

May 2, 1933.

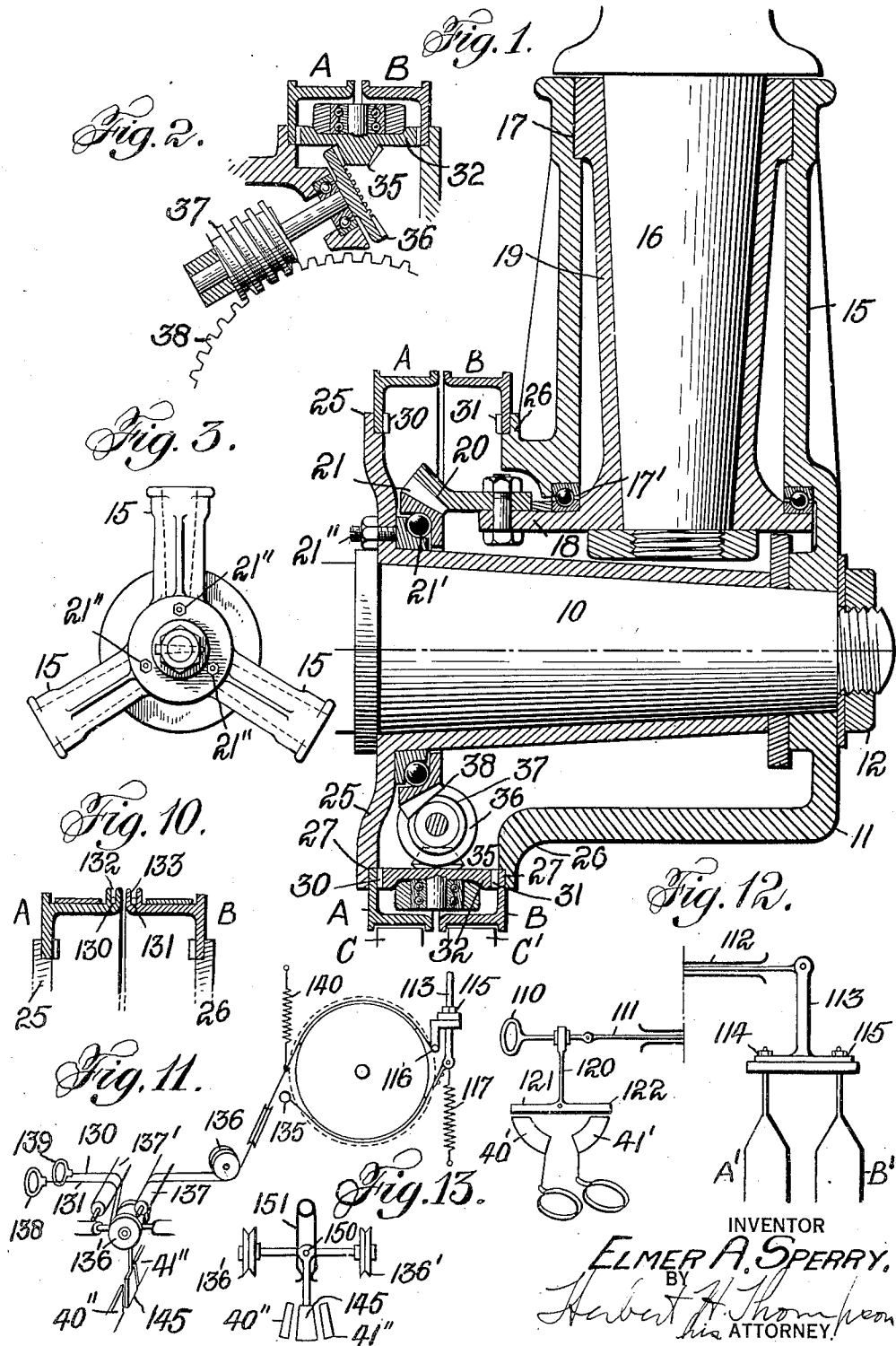
E. A. SPERRY

1,907,014

VARIABLE PITCH PROPELLER

Filed Nov. 28, 1928

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

