Nov. 2, 1954 J. H. STRANDELL ET AL 2,693,243

DOUBLE CRANK CONTROLLABLE PITCH PROPELLER

Filed July 23, 1952 6 Sheets-Sheet 1

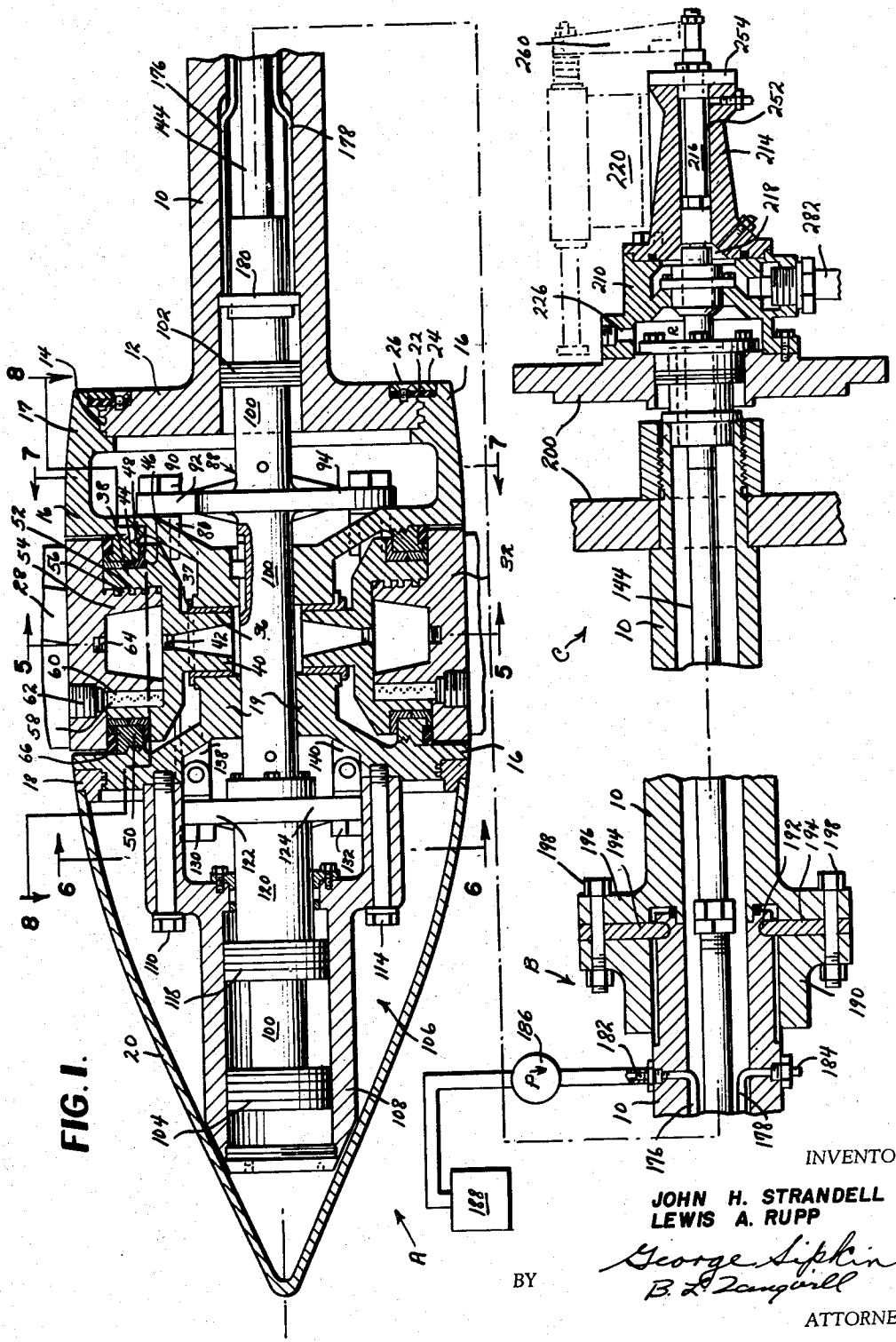


FIG. 1.

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DOUBLE CRANK CONTROLLABLE PITCH PROPELLER

Filed July 23, 1952 6 Sheets-Sheet 2

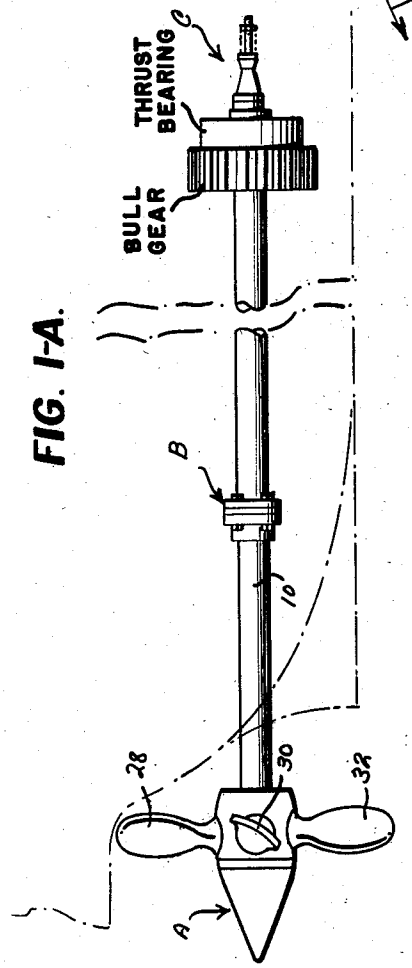


FIG. 1-A.

