Nov. 7, 1944. E. MARTIN 2,361,954

PROPELLER CONTROL MEANS

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Fig. 2

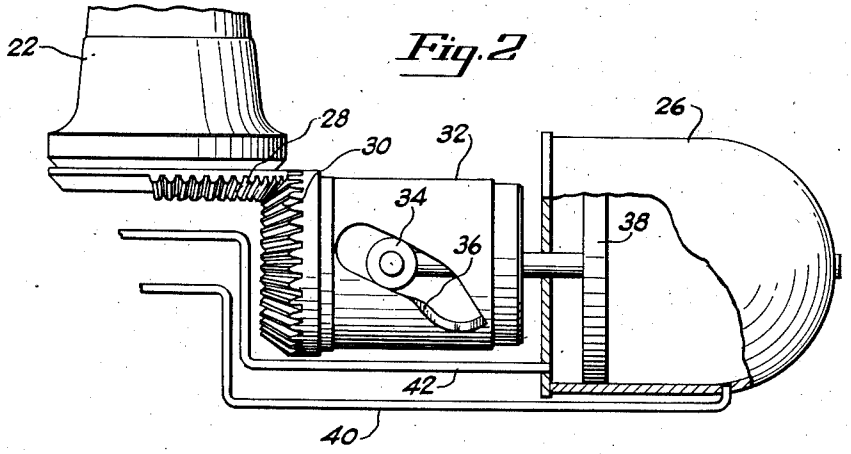
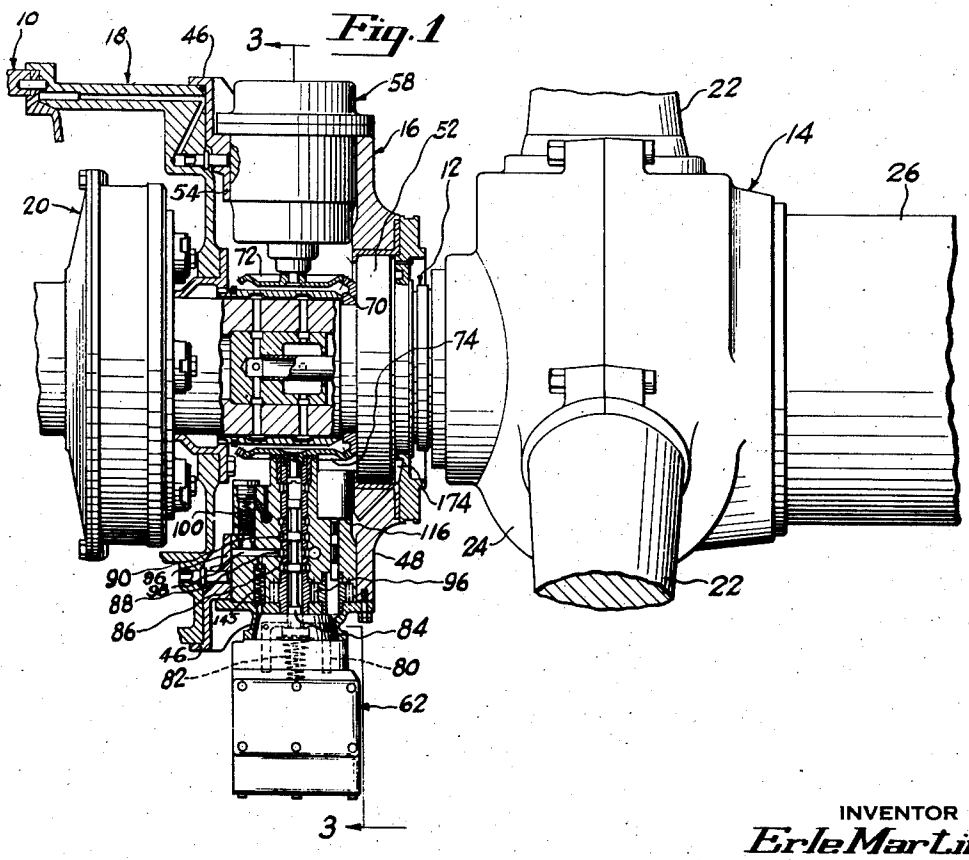