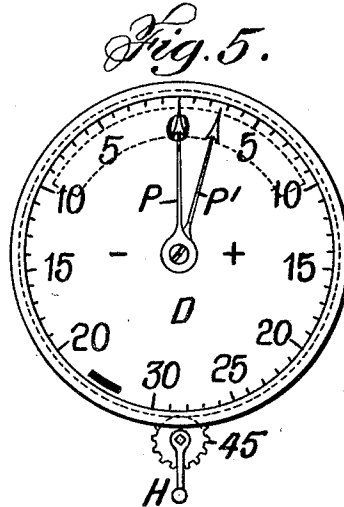
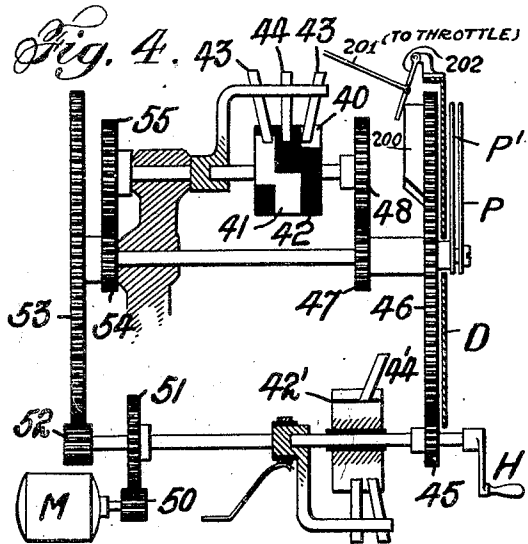
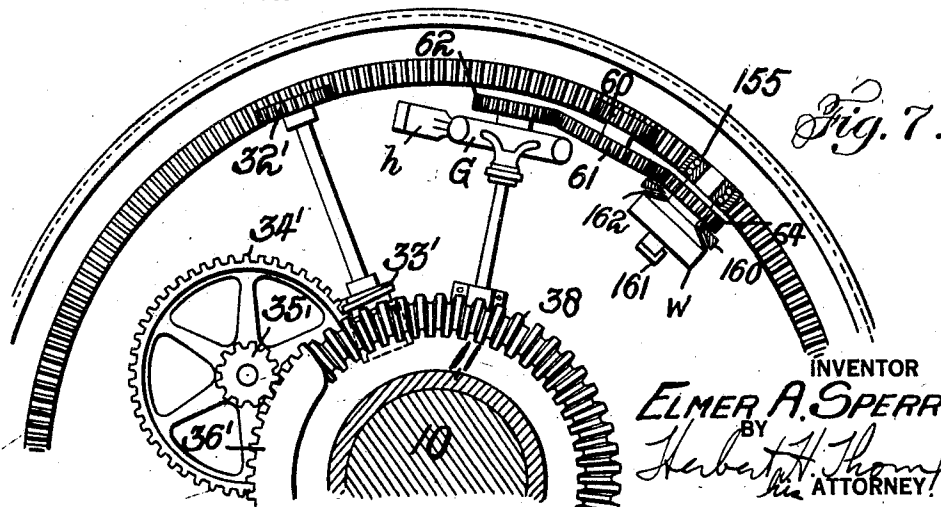
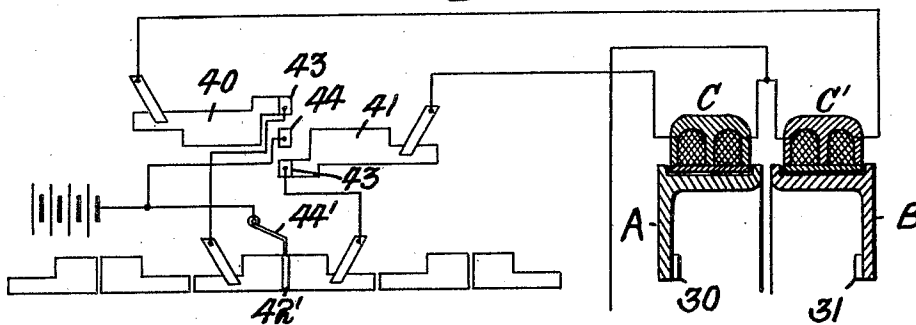


Fig. 6.