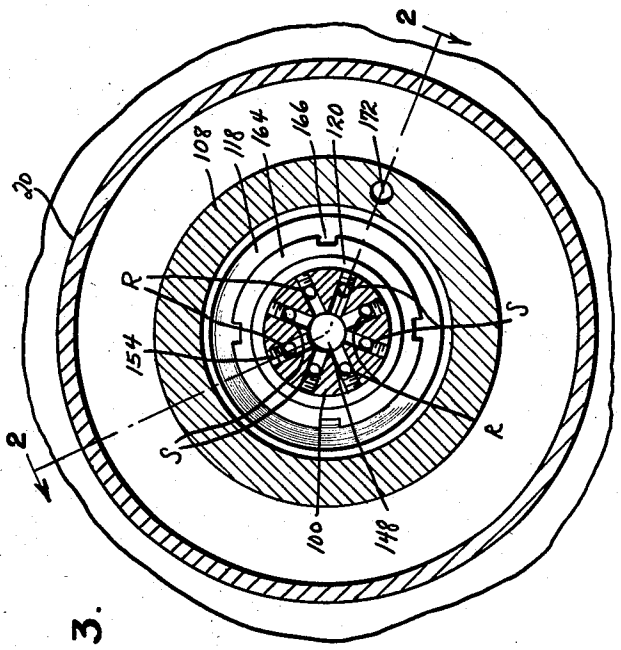


FIG. 3.

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DOUBLE CRANK CONTROLLABLE PITCH PROPELLER

Filed July 23, 1952 6 Sheets-Sheet 3

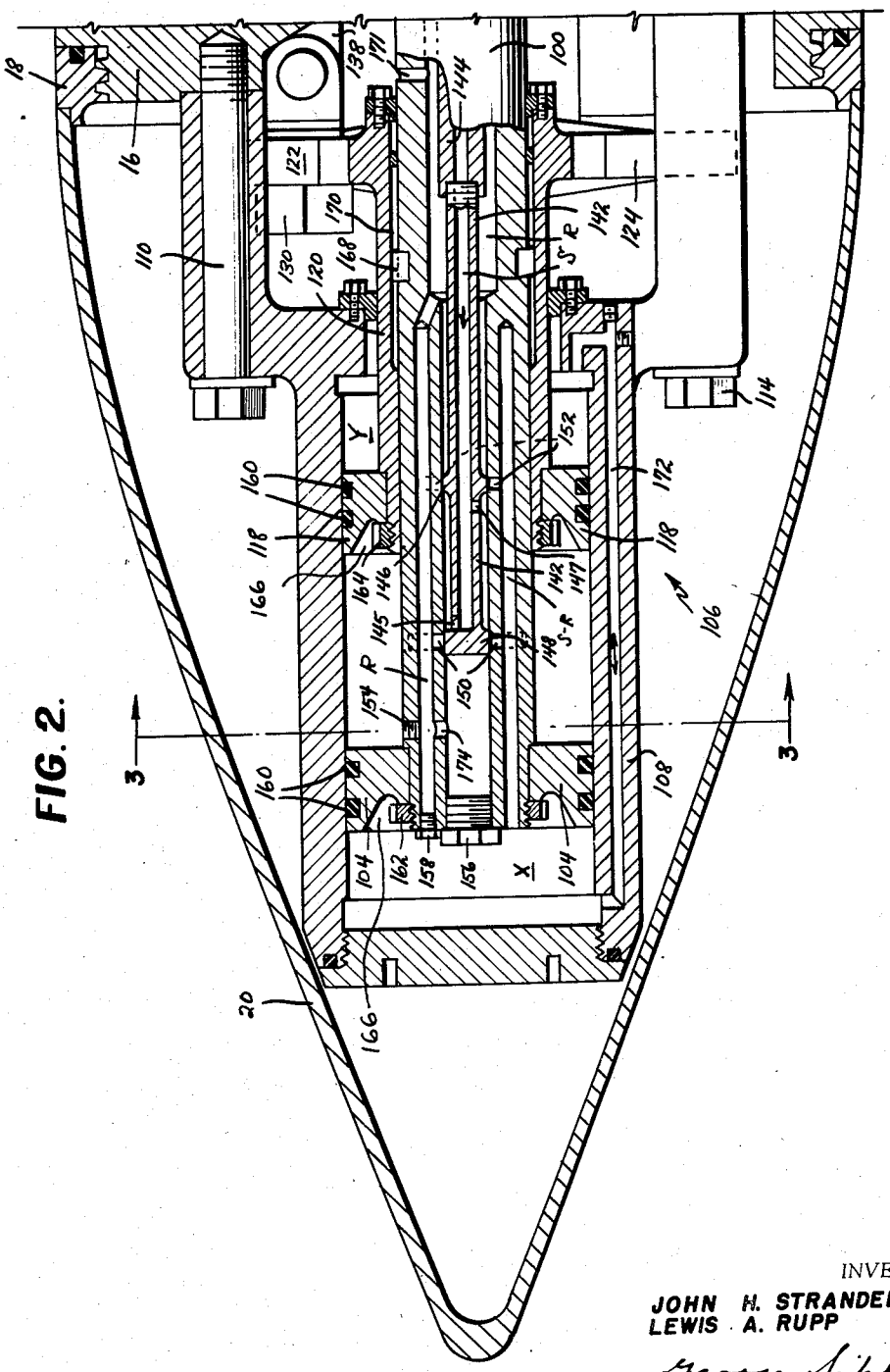


FIG. 2.