Fig. 1



INVENTOR
Erle Martin
BY Harris G. Luther
ATTORNEY

Nov. 7, 1944. E. MARTIN 2,361,954

PROPELLER CONTROL MEANS

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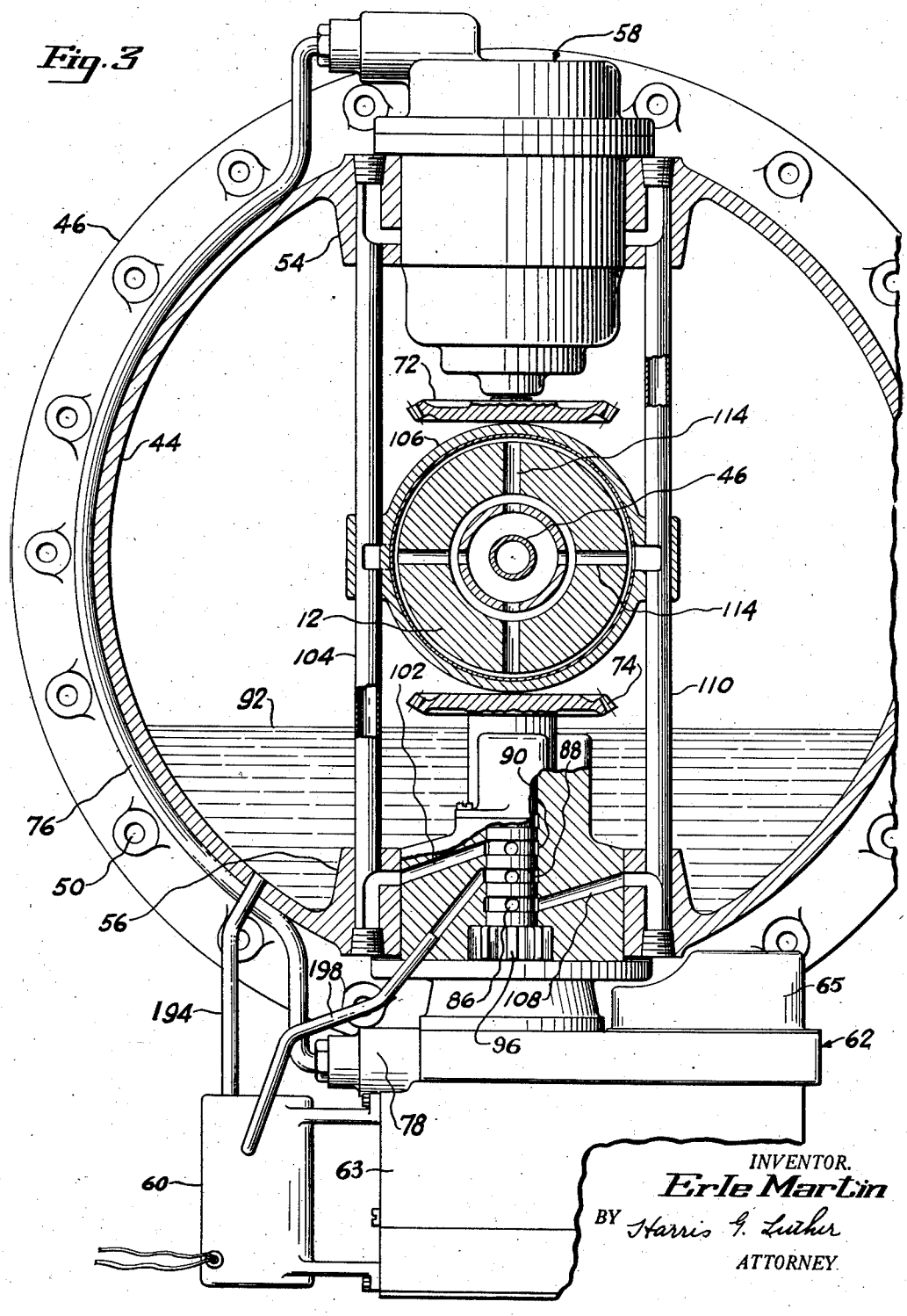
Fig. 3



INVENTOR.
Earle Martin
BY Harris G. Luther
ATTORNEY.

Nov. 7, 1944. E. MARTIN 2,361,954

PROPELLER CONTROL MEANS

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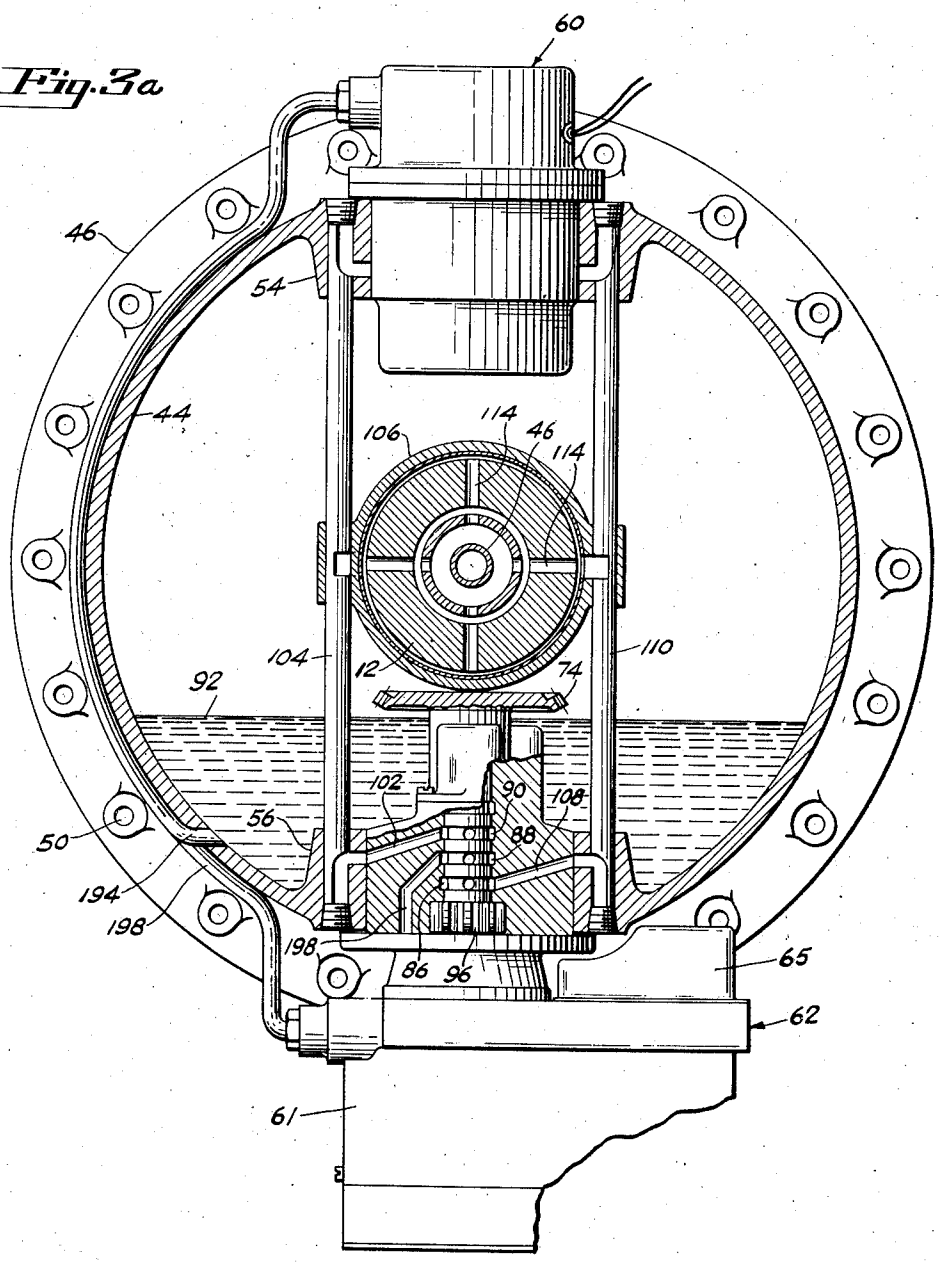
Fig. 3a



