rotation about said rotational axis of said hub; a pinion meshing with both said inner and outer gears; a pinion shaft carrying said pinion; means for journalling said pinion shaft relative to said rotatable structure to rotate about its own axis at a position spaced from the axis of rotation of said hub; means operatively connecting said pinion shaft to said propeller blade to turn same in proportion to the angular movement of said pinion; and means for momentarily retarding said inner and outer gears selectively while said rotatable structure is rotating to move said gears relative to said rotatable structure while avoiding locking or stopping of that gear which is momentarily retarded, said means including a pair of electromagnetic means respectively associated with said inner and outer gears for braking the motion thereof, each electromagnetic means including an armature connected to one of said inner and outer gears, an electromagnet for attracting said armature, and a resilient means biasing said armature and said electromagnet away from each other, energization of said electromagnet exerting sufficient attraction between said armature and said electromagnet to overcome the biasing force of said resilient means, said electromagnetic means including a pair of circuits normally open but acting when closed to brake said inner and outer gears selectively, and a control means for rapidly making and breaking either of said circuits selectively in response to a deviation in propeller speed from a desired value, the

period of time between each making and subsequent breaking being insufficient to stop either of said gears but sufficient to momentarily decelerate the braked gear with respect to the prevailing speed of said rotatable structure thereby momentarily retarding it to change the pitch of said propeller.

9. In an adjustable pitch propeller adapted to be coupled with the shaft of an engine, the combination of: a rotatable structure including a hub; a blade extending outward from said hub; means for pivotally securing said blade to said hub to turn about an axis of said blade; an outer gear comprising an internally-toothed gear ring concentric with the rotational axis of said hub; bearing means for journalling said outer gear for rotation about said rotational axis of said hub; an inner gear externally-toothed and concentric with the axis of rotation of said hub; bearing means for journalling said inner gear for rotation about said rotational axis of said hub; a pinion meshing with both said inner and outer gears; a pinion shaft carrying said pinion; means for journalling said pinion shaft relative to said rotatable structure to rotate about its own axis at a position spaced from the axis of rotation of said hub; means operatively connecting said pinion shaft to said propeller blade to turn same in proportion to the angular movement of said pinion; an annular armature for each of said gears; means for respectively mounting said armatures relative to said gears and including resilient means for biasing said armatures toward their respective gears; a braking ring disposed adjacent each armature but spaced very slightly therefrom when said resilient means retract said armatures but being contactable by said armatures in an annular zone of contact upon overcoming of the biasing force; and means for momentarily slapping either armature against its braking ring and for quickly releasing it thereby imparting a momentary retarding force to the gear associated therewith without stopping thereof, said means including an annular electromagnetic means associated respectively with each braking ring and means responsive to changes in speed of said propeller for momentarily and selectively energizing said electromagnetic means for a period of time insufficient to stop the corresponding armature and gear but sufficient to momentarily decelerate this gear with respect to the rotatable structure through a momentary slapping contact between the corresponding armature and braking ring, this momentary retardation being sufficient to slightly change the pitch of the propeller.

10. A combination as defined in claim 9 in which said last-named means includes a switch means adapted when in one position to send current to one of said electromagnetic means and when in another position to send current to the other of said electromagnetic means, and impulse-creating means responsive to a slight change in rotational speed of said hub for adjusting said switch means to send a momentary current to that one of said electromagnetic means effective in changing the pitch of said propeller in a direction to counteract said slight change in engine speed.

11. In an adjustable pitch propeller adapted to be closely coupled with the shaft of an engine, the combination of: a rotatable structure including a hub and an annular housing, said housing providing an outward-extending wall