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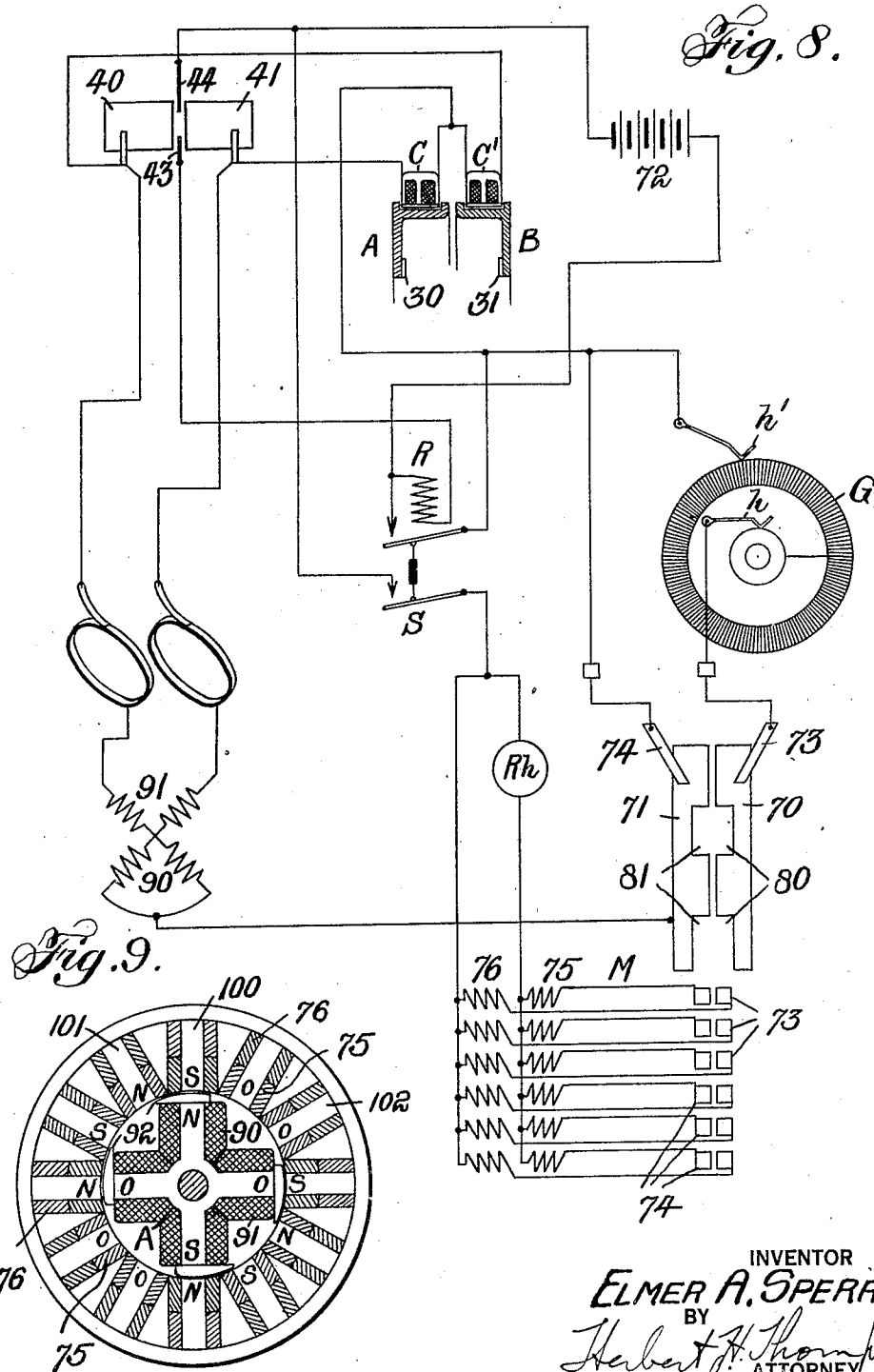
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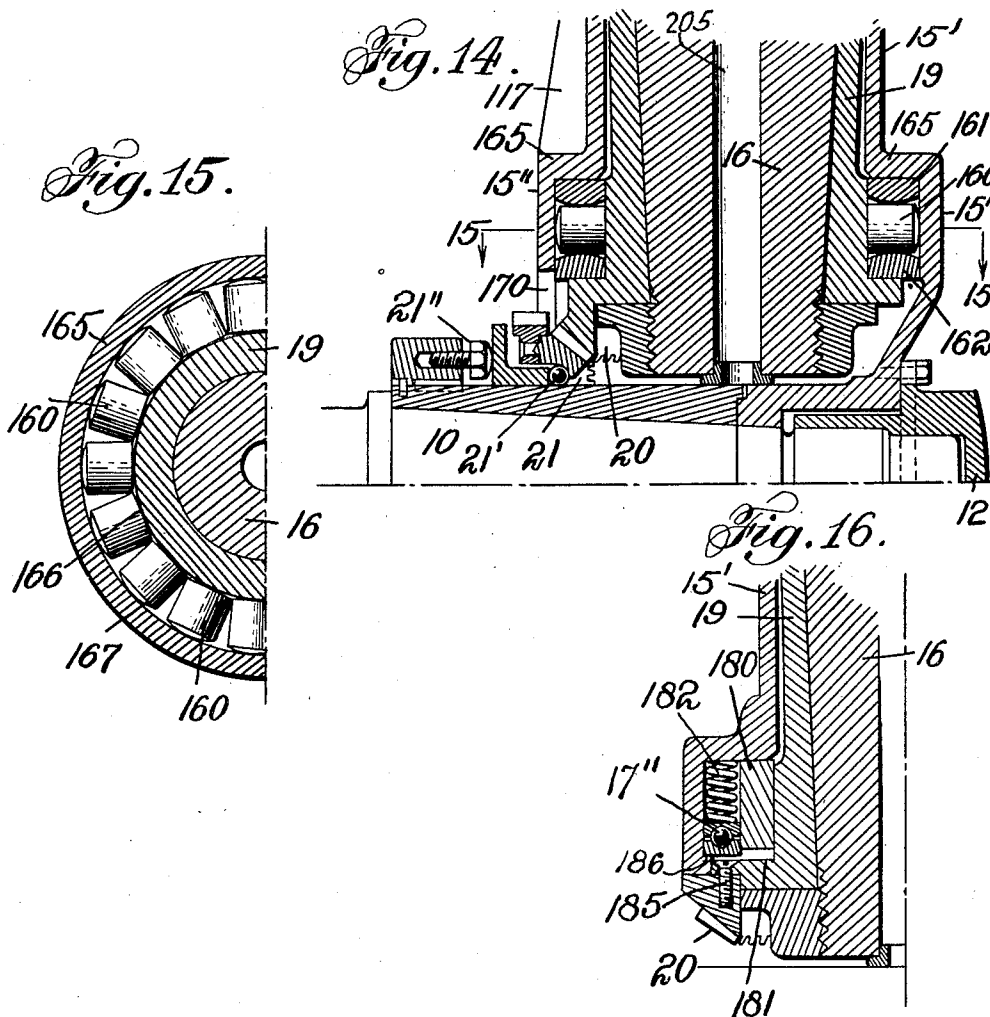
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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

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VARIABLE PITCH PROPELLER

Application filed November 28, 1928. Serial No. 322,320.