INVENTOR
Erle Martin.
BY Harris G. Luther
ATTORNEY

Nov. 7, 1944. E. MARTIN 2,361,954

PROPELLER CONTROL MEANS

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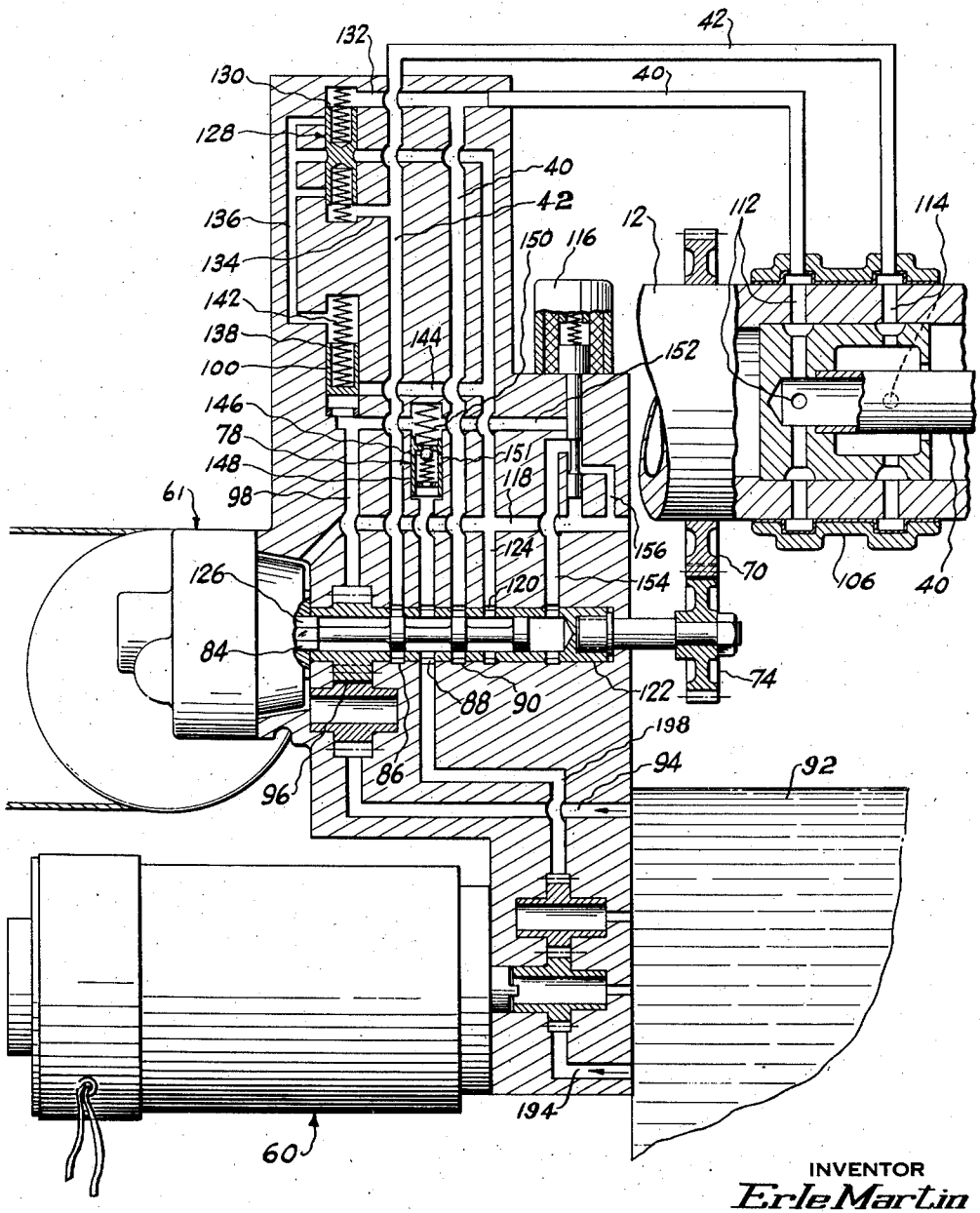
Fig. 4