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DOUBLE CRANK CONTROLLABLE PITCH PROPELLER

Filed July 23, 1952 6 Sheets-Sheet 4

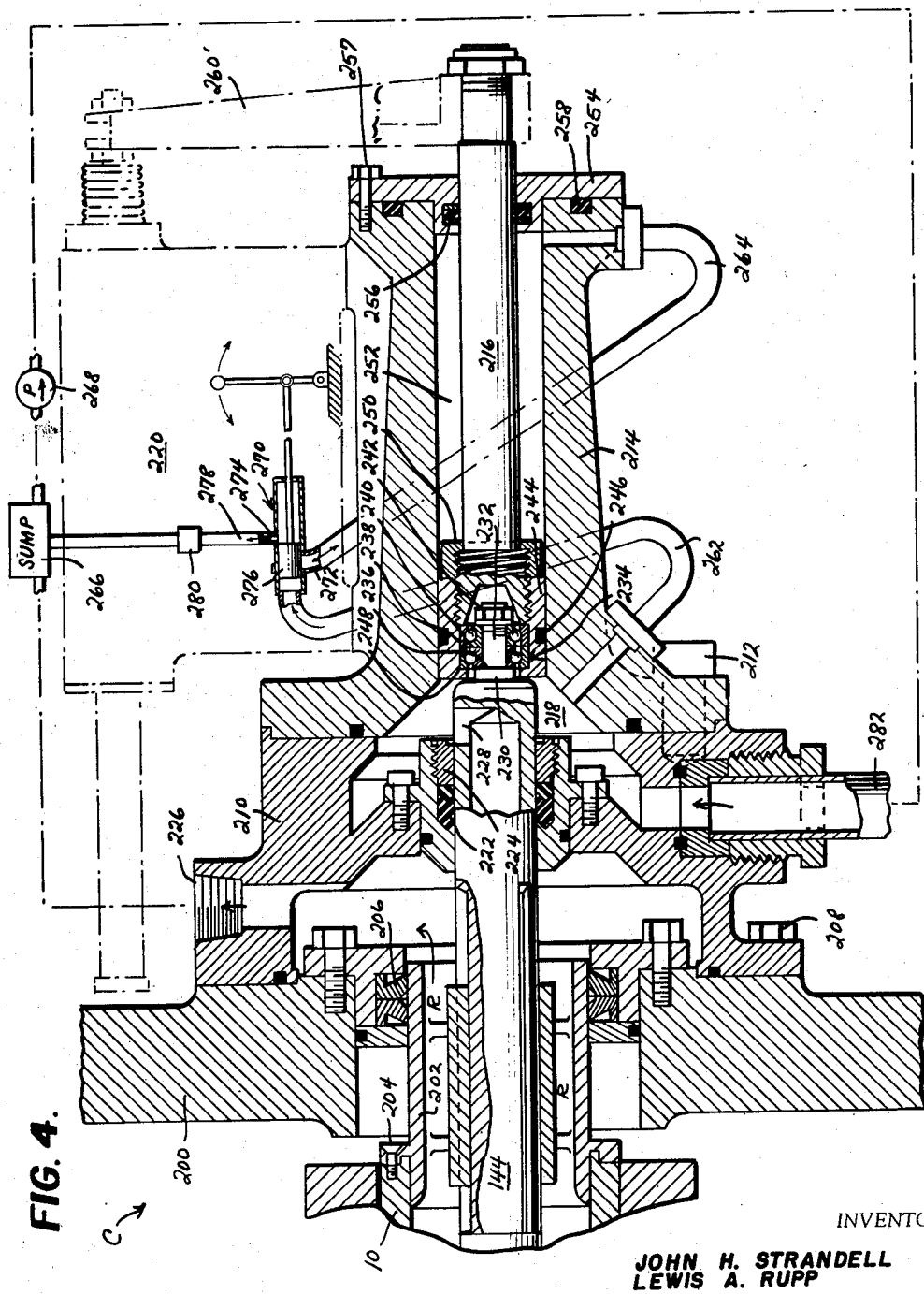


FIG. 4.

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DOUBLE CRANK CONTROLLABLE PITCH PROPELLER

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FIG. 5.