This invention relates to means whereby the pitch of the propeller blades of a craft, particularly an aircraft, may be varied in accordance with the varying conditions of engine speed and air density. It is well known that in starting an aircraft, the pitch of the blades should be preferably less than when the craft has picked up speed, and also that in higher altitudes with a lesser density of air the pitch of the blades should preferably be greater than in a denser atmosphere. It is an object of my invention, therefore, to provide effective means for simultaneously varying the pitch of all of the blades of a propeller.

Heretofore, in devices that have been proposed for varying the pitch of propeller blades, there has been no means whereby the operator could know the position of the blades at any time. It is a further object of my invention to provide a suitable follow-back system whereby the operator is at all times apprised of the exact setting of the propeller blades.

It is a further object of my invention to provide means for limiting the rate at which the pitch of the propeller blades is varied.

Other objects and advantages of this invention will become apparent in the following detailed description thereof.

In the accompanying drawings,

Fig. 1 is a vertical section through a propeller hub having one form of my invention applied thereto.

Fig. 2 is a side elevation of a detail of a portion of the gearing shown in Fig. 1.

Fig. 3 is a side elevation of the right end of Fig. 1.

Fig. 4 is a side elevation, partly sectioned vertically, of the means for predetermining the desired setting of the blades and a portion of the follow-back system.

Fig. 5 is a front elevation of the Fig. 4 device.

Fig. 6 is a diagrammatic view of the contact control system shown in Fig. 4.

Fig. 7 is a side view of a modified gear drive for setting the propeller blades.

Fig. 8 is a wiring diagram of the follow-up system.

Fig. 9 is a vertical section through the

motor forming part of the follow-back system.

Fig. 10 is a vertical section through a portion of a modified form of brake mechanism and means for operating the same.

Fig. 11 is a view partly in elevation and partly in perspective of the means for operating the brake mechanisms shown in Fig. 10.

Fig. 12 is a view partly diagrammatic and partly in elevation of still another means for operating the brake mechanism.

Fig. 13 is a front elevation of the circuit-closing mechanism of Fig. 11.

Fig. 14 is a view similar to Fig. 1 but showing a modified form of thrust bearing for the propeller blades.

Fig. 15 is a section taken substantially on the line 15—15 of Fig. 14.

Fig. 16 is a view similar to Fig. 14 showing still another modified form of supporting thrust bearing for the propeller blade.

Referring to the drawings, I have shown in Fig. 1 the end of the engine shaft 10 upon which is fixed the hub indicated generally by the numeral 11, which supports the propeller blades. Said hub may be locked to the end of the engine shaft by means such as locking nut 12 threaded thereon, and the hub may be formed with a plurality of receptacles, in this case three, as indicated at 15, within which are rotatably housed the hubs 19 fixed to the ends 16 of the propeller blades. Said propeller blades are mounted within said housing for rotation about bearing 17 and guide bearings 17' between the housing 15 and a flange 18 formed on each sleeve 19 which is preferably of steel. One of the bearing surfaces, either the sleeve or the casing, may be plated with a metal of greater hardness than either the sleeve or the casing. Said plating material may be chromium.

I may utilize said flange as a supporting means for a gear 20 meshing with an operating gear 21, so that rotation of said operating gear 21 will rotate each blade 16 about its axis to vary the pitch thereof. By this means it is apparent that by merely adjusting gear 21 with respect to hub 11 I may simultaneously vary the setting of all three

propeller blades or as many propeller blades as I may desire to employ, since each blade 16 is provided with its gear 20 and all of said gears mesh with the single gear 21. The ball race 21' may be adjusted by means of adjusting screws 21'' to tilt both gear 21 and its bearing out of their normal plane and thus vary the depth of tooth engagement between gear 21 and the plurality of gears 20 to insure the proper degree of engagement.

For adjusting the gear 21, in order to control the setting of blades 16, I may provide the following mechanism: I have shown two circumferential supporting members 25 and 26, each of which carries around its periphery brake-members, such as drums A and B, respectively, which may be connected to said supports 25 and 26 by frictional joints 27. Brake-members A and B will, therefore, normally be rotated together with hub 11, but if a sufficient force is applied to either member A or member B, said member may be caused to lag with respect to its support 25 or 26, and hence with respect to hub 11, to set up a relative motion therebetween. For effecting such lag of said brake-member A or B, I may provide some means for applying a force thereto, such as electro-magnets C—C', the members A and B being of magnetic material in this case.