INVENTOR
Erle Martin
BY Harris G. Lucker
ATTORNEY

Nov. 7, 1944. E. MARTIN 2,361,954

PROPELLER CONTROL MEANS

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Fig. 7

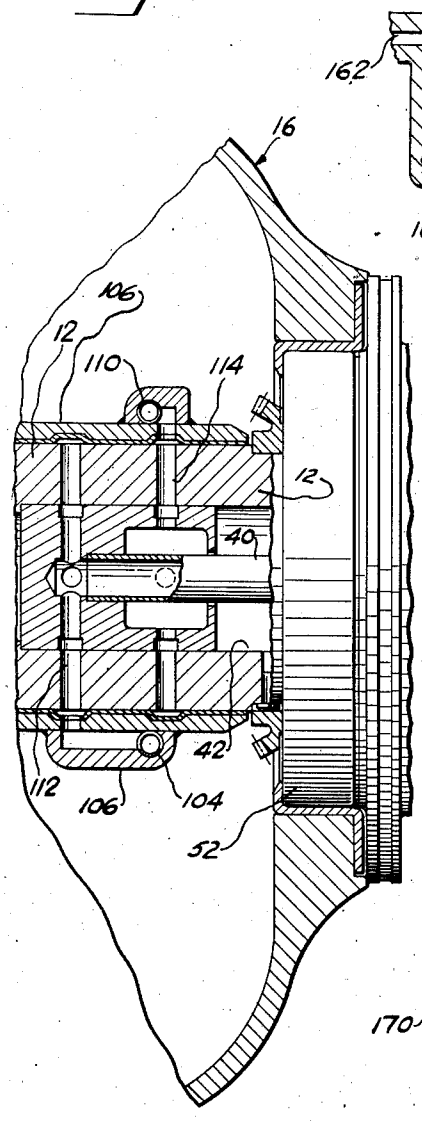
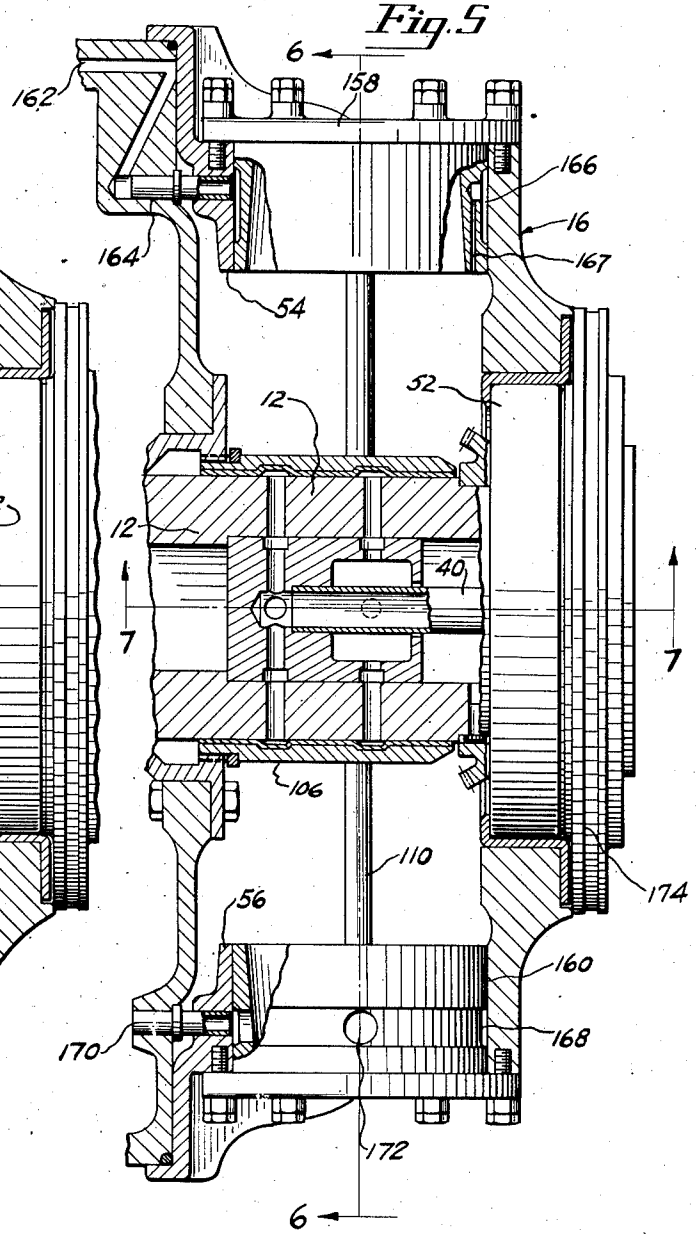


Fig. 5



INVENTOR

Erle Martin

BY Harris G. Luther

ATTORNEY

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PROPELLER CONTROL MEANS

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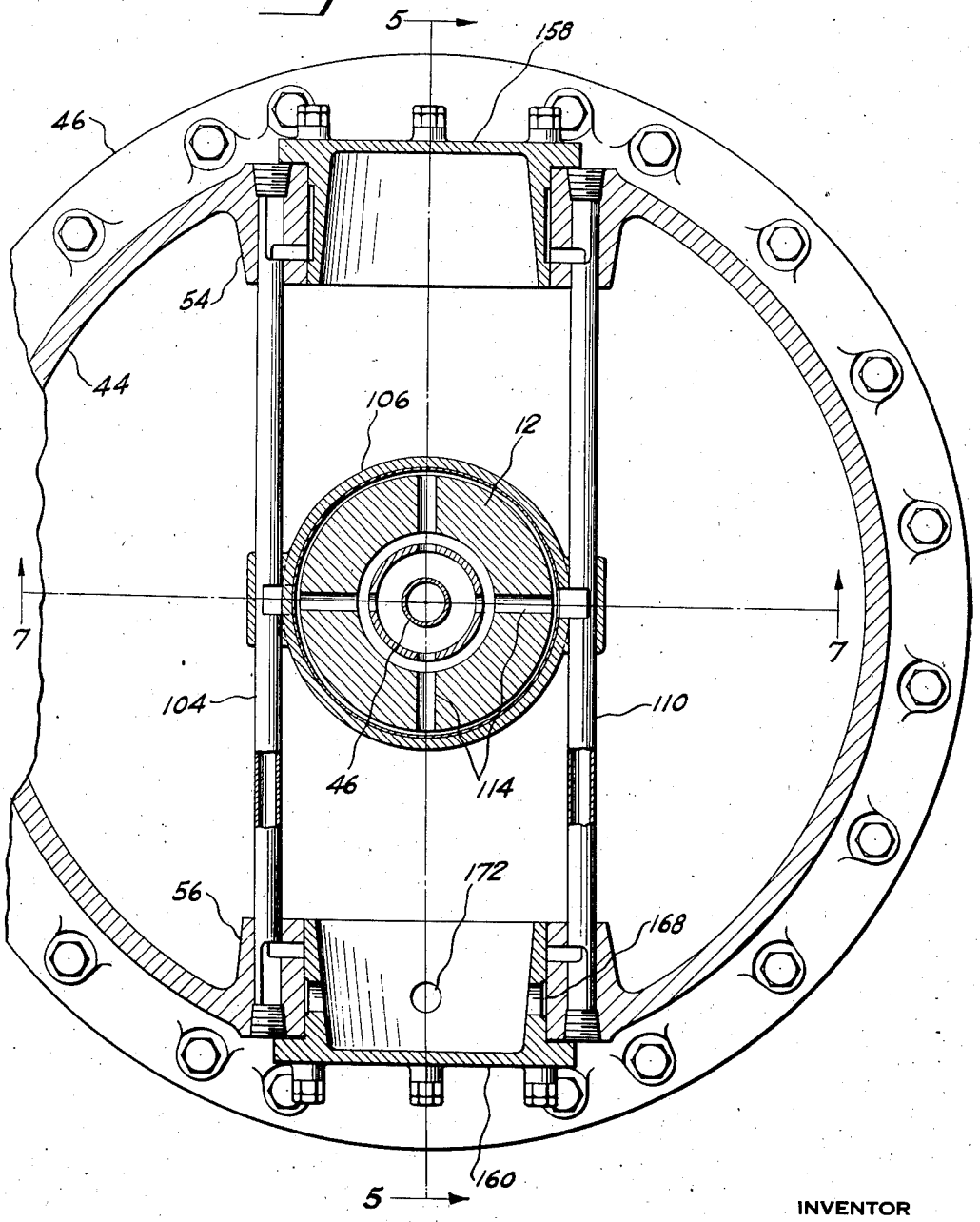
Fig. 6



INVENTOR
Erle Martin
BY Harris G. Luther
ATTORNEY

Patented Nov. 7, 1944 2,361,954

UNITED STATES PATENT OFFICE

2,361,954

PROPELLER CONTROL MEANS

Erle Martin, West Hartford, Conn., assignor to United Aircraft Corporation, East Hartford, Conn., a corporation of Delaware

Application December 13, 1939, Serial No. 308,994

6 Claims. (Cl. 170—163)

This invention relates to improvements in control means for controllable-pitch aeronautical propellers and has particular reference to improvements in the arrangement and support of the propeller controlling instrumentalities.