and a peripheral wall extending from said outward-extending wall in a direction away from said hub; a stationary plate extending outward from the axis of rotation of said hub to a position near said peripheral wall of said housing to cooperate therewith and with said outward-extending wall in defining a substantially closed annular chamber around the axis of rotation of said hub, said chamber being much larger in a plane normal to said axis of rotation than in a direction parallel to said axis of rotation; an inner externally-toothed gear in said annular chamber, said inner gear lying in a plane perpendicular to said axis of rotation and normally rotating with said rotatable structure; bearing means for freely journalling said inner gear about said rotational axis of said hub; an outer internally-toothed gear comprising a gear ring with an outer periphery somewhat smaller than said peripheral wall of said housing, said outer gear normally rotating with said rotatable structure and lying in said plane perpendicular to said axis of rotation, said inner gear lying within said outer gear; a bearing means disposed between said periphery of said ring gear and said peripheral wall of said housing to freely journal said gear coaxially with respect to said rotational axis of said hub; an externally-toothed pinion positioned in said annular chamber in said plane perpendicular to said axis and meshing with both said inner and outer gears, said inner and outer gears being disposed radially with respect to said pinion; a rotatable pinion shaft to which said pinion is secured and extending parallel to but spaced from said rotational axis of said hub; means for journalling said pinion shaft with respect to said rotatable structure; a propeller blade extending outward from said hub; means for pivotally securing said propeller blade to said hub to turn about the axis of said blade; means for operatively connecting said blade and said pinion shaft to turn said pinion and said blade simultaneously through proportional angles; an electromagnetic means including inner and outer windings, inner and outer electromagnetic cores respectively partially encompassing said inner and outer windings and disposed in a plane parallel to but spaced a short distance from said first-named plane perpendicular to said axis, two spaced electrical contacts electrically connected respectively to said windings, and a third electrical contact movable in response to changes in propeller speed from a desired value to electrically contact said two spaced contacts selectively to energize said windings selectively; and means for respectively retarding the normal rotation of said inner and outer gears with respect to said rotatable structure upon energization of said inner and outer windings.

12. In an adjustable pitch propeller including pivoted blade means, an armature normally rotating with said propeller and gear means for turning said blade means in proportion to a relative motion between said armature and said propeller, the combination of: an electromagnetic element adjacent said armature and cooperating therewith in defining a flux gap; means for resiliently mounting said armature for movement toward said electromagnetic element by electromagnetic attraction to decrease the size of said flux gap to such extent that said armature comes into contact with said electromagnetic element when said electromagnetic element is energized to create a retarding force

on said armature to slow this armature with respect to said propeller; circuit means for energizing said electromagnetic element; and means for rapidly making and breaking said circuit means in response to a change in the speed of said propeller from a desired value for returning the propeller speed to such desired value, said last-named means including means for making and breaking said circuit means at such rate as to create a plurality of rapidly recurring electric impulses, each of such short duration that application thereof to said electromagnetic element will momentarily retard but not stop the rotation of said armature.

13. In an adjustable pitch propeller including pivoted blade means, an armature normally rotating with said propeller and gear means for turning said blade in proportion to a relative rotation between said armature and said propeller, the combination of: an electromagnetic means adjacent said armature; yielding means for resiliently mounting said armature to permit resilient movement thereof toward and into braking contact with said electromagnetic means when said electromagnetic means is energized, thus creating a retarding force on said armature to slow this armature with respect to said propeller; and means for energizing said electromagnetic means to move said armature against the action of said yielding means and into brief slapping relationship with said electromagnetic means to change the pitch of said blade means, said means deenergizing said electromagnetic means before stopping of said armature can take place, said yielding means being biased to urge said armature away from said electromagnetic means to delay contact of the armature with the electromagnetic means when the electromagnetic means is energized and thereby cause the periods of contact to be substantially shorter than the periods of electromagnetic energization, said means for energizing said electromagnetic means including a circuit providing two spaced contacts and a third contact for selectively engaging said spaced contacts in response to a deviation in propeller speed from a desired value.

14. In an adjustable pitch propeller including pivoted blade means, the combination of: gear means normally rotating with said propeller; means for operatively connecting said gear means to said blade means in such manner that retardation of said gear means with respect to said propeller will change the pitch of said blade means; an annular electromagnetic element including a winding; circuit means electrically connected to said winding; means responsive to a change in propeller speed from a desired value for energizing said winding at intervals; and means for applying a retarding force to said gear means for a shorter period of time than the period of time during which said electromagnetic element is energized, said means including an armature operatively connected to said gear means, and spring means resiliently holding said armature away from said annular electromagnetic element but exerting a resilient force which is overcome by energization of said electromagnetic element and corresponding attraction of said armature to retard said armature by light frictional contact with said electromagnetic element, the first portion of the period of energization of the electromagnetic element being used up in an advancing movement of the armature toward said electromagnetic element in opposition to said spring means so

that short periods of retardation can be obtained with longer periods of energization of said electromagnetic element.