The means, whereby the relative movement between the brake-members and the hub is caused to rotate gear 20 with respect to the hub, may take the following form: Said brake-members A, B may be provided with internal annular racks 30, 31, respectively, which mesh with a single gear 32, said gear having connection with said gear 21 through some suitable gearing, preferably reduction gearing, which in Figs. 1 and 2 may take the form of bevel gears 35, 36 and worm 37 and worm-wheel 38. In a modified construction shown in Fig. 7, the said drive between the brake-members and gear 21 may take the form of a gear 32' operating through reduction gearing, such as worm 33', wormwheel 34', pinion 35', rack 36' fixed to gear 21. It will thus be seen that by merely applying a brake to member A or B, gear 32 or gear 32' is caused to rotate in one direction or the other to rotate gear 21 about its axis relative to the hub in one direction or the other to vary the setting of all the blades 16 simultaneously in the desired direction.

The energization of magnets C—C' may be effected by the operator from a remote position by merely actuating a handle H to cause a circuit to be completed through the said coils. For this purpose there may be provided a drum in the form of contact segments 40, 41 (shown in developed form in Fig. 6), separated by insulated portions 42, with which is adapted to cooperate a plurality of contact brushes 43, 44. Said brush 44 normally rests upon the insulated segment

42, and since the circuit through the coils lies through said brush, the magnets C, C' are normally ineffective. Upon actuation of handle H, the drum is caused to rotate at any desired rate by suitable gearing, such as 45—46—47—48. When the brush 44 and the respective brush 43 engage the contact segments 40 or 41, respectively, one or the other of magnets C—C' is energized to retard brake-member A or B and thus set the blades in the proper direction. In order that the blades shall not overrun the proper setting, or, in other words, in order that the blades shall not be continuously varied in position until the handle H is set back to its original position, I may provide a suitable follow-up from the blades, or the actuating mechanism therefor, to the brushes 43, 44 to cause the latter to follow the movements of the contact drum, whereby brush 44 will reach the insulated segment 42 shortly after handle H ceases to actuate said drum. Said follow-up may take the form of a motor M which acts through any suitable gearing 50 to 55 inclusive to rotate the brushes 43, 44 about the same axis as the drum 40 and in the same direction. The method of energization of motor M by the movements of the propeller blades will be described hereinafter.

In order to effect a fine setting of the blades, I may provide a vernier drum and contact brushes as shown in Figs. 4 and 6. Said vernier drum and brushes are geared to rotate at a faster rate than drum 40 and brushes 43, 44, and the contact segment 42' thereon is much finer than the dead segment 42 of the coarse drum. The circuit, it will be seen from Fig. 6, lies not only through the brush 44 but also through brush 44' so that it is not until the brush 44' reaches insulated segment 42' that the circuit is broken.

In order to keep the operator informed at all times as to the setting of the propeller blades, I may provide a dial D with which is adapted to cooperate a pointer P actuated from the follow-up gearing 50 to 54. I may provide a second pointer P' concentric with P and actuated by handle H through gearing 45—46 so that there is indicated at one and the same time upon a single dial the setting of the propeller blades desired by the operator and also the actual position of said blades. For operating the follow-up motor M I may provide the following mechanism: Meshing with annular gears 30—31 I may provide a gear 60, which through gearing such as 61, 62 rotates a Gramme ring G carried by the hub 11.

I may cause said gear 61 to actuate at the same time through gearing such as 64 a governor to control the speed of relative rotation between the brake-member and the hub. Said governor is preferably of the novel type disclosed in Fig. 7. This form is a gyroscopic governor and comprises a weight W

suspended in a universal bearing 155 and normally rotated about the axis of said bearing as well as around the axis of gear 21. Such combined rotation will cause precession of the weight (in this case, in a plane perpendicular to the plane of the paper) to move said weight into engagement with suitable stop mechanism 160 when the speed of rotation has increased to a predetermined amount. As here shown the weight is guided in its precessional movement by a guide 161, and may be provided with a friction surface such as leather washer 162 adapted to engage a circular stop, only the sectional ends 160 of which are shown.