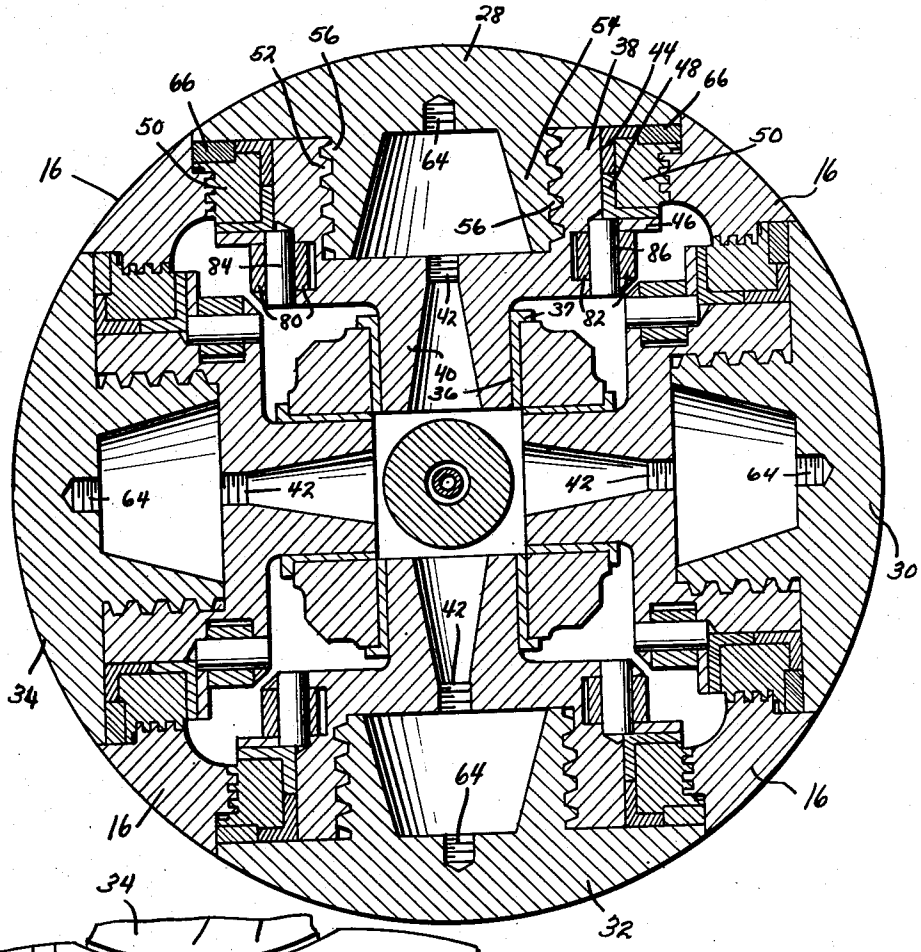
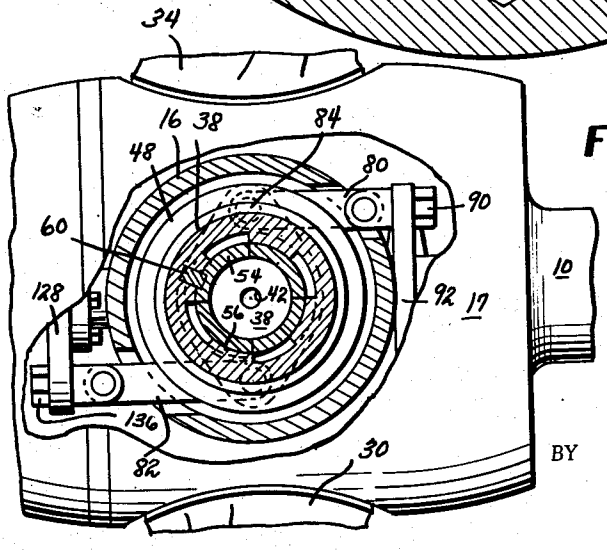


FIG. 8.



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DOUBLE CRANK CONTROLLABLE PITCH PROPELLER

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FIG. 6.

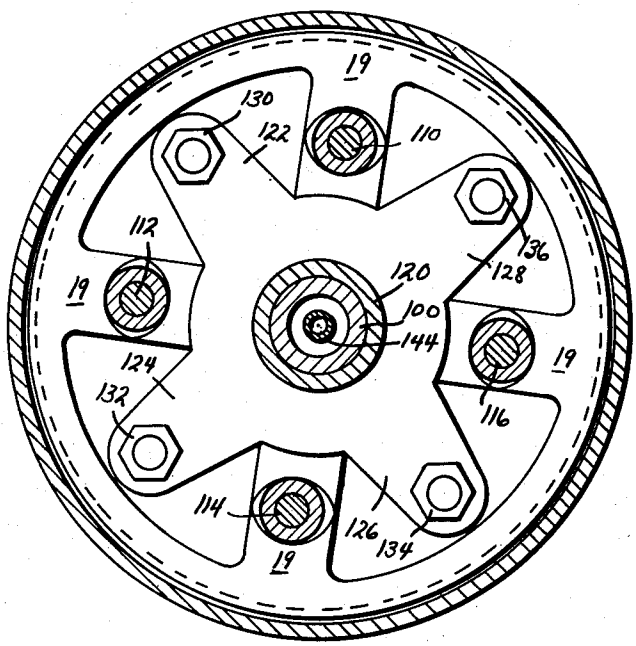
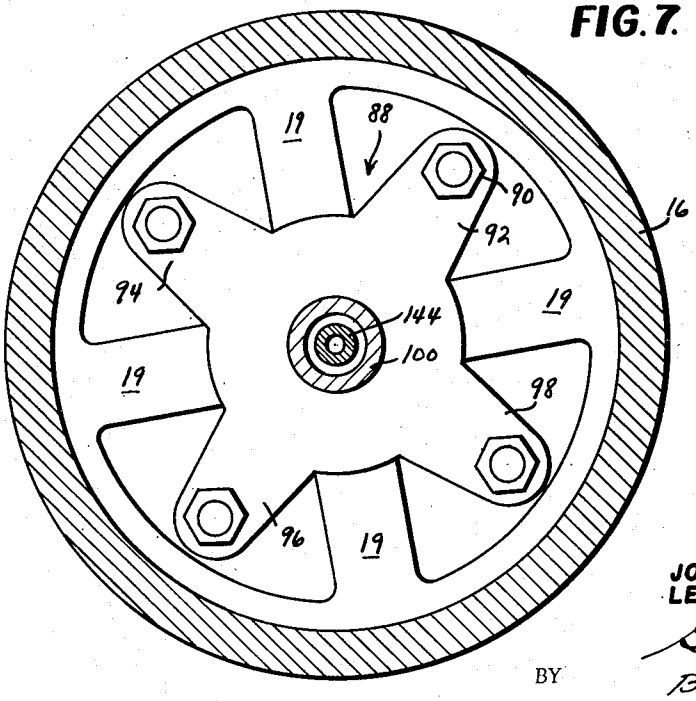