An object of the invention resides in the provision of an improved unitary construction containing substantially all of the instrumentalities necessary to control the propeller pitch.

A further object resides in the provision of an improved unitary propeller pitch control construction of the character indicated which, while it may be mounted or supported upon and driven by the engine, is otherwise independent of the propeller driving engine for its pitch controlling function.

A still further object resides in the provision of a unitary propeller pitch controlling mechanism of the character indicated which may be independently constructed and assembled as a unit in the engine propeller combination.

An additional object resides in the provision of an improved support for propeller pitch controlling instrumentalities which may be readily converted or adapted for use with control instrumentalities mounted independently of said support.

Other objects and advantages will be more particularly pointed out hereinafter or will become apparent as the description proceeds.

In the accompanying drawings, in which like reference numerals are used to indicate similar parts throughout, there is illustrated a particular mechanical arrangement for the purpose of disclosing the invention. The drawings, however, are for the purpose of illustration only and are not to be taken as limiting the invention since it will be apparent to those skilled in the art that various changes in the illustrated construction may be resorted to without in any way exceeding the scope of the invention.

In the drawings, Fig. 1 is a longitudinal sectional view through a propeller control unit constructed according to the invention and a fragmentary portion of a propeller driving engine, the center portion of the propeller being shown in elevation.

Fig. 2 is a diagrammatic view showing the operation of one type of controllable-pitch propeller with which the control unit may be utilized.

Fig. 3 is a sectional view on an enlarged scale on the line 3—3 of Fig. 1. Fig. 3a is a sectional view similar to Fig. 3 but showing the feathering pump installed in place of the generator.

Fig. 4 is a diagrammatic view to illustrate the operation of the propeller pitch controlling instrumentalities.

Fig. 5 is a longitudinal sectional view of the support for the propeller controlling instrumentalities when such support is converted or blocked off to adapt it for use with control instrumentalities mounted independently of the support, taken on the line 5—5 of Fig. 6.

Fig. 6 is a transverse sectional view on the line 6—6 of Fig. 5, and

Fig. 7 is a sectional view of the construction shown in Figs. 5 and 6 taken on the line 7—7 of Fig. 6.

Referring to the drawings in detail and particularly to Fig. 1, the numeral 10 generally indicates a propeller driving engine from which projects the drive shaft, generally indicated at 12, carrying the controllable-pitch propeller, generally indicated at 14. Between the engine and the propeller there is disposed the unitary propeller control means, generally indicated at 16, generally concentric with the shaft 12. If desired, an engine nose extension 18 may include and provide a casing for a vibration suppressing torque drive, generally indicated at 20, various forms of which are known to the prior art.

The propeller 14 may be of the type particularly illustrated and described in United States Patent No. 2,280,714, issued April 21, 1942, for Feathering propeller control. Such a propeller may have a plurality of blades, as indicated at 22, rotatably mounted at their base ends in a hub barrel member 24 and rotated in pitch changing directions by suitable pitch changing mechanism contained within the dome 26 and diagrammatically illustrated in Fig. 2. As shown in Fig. 2 each propeller blade is provided at its inner or base end with a gear segment 28 which meshes with a beveled gear 30 carried at one end of a rotatable member 32. The member 32 is rotated by means of a cam follower 34 movable along an inclined cam track 36 by a piston 38 reciprocable in the dome shaped cylinder 26 by force exerted by hydraulic fluid under pressure supplied to the opposite ends of the cylinder. Hydraulic fluid under a substantially constant relatively low pressure is supplied to the outer end of the cylinder 26 through a suitable conduit 40 to assist the action of centrifugal force on the blades to rotate the blades in a pitch decreasing direction, while hydraulic fluid at a higher pressure is supplied to the opposite end of the cylinder through the conduit 42, and this supply is controlled by suitable means including

a speed responsive governor to either overcome the action of centrifugal force and the oil pressure in the other end of the cylinder to move the piston 38 in a pitch increasing direction or to connect the conduit 42 with a drain and thus permit the centrifugal force and fluid pressure in the outer end of the cylinder to rotate the blades in a pitch decreasing direction. When it is desired to bring the propeller to a feathered condition, in which the blades are substantially parallel to the direction of travel of the propeller carrying aircraft, hydraulic fluid under high pressure is continuously supplied through the line 42 to the inner end of the cylinder 26 to move the piston 38 to its limiting outward position and when it is desired to return the blades to their normal operating position the line 42 is connected with a drain and hydraulic fluid under high pressure supplied through the line 40 to the outer end of the cylinder to return the piston 38 in a pitch decreasing direction.

As is particularly shown in Fig. 1 and Fig. 3, the casing 44 which serves as a support for the pitch controlling instrumentalities included in the pitch controlling mechanism, generally indicated at 16, is an annular member having an attaching flange 46 at one end of an annular intermediate portion and a bearing supporting flange 48 at the opposite end of said intermediate portion. The attaching flange 46 is secured to the front end of the engine nosepiece section 18 by suitable means, such as cap screws inserted through the apertures 50, and the bearing supporting flange 48 carries in its central aperture the shaft supporting main bearing 52, the bearing being retained in the flange by some conventional or desired construction. The intermediate portion of the casing 44 is provided with a pair of diametrically opposed annular bosses 54 and 56, which are positioned at the top and bottom respectively of the casing when the casing is mounted in position on the engine, as shown in Fig. 1, although the invention is not in any way limited to any particular positions of these bosses. The upper boss carries a generator, as generally indicated at 58 in Figs. 1 and 3. The generator 58 supplies electrical energy for operating the motor controlled governor, generally indicated at 62, and carried by the boss 56 and may in addition supply electrical energy for synchronizing the various engines of a multi-engine airplane.