15. In an adjustable pitch propeller adapted to be driven by an engine and including pivoted blade means, the combination of: a magnet housing adapted to be secured to said engine at a position between the engine and said propeller, said magnet housing including inner and outer electromagnetic elements; gear means rotatable with said propeller and operatively connected to said blade means to change the pitch thereof; inner and outer ring gears operatively connected to said gear means and normally rotating with said propeller; inner and outer armatures respectively adjacent said inner and outer electromagnetic elements; means for securing said armatures respectively to said inner and outer ring gears, said means including spring means normally retracting said armatures from contact with said electromagnetic elements whereby during normal rotation of said propeller said armatures are spaced from said electromagnetic elements; and means for selectively energizing said electromagnetic elements to draw said armatures into frictional engagement therewith to retard selectively the rotation of said armatures with respect to said propeller without immobilization of same, said means for selectively energizing said electromagnetic elements comprising two spaced electrical contacts respectively connected to said electromagnetic elements, a third contact movable to selectively engage said spaced contacts to selectively energize said electromagnetic elements, and means for moving said third contact into its selective engagement with said spaced contacts in response to a deviation in propeller speed from a desired value.

16. In an adjustable pitch propeller adapted to be driven by an engine and including pivoted blade means, the combination of: a magnet housing adapted to be secured to said engine at a position between the engine and said propeller, said magnet housing including inner and outer electromagnetic elements; gear means rotatable with said propeller and operatively connected to said blade means to change the pitch thereof; inner and outer ring gears operatively connected to said gear means and normally rotating with said propeller; inner and outer armatures respectively adjacent said inner and outer electromagnetic elements; means for securing said armatures respectively to said inner and outer ring gears, said means including spring means normally retracting said armatures from contact with said electromagnetic elements whereby during normal rotation of said propeller said armatures are spaced from said electromagnetic elements; and means for selectively energizing said electromagnetic elements to draw said armatures into frictional engagement therewith to retard selectively the rotation of said armatures with respect to said propeller without immobilization of same, said last-named means including circuit means respectively connected to said electromagnetic means, relays providing electrical contacts respectively in said circuit means, and means for selectively controlling the operation of said relays in response to a deviation of engine speed from a desired value.

17. In an adjustable pitch propeller adapted to be driven by an engine and including pivoted blade means, the combination of: a magnet housing adapted to be secured to said engine at a position between the engine and said pro-

5 peller, said magnet housing including inner and outer electromagnetic elements; gear means rotatable with said propeller and operatively connected to said blade means to change the pitch thereof; inner and outer ring gears operatively connected to said gear means and normally rotating with said propeller; inner and outer armatures respectively adjacent said inner and outer electromagnetic elements; means for securing said armatures respectively to said inner and outer ring gears, said means including spring means normally retracting said armatures from contact with said electromagnetic elements whereby during normal rotation of said propeller said armatures are spaced from said electromagnetic elements; and means for selectively energizing said electromagnetic elements to draw said armatures into frictional engagement therewith to retard selectively the rotation of said armatures with respect to said propeller without immobilization of same, said last-named means including circuit means respectively connected to said electromagnetic means, relays providing electrical contacts respectively in said circuit means, and manually operable switch means respectively in said circuit means for selectively controlling the energization of said electromagnetic means.

18. In an adjustable pitch propeller including blade means pivoted in a housing, the combination of: gear means normally rotating with said housing; an annular armature associated with said gear means to rotate therewith, said armature providing a braking surface; means for operatively connecting said gear means to said blade means in such manner that retardation of said armature and gear means with respect to said housing will change the pitch of said blade means; an annular electromagnetic element including a winding and a braking surface; mounting means for mounting said electromagnetic element and said armature for relative movement therebetween from a normal spaced position in which said braking surfaces are spaced from each other to a braking position in which said braking surfaces are in contact with each other, said mounting means including resilient means exerting a biasing force tending to separate said braking surfaces, energization of said electromagnetic element exerting an attractive force between said electromagnetic element and said armature sufficient to overcome said biasing force to bring said braking surfaces into braking engagement with each other to retard the rotation of said armature and said gear means with respect to said housing; circuit means for energizing said winding of said electromagnetic element; and means for rapidly making and breaking said circuit means in response to a change in the speed of said propeller from a desired value for returning the propeller speed to such desired value, said last-named means including means for making and breaking said circuit means at such rate as to create a plurality of rapidly recurring electric impulses, each of such short duration that application thereof to said electromagnetic element will momentarily retard but not stop the rotation of said armature whereby said armature is moved relative to said housing by repeated application of such momentary retardations to change the pitch of said blade means to the degree necessary to return the propeller speed to the desired value.

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