FIG. 7.



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United States Patent Office

2,693,243

Patented Nov. 2, 1954

2,693,243

DOUBLE CRANK CONTROLLABLE PITCH PROPELLER

John H. Strandell, Springfield, Va., and Lewis A. Rupp, Washington, D. C.

Application July 23, 1952, Serial No. 300,564

8 Claims. (Cl. 170—160.32)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to an improvement in controllable pitch propellers, such as used on ships, having blades which can be angularly adjusted in pitch from a remote point while the ship is waterborne. The blades are mounted on the propeller shaft hub and are simultaneously rotated about their own axis to achieve a change in pitch by a servo-motor mounted inside of the hub, which is responsive to a hydraulic power source located inside of the ship. The prior art discloses controllable pitch propellers of this general design but they are subject to many inherent disadvantages such as uneven and excessive wear on blade during surfaces, leaky hubs, improper hub lubrication, lack of positive means for moving the blades to a forward pitch position in the event of a casualty to the blade moving means, etc. It is these deficiencies that have been corrected or eliminated by the present invention, culminating several years of research and testing of experimental models installed in operating ships.

It is therefore an object of the invention to provide an improved controllable pitch propeller suitable for use on marine vessels.

A further object of the invention is the provision of a unique two-piston servo-motor for actuating the propeller blades.

Another object is the provision of a mechanism for changing the pitch of the blades which comprises a pair of crank arms connecting the servo-motor with the blades for accommodating large loads at high speeds and still maintaining a uniform bearing load on the structure.

A still further object of the invention is to provide a novel positive locking means for holding the propeller blades in a forward pitch position when the blade actuating means is inoperative.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description, when considered in connection with the accompanying drawings, in which like reference numerals designate like parts throughout the figures thereof and wherein:

Figure 1 is a sectional view in elevation longitudinally of the propeller hub, propeller shaft coupling and differential servo-motor.

Figure 1A is a schematic showing of the controllable pitch propeller and control unit therefor as applied to a ship.

Figure 2 is a detailed sectional view taken on lines 2—2 of Figure 3 showing in elevation the servo-motor located in the propeller hub.

Figure 3 is a sectional view taken on lines 3—3 of Figure 2.

Figure 4 is a detailed sectional view in elevation of the differential servo-motor shown in the lower right side of Figure 1.

Figure 5 is a detailed view taken on line 5—5 of Figure 1.

Figure 6 is a detailed sectional view taken on line 6—6 of Figure 1.

Figure 7 is a detailed sectional view taken on line 7—7 of Figure 1.

Figure 8 is a plan view taken on lines 8—8 of Figure 1 showing the crank clevis connections to the blade adapter.

Referring now to the drawings, wherein like reference characters designate like or corresponding parts throughout the several views, there is shown in Figure 1A, a propeller hub indicated at A, a thrust coupling connecting two sections of the propeller shaft at B and a differential servo-motor at C. Positioned between coupling B and differential servo-motor C is a bull gear which is appropriately shafted to the main propulsion equipment in the engineering spaces of the ship. The location of elements A, B and C relative to the ship's structure is as follows: Differential servo-motor C is connected to the cover of a Kingsbury thrust bearing, the latter being secured to the forward end of the bull gear. Hollow propeller shaft **10** is shafted to the after end of the bull gear and extends for a short distance aft, where coupling B connects two sections of the propeller shaft together. Aft of this coupling, the propeller shaft **10** extends through the ship's hull to hub A containing the propeller blades.

Referring now to hub A, shown in Figure 1, it will be seen that the shaft **10** flares outwardly at **12** and is provided with screw threads **14** for receiving blade holding hub casting **16**, and threadably secured to said hub casing **16** is a spacer ring **18** which properly positions and connects dunce cap **20** to the hub body. These members are snugly fitted to one another by means of packing so as to form a watertight fit, thus preventing the entry of water into or the escape of oil from the hub, since the latter is adapted to be filled with oil at a pressure somewhat higher than the outside water pressure at all times. In some cases where the parts cannot form such a watertight fit, circular rubber seals are provided as shown at **22**, for example, this particular seal being held in place by a circular ring **24** of like size and machine screws **26** which secure the seal and ring to the hub structure.