The generator 58 and the governor 62 are both driven from a common bevel gear 70 mounted on the propeller shaft and meshing with gears 72 and 74 drivingly connected respectively with the generator and the governor and the governor has incorporated in the head portion 63 thereof an electric motor 65 operatively associated with the governor speed setting mechanism in any suitable manner, such, for example, as is particularly illustrated and described in United States Patent Number 2,144,429 issued January 17, 1939, to Erle Martin for Electrical engine control mechanism. An electrical conduit 76 carries the output of the generator to a manually or automatically controlled switch not illustrated, connected with the governor motor. The control for the governor 62 may be of the type particularly illustrated and described in United States Patent No. 2,252,518, issued August 12, 1941, to Erle Martin for Power plant control means. Such a governor may include a plurality of flyballs, as indicated at 80, acting against a speeder spring 82, the load on which may be adjusted by a motor as shown in Figs. 1 and 3, or manually as shown in Figs. 3a and 4 if desired, the flyballs acting to move a valve stem 84 relative to ports 86, 88 and 90 to control the flow of hydraulic fluid to and from the pitch changing mechanism of the propeller 14 in a manner which will present appear. The casing 44 serves as a reservoir for special hydraulic fluid for operating the propeller pitch changing motor, the fluid being contained in the lower part of the casing as indicated at 92 in Figs. 3 and 4, permanently separated from the engine lubricating oil. From this reservoir the hydraulic fluid may be led through a conduit 94 (Fig. 4) to a booster pump 96 and from the pump through a conduit 98 to the governor valve port 88. The pressure of the fluid supplied to the port 88 is controlled by a pressure relief valve 100 shown in Figs. 1 and 4 which may be of the type particularly illustrated and described in my co-pending United States application Serial No. 287,874, filed August 2, 1939, for Propeller governors.

The governor valve port 90 is connected, through a passage 102, with a tube 104 which extends transversely across the interior of the casing 44 and has a connection intermediate its length with a sleeve 106 mounted on the propeller drive shaft within the casing 16. The governor valve ports 86 are similarly connected through a channel 108 and a transversely extending tube 110 connected with the side of the sleeve 106 opposite the side to which the tube 104 is connected, the arrangement of these tubes being particularly shown in the sectional view illustrated in Fig. 7. As shown in this figure, the tube 104 is connected through a channel 112 in the propeller shaft with the interior of the conduit 40, which may be a tube coaxial with the propeller shaft leading to the space at the forward or pitch reducing side of the piston 38, while the tube 110 is connected through a channel 114 with the conduit 42, which may be the space between the tube 40 and the interior of the hollow propeller shaft, which space leads to the space at the rear of pitch increasing side of the piston 38. The feathering and unfeathering operations of the propeller pitch changing mechanism are controlled by an electro-magnetically operated valve 116, preferably disposed in the base of the governor 62.

Reference may now be had to Fig. 4 for a description of the operation of the mechanism so far described. In this schematic view the generator 58 has been omitted and the governor 61 is shown as a manually controlled governor for the sake of clearness. A motor driven pump 60 and a valve 78 referred to hereinafter are shown in Fig. 4 but the drawings will first be explained as if they were not present. The governor booster pump 96 draws hydraulic fluid from the reservoir within the casing 44 and directs it at an increased pressure through the conduit 98 to the governor valve port 88. When the propeller is operating under constant speed control by the governor 62, the engine speed above the speed setting of the governor will cause the governor to move the governor valve member 84 to the left, as viewed in Fig. 4, with relation to the ports 86, 88 and 90 while an engine speed below the speed setting of the governor will cause the governor to move the valve member 84 to the right. When the engine speed is high the governor valve acts to connect the channel 98 with the lines 42 leading to the pitch increasing side of the piston 38

simultaneously connecting the conduit 40 with the drain channel 118 so that the piston 38 will be moved in a direction to increase the pitch of the propeller and reduce the speed of the engine. The connection from the conduit 40 to the drain line 118 leads through additional ports 120 in the hollow governor drive shaft 122 and through a branch line 124 connecting the ports 120 with the drain channel. When the engine speed tends to fall below the governor speed setting and the valve member 84 is moved to the right by the force of the speeder spring 82, the conduit 40 is connected with the outlet 98 of the pump 96 to apply hydraulic fluid under pressure to the piston 38 in a direction to reduce the propeller pitch, while the conduit 42 is simultaneously connected with the drain line 118 through suitable channels 126 provided in the governor end of the valve member 84, to move the piston 38 in a pitch reducing direction.

A slide valve, generally indicated at 128 is disposed between the conduits 40 and 42 and the pressure relief valve 100. This slide valve has a spring balanced plunger 130 disposed, when the valve is in the neutral or intermediate position illustrated, between the branch conduit 132 connecting the valve with the pressure conduit 40 and the branch conduit 134 connecting the opposite end of the valve with the conduit 42. A line or channel 136 connects the space at the rear of the plunger 138 of the pressure relief valve 100 with the slide valve 128 and has three branches leading to the slide valve, one to the center of the valve and one to the intermediate portion of each end half thereof. In the position of the slide valve illustrated the two end branches are cut-off by the plunger or slide 130 while the intermediate branch is connected through a reduction in the plunger 130 with a line 140 leading to the drain channel 118 so that the space at the rear of the pressure relief valve plunger is connected with drain. When hydraulic fluid under pressure is admitted to either of the conduits 40 or 42 by the action of the governor valve, the slide 130 is moved to connect the corresponding end branch of the channel 136 with the respective conduit to apply the pressure of the hydraulic fluid in the conduit to the rear of the plunger 138 of the pressure relief valve simultaneously cutting off the drain channel 140. This causes the pressure valve to apply to the particular conduit a hydraulic pressure which increases or decreases as the pressure in the conduit changes and which may be in excess of the pressure in the conduit by the amount of force exerted by the spring 142 which acts to urge the pressure relief valve towards closed position. The drain or overflow from the pressure relief valve may be through a channel 144 connected with the drain line 118. With this arrangement the pressure exerted by the pump 96 will be controlled according to the requirements of the propeller pitch changing mechanism and will always be sufficient, within the capacity of the pump 96, while the load on the pump 96 will be relieved when no hydraulic fluid under pressure is required by the pitch controlling mechanism. Thus the pump will supply fluid only at the required pressure and will not unnecessarily detract from the horsepower output of the propeller driving engine. If desired, a safety valve, 145 (Fig. 1) is interposed between channel 98 and a drain or as shown in my co-pending United States Application Serial No. 287,874 referred to above, but not illustrated in the accompanying drawings, could be interposed between the channel 136 and the channel 140 leading to the drain line 118.