When relative rotation is set up between a brake member and a hub, Gramme ring G will be rotated about its axis so that brush *h* is caused to rotate with respect to brush *h'*, brush *h* being carried around by the hub of the Gramme ring while brush *h'* remains relatively stationary. Throughout each revolution of the Gramme ring G, therefore, there will be a maximum and minimum of current passing between brushes *h* and *h'*, so that for each revolution of the Gramme ring there will be an impulse of current ranging from zero to a predetermined maximum. I cause said impulses of current to be transmitted to one member 70 of a commutator controlling the said motor M, the other member 71 of said commutator having a predetermined current impressed thereon from some source, such as a battery 72. Said commutators 70, 71 are mounted on the shaft of armature A. Co-acting with said commutator members 70 and 71 respectively are two sets of six brushes 73—74. The brushes 73 are in circuit with coils 75 and brushes 74 in circuit with coils 76, one coil 75 and one coil 76 being wound oppositely about each pair of the six pairs of poles of the motor M. The voltage through coil 75 may be predetermined by means of a rheostat R_h, to about one-half the maximum current impulse generated in each revolution of ring G, while the voltage through coils 76 will vary from zero to a maximum as transmitted thereto from ring G, so that during each revolution of the Gramme ring G there will be a period in each armature pole when the voltage in coil 75 exceeds that of coil 76, and another period during which the voltage in coil 75 is less than that of coil 76. Since the coils are oppositely wound, it will be seen that once for each revolution of Gramme ring G the flux through the armature poles will be reversed accordingly as the voltage in coil 75 or the voltage in coil 76 predominates. By providing suitable cut-out portions 80, 81 in the commutator members 70, 71, the engagement of brushes 73, 74 with the live portions of the commutator members 70, 71 may be predetermined to give successive energization to the field poles of the motor.

As shown in Fig. 9, with coil 90 energized, it will be seen that four pairs of field poles marked N—S are oppositely energized, while two pairs of field poles marked O (corresponding to the brushes on the cut-out or dead portions of the commutator members) are deenergized. The N end of armature coil 90 is attracted to the S end of the adjacent field pole 100. As the Gramme G revolves, however, said field pole changes its polarity, as hereinbefore described, to N, while the adjacent field pole 101 becomes S. The armature coil 90 is, therefore, repelled by pole 100 and attracted by pole 101 to cause the armature to rotate one step in a counterclockwise direction. In so rotating, the armature carries with it the commutator members 70, 71 and the brushes connected to pole 101 engage the cut-out portion to deenergize said pole. At the same time the brushes of pole 102 engage the live portion of the commutator members to become energized. Thus it is clear that as long as Gramme ring G is rotated in this direction, and the coil 90 is energized, the motor armature will be actuated step-by-step in a counterclockwise direction in synchronism with the rotations of ring G.

The armature A of said motor may comprise four poles about which are wound two coils 90—91, one for each pair of poles. Only one coil 90 or 91 is adapted to be energized at any time, said energization being effected by the contact system of Fig. 4 so that whenever magnet C or C' is energized to effect turning of the propeller blades in one direction or the other, the respective armature coil 90 or 91 is energized. The provision of the two armature coils, selectively energized, is necessary in order to effect reversal. The reason for this is as follows: The cut-out portions of commutators 70, 71 are such that two pairs of field poles immediately behind the energized armature coil are deenergized. In Fig. 9, coil 90 is shown energized and operating in a counterclockwise direction to co-operate successively with the energized field coils which change their polarity once during each revolution of Gramme ring G, while behind said armature coil there are always two deenergized field coils. Because of said deenergized field coils it would be impossible to reverse the direction of the armature when handle H is reversed, were it not for the fact that when handle H is reversed, armature coil 90 is deenergized and coil 91 is energized. Said armature coil 91 is three field pole positions ahead (in a clockwise direction) of the armature coil 90, thus being positioned beyond the deenergized field poles and registering with the energized field poles so that it may rotate in the opposite direction, i. e., clockwise.

Fig. 8 shows the wiring system whereby when handle H is actuated in one direction or the other to cause brushes 43, 44 to engage

contact segment 40 or 41, there is energized the respective coil 90 or 91. At the same time that coil 90 or 91 is energized there is also energized a relay R to operate a switch S to close the circuit through the motor field coils.

It will be seen that as the pitch of the propeller is reduced there will be offered less resistance to the air and there will be a tendency for the engine to speed up. As the pitch of the propeller approaches the position of zero inclination there will be a tendency for the engine to race ahead to an undesirable extent. In order to prevent such a condition from arising, I may provide means for slowing down the engine as the pitch of the propeller is reduced in the vicinity of the position of zero pitch. For this purpose I may provide upon some member whose movement is tied up with the setting of the propeller pitch, such as the gear 46, a cam 200 which extends, for example, for approximately 10° to either side of the zero pitch angle so that as the pitch of the propeller is reduced below 10° in either direction, forward or reverse, the said cam 200 will operate a link 201 through means such as lever 202, the said link 201 being connected to the throttle of the engine in such manner that as lever 202 rides up on cam 200 the engine will be throttled down to such degree that as the pitch of the propeller passes through the zero setting it will be impossible for the engine to race ahead.

Referring to Figs. 10 to 12 inclusive, it will be seen that I have provided several modifications to take the place of the electro-magnets C—C' and the mechanism for energizing the same for actuating the brake-members A and B for changing the position of the propeller blades. In Fig. 12 I have disclosed a mechanical hand-operated means which may take the form of a handle 110 adapted to actuate one member 111, here shown as the inner member, of a Bowden wire 112 connected to a member 113 in the form of a T, the ends 114, 115 of whose cross bar are connected to the loose ends of brake bands A', B'. The bands surround the brake drums and the other ends thereof are connected to fixed points 116. Springs 117 normally disengage said bands from the drums but when said Bowden wire is actuated by means of the handle in one direction or the other, the T-shaped member will pivot about one or the other of points 114, 115 to draw one or the other of said bands into engagement with the respective brake drums to cause actuation of the propeller blades in the corresponding direction. At the same time that the handle is actuated to operate the Bowden wire there is also actuated a contact member 120 having two arms 121, 122, one or the other of which engages with one or the other of cooperating contact segments 40', 41' sim-

ilar to contact segments 40–41 for energizing the follow-up motor M.