The blade holding spider **16** has four circular openings equidistantly spaced and extending around its periphery, the diameter of each being sufficiently large to accommodate a propeller blade and its associated parts for securing the blade to hub casting **16**. The forward end of the hub casting is provided with an extended portion **17** which is internally threaded and adapted to mate with the threads **14** on the flared portion of the propeller shaft. The structural members of the hub casting for forming said circular openings are indicated at **19** (Figures 1, 6 and 7) and provides the casting with the strength for supporting the blades. The propeller blades are respectively indicated at **28**, **30**, **32** and **34** and since each part employed for holding the blades to the hub casting are exactly the same, description of only one of such blades and its associated parts will be given, with the same reference characters being used to denote like parts throughout the corresponding views. Positioned deep in casting **16** is a bearing member **36** adapted to fit into a circular opening in said casting. This bearing member **36** has a flange **37** extending outwardly and at the top of the bearing for properly positioning said bearing in the casting opening. Rotatably mounted within said bearing is a crank pin ring **38** formed in the shape of a cup, having a neck **40** extending downwardly from the bottom of the cup and is adapted to fit in bearing **36**, this crank pin serving the function of securing the blade to the propeller hub. The neck **40** is hollow and has a screw threaded opening **42** at its upper end for receiving a crank pin ring puller when it is necessary to remove said crank pin ring from the bearing and hub casting for repairs. The outer upper peripheral portion of crank pin ring **38** is cut away forming a vertical wall **44** and horizontal seat **46** for reeciving bearing or bushing member **48**. Bearings **48** are soft soldered to ring **50** and are adapted to take the thrust exerted by blade **28** and is held in rigid position between casting **16** and crank pin ring **38** by means of ring **50** which is screw threaded to casting **16**. It is to be understood that there are sixteen bearing surfaces for the four propeller blades, or four for each blade. They are the inner cylindrical bearings appearing at the point of contact of the outer peripheral portion of crank pin ring neck **40** with the inner surface of bearing member **36**; the outer cylindrical bearing appearing at the point of contact of ring **38** with the inner portion of

bearing members or bushings **48**; the inner thrust bearing appearing at the point of contact of horizontal seat **46** with the bottom portion of lower bushing **48**; and the outer thrust bearing appearing at the point of contact of the blade flange with top portion of upper bushing **48**. The purpose of this propeller blade bearing arrangement is to give the best possible distribution of the extremely large bearing forces in the space available in the relatively small hub casting. During the blade turning moment or reversing period of the propeller, the following large forces are acting on the bearings: the inner and outer cylindrical bearings are subjected to radial load caused by the following:

(*a*) Propeller thrust and torque.
(*b*) The radial load caused by the centrifugal couple due to the centrifugal force of the propeller blade itself when rotating.
(*c*) The forces from the connecting rods turning the crank arms consisting of the reaction forces, large frictional forces and dynamic forces.

The inner thrust bearing takes the thrust caused by the centrifugal force of the propeller blade assembly. It also takes the force caused by the tipping action of the propeller blade thrust and torque.

The outer thrust bearing takes the reaction force caused by tipping action of the propeller blade thrust and torque.

The inner portion of the cup shaped crank pin ring **38** is provided with female threads **52** which are of the type normally found in the breech mechanism of guns having a bore greater than, say, 3 inches, i. e. the threads are of the interrupted type in which the inner portion is threaded, and then every other 45° sector of threads is milled out leaving an inner cylindrical portion that alternately contains a sector of threads at 45° intervals, the remaining inner portion between each sector of threads being of a smooth surface and of the same curvature of said threads. The blade **28** has a reduced neck portion **54**, having on its outer peripheral portion a like set of interrupted male threads **56** such as those explained above, which are adapted to mate with the threads on the crank pin ring. In operation, the male threads **56** of the blade neck are aligned with the smooth cut away section between the sectors of threads on the crank pin ring, the blade neck is dropped into the crank pin ring and when it bottoms, the blade is turned 45° thus interlocking the threads and securing the blade in a fixed position. The blade and crank pin ring respectively have a slot **58** which align with one another when the blade is in a fixed or secure position and said slots are adapted to take a key **60**, Figures 1 and 8, which positively locks the blade and crank pin ring in position. Cap **62** is screwed into the slotted blade portion so as to prevent the key from dropping out when the hub is rotated. The blade neck is hollowed out and contains a threaded opening **64** for receiving a blade carrying tool when the blade is removed from the hub and transported from one location to another. In order to prevent leakage of water into or loss of oil from the hub, circular rubber seal **66** is provided between metal ring **50** and blade **28**.

As mentioned above, the hub A, with the attached blades **28**, **30**, **32** and **34** is rotated by the main propulsion equipment located inside the ship, and in order to eliminate stopping and then physically reversing the direction of rotation of the propeller shaft to secure reverse movement of the ship, the angle of pitch of the propeller blades is changed, while the hub, and propeller shaft blades are rotating in the same direction, from an ahead to astern pitch, or vice versa, to effect such reversal in the direction of movement of the ship. Each blade is turned or rotated in its bearings by means of two crank clevices which are respectively connected to guides positioned on opposite sides of the center line of the blades, which in turn receive their power from two pistons, one serving each of the guides. Referring more specifically to the drawings, it will be seen in Figures 1 and 5 that crank pin ring **38** is recessed on opposite sides thereof to provide for free movement of crank clevises **80** and **82** which are respectively secured to the crank pin ring by means of pins **84** and **86**. As shown in Figures 1 and 8 crank clevis **80** is connected at its other end to arm **92** of guide **88** by means of bolt **90**. As more clearly shown in Figure 7, guide **88** comprises four guide arms, **92**, **94**, **96** and **98**, each of said guide arms being respectively apertured to receive the

securing means for each crank clevis, i. e. guide **88** has four arms which extend outwardly from its center and to each of these guide arms is secured a crank clevis and the other end of each crank arm, to which is also attached a crank clevis, extends to and is connected to its own crank pin ring. One such arrangement of guide arm, crank arm and crank pin ring is shown in Figure 1 and respectively designated by reference characters **92**, **80** and **38**. Formed integrally with guide **88** and extending on each side thereof is a hollow shaft **100**, which extends forwardly to emergency piston **102** and aft to servo-piston **104**.