In installations where the pressure of the pump 96 alone is relied upon to perform the feathering and unfeathering operations, both the high pressure pump 60 shown in Figs. 3, 3a, and 4 and the control valve 78 shown in Fig. 4 and referred to hereinafter would be omitted. Energizing the electro-magnetic valve 116 will apply pressure to the chamber behind the governor valve plunger 84 as follows. Valve 116 will be moved to connect the line 152 with the line 154 simultaneously cutting off the drain line 156. The line 154 leads to a chamber between the end of the governor valve plunger 84 and the closed end of the hollow governor drive shaft 122. This chamber is ordinarily connected with drain through the channel 156 but, when this drain channel is cut off and the channels 152 and 154 are connected, hydraulic fluid under pressure is admitted to the chamber to force the valve member 84 to the left as viewed in Fig. 4 and maintain it in that position. The hydraulic pressure will then maintain the governor valve in a pitch increasing position connecting line 98 with line 42 and increasing the pitch until the feathered condition of the propeller has been reached regardless of the action of the governor in attempting to reduce the pitch as the engine slows down. As the engine may be made to rotate at a relatively slow speed even when the propeller is feathered, deenergizing the valve 116 will drain the chamber between the governor valve plunger and the closed end of the hollow drive shaft 122 and permit the governor valve to assume its pitch decreasing position under the influence of the speeder spring and connect the pump 96 with the pitch decreasing side of the propeller pitch control mechanism. Even at the above-mentioned relatively slow engine speed the pump 96 might be relied upon to supply sufficient pressure to the pitch decreasing side of the pitch control mechanism to start the propeller blades out of their feathered condition. As soon as the propeller pitch begins to decrease the engine will speed up enabling the pump 96 to supply hydraulic fluid at a faster rate and this, coupled with the centrifugal force acting on the propeller blades in a pitch decreasing direction, will quickly restore the propeller to the constant speed control range of propeller pitch angles.

In some installations it is desirable to have a separate source of fluid pressure for supplying the power for feathering and unfeathering. In such installations an auxiliary fluid system such as is frequently provided for operating retractable landing gears and moving wing flaps or other movable parts of the airplane may be utilized or an electrically operated pump generally indicated at 60 (Figs. 3, 3a, and 4) may be added to the above described structure. If the particular installation does not require the generator 58 for either governor control (as where a manual control is used) or synchronizing (as where there is but one engine) or if the generator is mounted on some other portion of the engine the pump 60 may be installed in the boss 54 in place of the generator (see Fig. 3a). When so installed the pressure and suction lines 192, 194 of the pump would occupy the space occupied by conduit 76 in Fig. 3. The pressure line 192 leads to port 88 as shown in Figs. 3, 3a, and 4 and the suction line is connected with the fluid 92 in the lower part of casing 44.

When it is desired to bring the propeller to its feathered condition, assuming the motor driven feathering pump 60 to be included in the combination, the motor of the pump 60 and the electro-magnetically controlled valve 116 may be simultaneously energized. Since the outlet pressure of the pump 60 is materially higher than the pressure produced by the pump 96 the ball 146 in the control valve 78 will be seated and the plunger 148 moved to its uppermost position against the force of the spring 150 to cut off the line 98 and connect the feathering pump outlet 76 with the valve 116 through the port 151 and branch line 152. At the same time the valve 116 will be moved to connect the line 152 with the line 154 simultaneously cutting off the drain line 156. The line 154 leads to a chamber between the end of the governor valve plunger 84 and the closed end of the hollow governor drive shaft 122. This chamber is ordinarily connected with drain through the channel 156 but, when this drain channel is cut off and the channels 152 and 154 are connected, hydraulic fluid under pressure is admitted to the chamber to force the valve member 84 to the left as viewed in Fig. 4 and maintain it in that position. The conduit 198 leading from the pump 60 is then connected with the conduit 42 to apply hydraulic fluid to the propeller pitch changing mechanism in a direction and at a pressure sufficient to bring the propeller to its feathered condition. At the same time the conduit 40 will be connected with drain through the channel 124 to permit draining of the hydraulic fluid in the pitch decreasing side of the pitch changing mechanism.

When it is desired to return the propeller from its feathered condition to the constant speed control range of propeller pitch angles the pump 60 will be energized without energizing the electromagnetic valve 116 which will have returned to the position illustrated in Fig. 4 in which the chamber at the end of the governor valve member is connected through the channel 156 with the drain. Since the engine cannot be rotated rapidly and is usually stationary when the propeller is in its feathered condition the governor 62 will be attempting to move the governor actuated valve to a pitch reducing position through the force of its speeder spring 82. The valve member 84 will, therefore, move to a position to connect the ports 88 and connected channel 198 with the pitch reducing side of the pitch controlling mechanism through the conduit 40, simultaneously connecting the conduit 42 with the drain line 118 to drain the hydraulic fluid from the pitch increasing side of the propeller pitch controlling mechanism. Operation of the pump 60 will then force hydraulic fluid at high pressure through the conduit 40 to return the propeller to the normal or constant speed range of propeller pitch angles. As soon as the operation of the pump 60 is discontinued the spring 150 will force the plunger 148 downwardly and pressure exerted by the pump 96 will then open the small valve 146 to connect the pump 96 with the port 88 so that the governor will control the propeller pitch in the manner described above.

Where an auxiliary high pressure hydraulic system is relied upon to perform the function of the high pressure pump 60 a valve between such an auxiliary system and the conduit 198 may be substituted for the pump 60.