In Figs. 10 and 11 I have shown still another method of actuating the brake drums, this method being capable of substitution for the form shown in Fig. 12, or as shown in Fig. 10, capable of use therewith as an auxiliary operating mechanism. In this form brake cables 130, 131 are wrapped around the brake drums A, B preferably in special grooves 132, 133 provided therein, one end of each of said cables being fixed at 135 and the other end extending over suitable sets of pulleys 136, 136' and rollers 137, 137' to respective handles 138, 139. Said cables are normally maintained out of braking engagement with the drums by springs 140 similar to the springs utilized in connection with the Fig. 12 form. When either of the handles is actuated to the left in Fig. 11 the respective brake cable is caused to engage its drum to cause operation of the propeller blade-setting mechanism. Such operation oscillates shaft 149 carrying pulleys 136' to actuate a contact member 145 carried by hub 150 into engagement with one or the other of a set of contact members 40'', 41'' corresponding to contact members 40, 41 to energize the follow-up motor M as in the other instances. A centralizing spring 151 may engage member 145 to tend to restore the same to initial position.

In Figs. 14 to 16 inclusive I have shown two modifications of the bearing 17' of Fig. 1, designed more effectively to take up the thrust due to centrifugal force. In the form shown in Figs. 14 and 15, the bearing 17' is replaced by roller bearings comprising a series of rollers 160' circumferentially disposed between upper and lower races 161', 162' between the sleeve 19 surrounding the propeller blade and the casing 15'. Said casing is provided with a radially extending portion 15'' terminating in a ledge 165 designed to take the centrifugal thrust of the blades when the speed picks up. The rollers 160 are of a special design having a flat inner face 166 engaging the sleeve 19 along a vertical tangential line and having an outer convex surface 167 engaging the housing 15'' in a plane at right angles to said inner line of tangency. The horizontal bearing surfaces of the rollers may be made convex and engaging with flat surfaces on the races 161', 162' or else the thrust surfaces of the rollers may be straight and the faces of the races made convex as shown in Fig. 14.

The radially extending portion 15'' of the casing 15' must be cut out adjacent that section through which the gearing 20, 21 projects, forming a cut-out portion shown at 170. Since the support for the ledge 165 adjacent that portion is thus diminished I may provide a reinforcing web 117 for the

ledge 165 in that portion of the casing 15" having the cut-out portion 170.

In Fig 14 it will be seen that I have a hollow shank 16 surrounded by a tight-fitting sleeve of metal 19 of different coefficient of expansion. A hole 205 is pierced centrally through the shank 16 for the purpose of taking up differential expansion and contraction between the two.

In Fig. 16 I have disclosed still another modified form of bearing for the propeller blades designed to take up the thrust due to centrifugal force. In this form of bearing I provide a bearing block 180 with which the projecting surface 181 of the propeller sleeve 19 is adapted to engage when the centrifugal force is sufficiently great. The friction of such engagement is in part relieved by a spring 182 pressing against said surface 181. Between the surface 181 and said spring there is interposed a ball bearing 17" similar to bearing 17', but it will be seen that when surface 181 engages block 180 that the thrust is practically entirely removed from said bearing 17" and it is only when the speed of the propeller drops sufficiently to cause extension 181 to disengage block 180 that the bearing 17" becomes effective. The movement of the blade axially of the hub in this instance is permitted by reason of a key 185 between the extension 181 and the races of the bearing 17". When the centrifugal force diminishes or when the blades are at rest, the great pressure exerted by the springs 182 is taken off the propellers by means of a tongue 186 on the casing 15' projecting slightly above bearing surface 181.

In accordance with the provisions of the patent statutes, I have herein described the principle and operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means. Also, while it is designed to use the various features and elements in the combination and relations described, some of these may be altered and others omitted without interfering with the more general results outlined, and the invention extends to such use.

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

1. In combination, a member having a plurality of propeller blades, means for varying the pitch of said blades, means for controlling said first means comprising a two-part controller, means whereby one of said parts may be set by an operator, a follow-up from said first means to said other part, and means whereby movement of said first means ceases when said parts reach a predetermined relation.

2. In combination, a member having a plu-

rality of propeller blades, means for varying the pitch of said blades, means for controlling said first means comprising a coarse controller and a fine controller, said fine controller being connected to said coarse controller in vernier relation thereto, each controller comprising two parts, means whereby one part of each controller may be set by an operator, a follow-up from said first means to the other part of each controller, and means whereby movement of said first means ceases when said parts reach a predetermined relation.