Referring to Figures 1, 2 and 6, there is shown a servomotor mechanism at **106**. This mechanism comprises a cylindrical housing **108** which is secured to hub casting **16** by means of bolts **110**, **112**, **114** and **116** and serves as a working area for guide piston **104** and second guide piston **118**. Movably mounted within said housing **108** and threadably connected with piston **118**, is a second guide **120**, which is slightly shorter but identical in construction to guide **88**. This second guide likewise has four arms, indicated by **122**, **124**, **126** and **128** in Figure 6, each guide arm having an aperture therein through which is inserted a bolt **130**, **132**, **134** and **136** (one for each guide arm) for securing to the guide arm, a crank clevis such as indicated at **138** and **140**, each respectively being secured to guide arms **122** and **124**. Each of the four crank arms respectively extend from each guide arm to one of the four crank pin rings, or in other words, each guide arm is connected to one of the four crank pin rings by means of a crank arm which transmits the power from the second guide piston to the crank pin ring for turning the blade.

The servo-motor mechanism specifically shown in Figure 2 houses the means for making possible the movement of guides **88** and **120** to effect rotation of the propeller blades in their sockets. This mechanism comprises a housing **108** which is secured to hub casting **16**, as aforementioned, and pistons **104** and **118**, shafted to their respective guides, are mounted for reciprocating movement within said housing. Guide shaft **100** is hollow and slidably mounted therein is a hollow and movable valve stem **142** which is an extension of hollow control rod **144** employed for supplying oil to the pistons. The valve stem **142** is threadably secured to control rod **144** and contained thereon at **146** and **148** are the lands of the valve proper, which as shown, control the openings of ports **150** and **152** formed in guide shaft **100** and openings **145** and **147** provide access from the hollow valve stem to said ports. Guide shaft **100**, in addition to being centrally hollow and ported, also contains a plurality of longitudinally bored holes or passageways S, R and S—R which are utilized for supplying high pressure oil to the pistons **104** and **118** and returning same to the source of hydraulic supply. It will be noted that there are several plugs inserted in shaft **100**, such as indicated at **154**, which merely serve to close the opening made as a result of drilling holes in the inner part of said shaft, that is, it is necessary to have openings extending from the hollow portion of shaft **100** to the bored passageways and to provide such openings, it is convenient to drill such openings from outside the shaft, and when the drilling process is completed, the outer openings are plugged since they are not necessary in the operation of the device. The after end of shaft **100** is closed by a plug **156** and similar plugs **158** are inserted in the bore R for containing the oil within said shaft. As clearly shown in Figure 2, the pistons carry oil seal rings **160** and the pistons are secured to the guide shafts **100** and **120** by rings **162** and **164** respectively, each of said rings having grooved openings **166** to facilitate removal of said rings from the guide shafts. In order to prevent each of the guide shafts from turning relative to one another, a key **168** is embedded in the outer portion of guide shaft **100** and the shaft for guide **120** is appropriately slotted at **170** to the same size as the key so that the key rides in the slot, thus preventing relative rotary movement of one shaft with respect to the other. The hub A is normally filled with oil, although this is not necessary, and since the oil carrying passageways will leak slightly under normal operating conditions, opening **171** is provided in shaft **100** connecting the inner spaces of hub A with return line R for transferring such oil back to the source of supply.

In the operation of the servo-motor mechanism section

of the invention, oil under pressure from differential servo-motor unit C flows through control rod **144** and valve stem **142**, through openings **145** and **147** to the space enclosed by valve lands **146** and **148**. When it is desired to change the pitch of the blades to an ahead pitch position, the control rod **144** is caused to be moved in an aft or rearward direction which causes valves **146** and **148** to uncover ports **150** and **152**. Oil then flows through ports **150** into the space between pistons **104** and **118** where the oil pressure is exerted against exposed piston surfaces to move said pistons away from each other. Since piston **104** is directly connected to each propeller blade through guide shaft **100** and guide arms **92**, **94**, **96** and **98** with a crank arm extending from each of said guide arms to the crank pin ring for each blade, it is evident that the blade will be turned in a counterclockwise direction which corresponds to an ahead pitch on the blades. Piston **118** moves in the opposite direction from piston **104** and is likewise directly connected to each of the blades by means of a guide shaft and guide arms **122**, **124**, **126** and **128** and connected between each of the guide arms and the crank pin ring for each blade are crank arms, two of same being indicated by **138** and **140**. It is to be understood that two crank arms are connected to each crank arm ring, one arm extending between guide **88** and one side of the crank pin ring and the other arm extending between guide **120** and the other or opposite side of the crank pin ring, as clearly shown in Figure 8. Movement of piston **118** therefore aids in turning the blades to the ahead pitch position. The oil displaced by such outward movement of piston **118** causes the oil to flow from area Y through passageway **172** to area X where it joins with the oil therein to return to the source through passageway S—R, ports **152**, past valve **146** which partially uncovers ports **152**, into passageway R and back to the oil supply pump **268** in unit C. When the control rod **144** and attached valve stem **142** is initially moved and stopped, it remains in the stopped position until moved again. The piston **104**, along with ported shaft **100**, serves as a follow-up since the oil pressure will move the piston until the ports in shaft **100** align with valves **146** and **148** and when such alignment occurs, oil flow to the piston is stopped and stoppage of piston movement subsequently follows. The pistons will not be moved until the control rod is actuated to uncover the ports and to commence repetition of the process.