In some cases it may be desirable to provide an engine equipped with the special nose section and propeller shaft for the above-described unitary governor pitch control for a hydro-controllable pitch propeller with a different kind of propeller such as an electrically controlled or fixed pitch propeller. In such a case it is not necessary to remove the casing 44 or make any other material change in the construction since both of the bosses 54 and 56 may be fitted with plugs, as indicated at 158 and 160 respectively, which will adapt the construction to use with such a propeller. The engine may be provided with a fluid channel 162 leading to the front of the engine nosepiece within the area of the upper boss 54. From this channel a connecting tube 164 leads to the interior of the boss and to an annular groove 166 provided in the outer surface of the plug 158. The tubes 104 and 110 may be connected with this annular groove and will then conduct hydraulic fluid to the oil transfer bearing within the sleeve 106 to lubricate this bearing. Some of the oil may flow through the small aperture 167 from the annular channel 166 to lubricate the propeller outboard bearing 52. The plug 160, which closes the lower boss 56, may also be provided in its outer wall with an annular groove 168, connected with a drain connection 170 leading back to the engine oil sump, and with the interior of the plug by suitable ports as indicated at 172. With this construction lubricating oil leaving the oil transfer bearing within the sleeve 106 and returned oil from the bearing 52 will be returned to the engine through the plug 160 and the drain connection 170. When an electrically controlled or fixed pitch propeller is used the outer end of the propeller shaft 12 would be suitably plugged to prevent a flow of lubricating oil from the oil transfer bearing into the propeller hub except such a flow as might be desired to lubricate the pitch changing mechanism of the propeller. The oil transfer bearing could be utilized as a feed and drain for such lubricating oil if desired.

Fig. 7 shows the general shape of the casing 16 in the spaces between the bosses 54 and 56.

While a particular constructional arrangement has been hereinabove described and illustrated in the accompanying drawings for the purpose of disclosing the invention, it is to be understood that the invention is not limited to the particular arrangement so illustrated and described but that such changes in the size, shape and arrangements of the various parts may be resorted to as come within the scope of the subjoined claims.

Having now described the invention so that others skilled in the art may clearly understand the same, what it is desired to secure by Letters Patent is as follows:

1. A propeller pitch control unit casing having bosses providing seats for a governor and a propeller feathering pump, propeller connected fluid conduits leading to said seats, and closure members having annular portions fitting said bosses for blanking off said seats and blocking the connections of said conduits with the propeller in order that said casing may be retained as a part of an engine propeller combination when the function of said control unit is not desired.

2. In combination with a hydro-controllable propeller and a propeller driving engine having a casing and a propeller shaft projecting from said casing, a unitary control for said propeller comprising, an auxiliary casing attached to said engine casing surrounding said propeller shaft, a pump carried by said auxiliary casing for sup-

plying pitch changing fluid under pressure to said propeller, a governor actuated valve carried by said auxiliary casing and hydraulically interposed between said pump and said propeller, a governor carried by said auxiliary casing for controlling said valve, a propeller feathering and unfeathering pump carried by said auxiliary casing, and means within said auxiliary casing for automatically blocking the connection between said first-mentioned pump and said governor operated valve and simultaneously connecting said feathering pump with said propeller through said governor operated valve when said feathering pump is rendered operative.

3. In combination with a feathering type hydro-controllable propeller, a propeller driving engine, and a propeller drive shaft projecting from said engine and containing conduits for pitch changing fluid connected with said propeller, a unitary control for said propeller comprising, a casing attached to said engine and surrounding said shaft, a pump carried by said casing for supplying pitch changing fluid under pressure to said propeller, a speed responsive governor carried by said casing, a governor actuated valve connected with the outlet of said pump, means within said casing connecting said valve with said shaft contained conduit to render said governor effective to control the speed of said engine by changing the pitch of said propeller, a propeller feathering and unfeathering pump carried by said casing, means within said casing for automatically blocking the connection between said first-mentioned pump and said valve and simultaneously connecting said feathering pump with said propeller when said feathering pump is rendered operative, and means within said casing for controlling said connection to render said feathering and unfeathering pump operative to feather or to unfeather said propeller.

4. In combination with a hydro-controllable propeller, a propeller driving engine, and a propeller drive shaft projecting from said engine and containing conduits for pitch changing fluid connected with said propeller, a unitary control for said propeller comprising, an auxiliary casing attached to said engine surrounding said shaft, a speed responsive governor carried by said auxiliary casing and operative to control the speed of said engine by changing the pitch of said propeller, an electric motor carried by said auxiliary casing and operatively connected with said governor for adjusting the speed setting of said governor, a motor energizing generator carried by said casing and electrically connected with said motor, and means within said casing providing drives between said drive shaft, said governor, said pump and said generator.

5. In combination with a feathering-type hydro-controllable propeller, a propeller drive shaft projecting from said engine and containing conduits for pitch changing fluid connected with said propeller, a unitary control for said propeller comprising, a casing attached to said engine surrounding said shaft, a pump for supplying pitch changing fluid under pressure to said propeller, a speed responsive governor carried by said casing, a governor actuated valve connected with the outlet of said pump and with the shaft contained conduit to render said governor effective to control the speed of said engine by changing the pitch of said propeller, and a propeller feathering and unfeathering pump also connected with said shaft contained conduit, the means connecting said governor actuated valve and said feathering pump with said shaft contained conduits including, a pair of tubes extending across the interior of said casing, a sleeve on said shaft between said tubes connected with said conduits, and hydraulic connections between said tubes and the conduit connection of said sleeve.

6. In combination with a hydro-controllable propeller having hub carried pitch changing mechanism, and a propeller driving engine having a casing and a propeller shaft projecting from said casing, a control unit for said pitch changing mechanism disposed between said engine and said propeller comprising, a casing member adapted to be secured to said engine casing surrounding said propeller shaft and having a pair of diametrically opposed seats for speed controlling and propeller feathering devices, an oil transfer bearing on said propeller shaft within said casing in alignment with said seats, a pair of conduits extending between said seats and connected with said oil transfer bearing, and pitch controlling and propeller feathering devices on said seats hydraulically connected with said conduits.

ERLE MARTIN.