3. In combination, a rotating hub, a plurality of propeller blades carried by said hub, a plurality of members in frictional engagement with said hub and normally rotatable therewith, a plurality of independent means for selectively retarding said members relative to said hub, and means whereby relative movement between said respective members and said hub actuates said blades to vary the pitch thereof in either of opposite directions.

4. In combination, a member having a plurality of propeller blades, means whereby the pitch of said blades may be varied, means for indicating the pitch of said blades, and means whereby said first means actuates said indicating means, said last-named means comprising a motor, an electrical transmission system between said first-named means and said motor, and means whereby said first-named means actuates said transmission system.

5. In combination, a member having a plurality of propeller blades, means whereby the pitch of said blades may be varied, means for indicating the pitch of said blades, and means whereby said first means actuates said indicating means, said last-named means comprising a motor, a self-synchronous reversing step-by-step transmission system between said first-named means and said motor, and means whereby said first-named means actuates said transmission system.

6. In combination, a rotating hub, a plurality of propeller blades carried by said hub, a plurality of members in frictional engagement with said hub and normally rotatable therewith, means for selectively retarding said members relative to said hub, means whereby relative movement between said respective members and said hub actuates said blades to vary the pitch thereof in either of opposite directions, and means for limiting the speed of said relative movement between said members and said hub.

7. In combination, a member having a plurality of propeller blades, means for varying the pitch of said blades in either direction, settable means for controlling said first means, a follow-up from said first means to said settable means, said follow-up including a synchronous step-by-step motor, and means whereby the direction of operation of said

settable means controls the direction of operation of said motor.

8. In combination, a member having a plurality of propeller blades, means for varying the pitch of said blades in either direction, settable means for controlling said first means, a follow-up from said first means to said settable means, said follow-up including a synchronous step-by-step motor having field poles and an armature, said armature having a pair of coils angularly disposed with respect to each other, means whereby the direction of operation of said motor is controlled by the energization of the respective armature coil, and means whereby the direction of operation of said settable means controls the energization of the respective armature coil.

9. In combination, an engine, a plurality of propeller blades driven thereby, means whereby the pitch of said blades may be varied rearwardly and forwardly, and means rendered effective when said blades approach the position of zero inclination for preventing racing of the engine.

10. In an adjustable pitch propeller having a plurality of blades, a pinion, a plurality of gears for feathering the blades engaging such pinion, means for independently adjusting the depth of tooth engagement between the pinion and each of the gears, and means for operating the gears for varying the pitch of the blades.

11. In combination, a rotating hub, a plurality of propeller blades carried by said hub, each of said blades having a gear segment, a ring-gear engaging all of said segments and organized to be in a plane transverse to the axis of said hub, and means for tilting said ring-gear out of its normal plane.

12. In combination, a rotating hub, a plurality of propeller blades carried by said hub, each of said blades having a gear segment, a ring-gear engaging all of said segments and organized to be in a plane transverse to the axis of said hub, a journal bearing for such gear, and means for tilting both said gear and its bearing out of their normal plane.

13. In an adjustable pitch propeller, a reversible operating mechanism at the hub, a reversible electrical indicator near the control position, a reversible actuating means for varying the pitch extending therebetween, and a connection between the actuator and the indicator for simultaneously reversing the mechanism and the indicator.

14. In combination, a rotating hub, a plurality of propeller blades carried by said hub, a plurality of members in frictional engagement with said hub and normally rotatable therewith, means for selectively retarding said members relative to said hub, said means including brake-bands coacting with said members and normally ineffective, a hand-

operated Bowden cable consisting of an inner wire and outer sheath, said wire and sheath being relatively movable, and a connection between said wire and said bands such that movement of said wire in one direction with respect to its sheath renders one band effective while movement of said wire in the other direction renders said other band effective, and means whereby relative movement between said respective members and said hub actuates said blades to vary the pitch thereof in either of opposite directions.

15. In combination, a rotating hub, a plurality of propeller blades carried by said hub, a plurality of members in frictional engagement with said hub and normally rotatable therewith, means for selectively retarding said members relative to said hub, means whereby relative movement between said respective members and said hub actuates said blades to vary the pitch thereof in either of opposite directions, and means for limiting the speed of said relative movement between said members and said hub, said last-named means comprising a rotatable body adapted to be revolved around the axis of said hub during rotation of said hub and to be rotated around another axis at an angle to said first axis during relative movement between said members and said hub to cause gyroscopic precession of said body, and braking means with which said body is adapted to engage after a predetermined degree of precession.

16. In a variable pitch propeller, a rotating cylinder of steel fixed to the propeller, a steel socket in which said cylinder fits forming a bearing for said cylinder, one of the contacting surfaces of said bearing having a metallic coat of a hardness greater than that of either cylinder or socket.

17. In combination, a propeller having a shank and a tight-fitting sleeve closely surrounding said shank, said sleeve having a different coefficient of expansion than said shank, said shank being pierced with a centrally located hole axially disposed with respect thereto.

In testimony whereof I have affixed my signature.

ELMER A. SPERRY.