When it is desired to reverse the pitch of the propeller to achieve astern movement of the ship, the control rod **144** is moved in the opposite direction, i. e. forwardly. This movement causes valve **148** to uncover ports **150** and valve **146** uncovers ports **152**. Oil flows through valve stem passage S, through openings **145** and **147**, ports **152** to passageway S—R, and into area X where this oil pressure is exerted against the outer face of piston **104**; passageway **172** which connects with area X, transmits the oil pressure to area Y where it acts against the outer face of piston **118**, the oil pressure causing both of said pistons to move inwardly or toward one another. The oil displaced by such inward movement flows from between said pistons, through ports **150**, ports **174** to return passageway R which carries the oil back to the source in unit C. This direction of piston movement causes the blades to be rotated in a clockwise direction which corresponds to reverse pitch for astern movement of the ship. The structure connected between the pistons and the propeller blade is of course the same as that described above in relation to movement of the blades to an ahead pitch position. It is to be noted that passageway S—R in one case acts as a supply conduit and in the other, serves as a return conduit for the oil.

Referring now to unit B, shown in Figure 1, there is shown the means for moving the blades to the ahead or forward pitch position in the event of a casualty in the hub mechanism so that the ship can be moved, even though the ship's main hydraulic system becomes inoperative. The structure comprises two hollow tubes which extend rearwardly between the control rod **144** and propeller shaft **10** to a stationary plate **180** which is snugly fitted by means of packing within the propeller shaft to prevent leakage of oil from the hub A into the forward section of said shaft. The purpose of upper supply line **176** is to provide means for supplying oil to the space between plate **180** and piston **102** when it is necessary to manually change the position of the blades, while conduit **178** serves as an air vent to vent air from said space to the atmosphere. The means for closing both conduits comprises two plugs **182** and **184** respectively, which normally, are open to the atmosphere. In operation, in the case of an emergency when it is necessary to set the pitch of the blades to a forward position, the propeller shaft is stopped, hand pump **186** with its associated oil supply tank **188** is connected by conduits to plug **182** and oil manually pumped into the area between piston **102** and plate **180** which displaces air therebetween. The air flows out through conduit **178** to plug **184** and when oil commences to flow out of plug **184** the latter is closed, as by means of a cock, or the plug completely removed and replaced by a solid plug. The continued operation of the pump builds up hydraulic pressure behind piston **102** until it is sufficient to move the blades to an ahead position. The cock on plug **182** is then moved to a closed position and the pump disconnected therefrom so that free rotary movement of the propeller shaft may be obtained.

A coupling is shown in Figure 1 and comprises one of several of this type that are employed for connecting various sections of the propeller shaft. The coupling comprises a cylindrical section **190** which is splined to shaft **10** and grooved at **192** to take half-moon shaped keys **194**. The forward section of the propeller shaft, also indicated as **10**, is outwardly flared at **196** and apertured to take bolts **198** which extend through and secure said flare, key **194** and section **190** together so as to form a shaft rigid in construction.

Referring now to the differential servo-motor mechanism indicated by C in Figures 1 and 4, there is shown a stationary thrust plate **200** comprising a part of a Kingsbury thrust bearing used for taking the thrust developed by the propeller blades. Plate **200** is centrally apertured to enclose a short cylindrical shaft **202** which is connected to propeller shaft **10** by means of bolts **204**. Control rod **144** is keyed to shaft **202** in order to secure rotary movement of said control rod. Secured between shaft **202** and thrust bearing plate **200** is a seal **206**, held in place by appropriate means for preventing leakage of oil from the return line R to the thrust bearing. The following description of the differential servo-motor unit C is the same as that disclosed in the application of John H. Strandell, Serial No. 296,515, filed June 30, 1952. Secured to the forward end of thrust bearing plate **200** by means of bolts **208** is a first housing **210** which completes return passage R and fixed in sealed relation to said first housing **210** by bolts **212**, is a second housing **214** for containing control rod extension **216**, said second housing forming with said first housing an oil chamber **218** adapted to receive oil at pressures approximately 1500 p. s. i. which is supplied to pistons **104** and **118** through control rod **144**. Mounted above the second housing is a control box **220** containing the means for controlling the supply of oil to said chamber **218**. Referring more specifically to these parts, first housing **210** is centrally apertured for receiving the forward end of control rod **144**, and positioned around said rod in fluid tight relation therewith and with the first housing is a high pressure packing gland **222** secured to the first housing by the usual appropriate means including a nut **224** for taking up on the packing when it becomes worn. In the specific embodiment shown, the oil return passageway R is under a pressure of approximately 15 p. s. i. while oil chamber **218** contains pressures in the neighborhood of 1500 p. s. i., although other pressures may be used in this system, and the packing **222** serves to prevent leakage of oil from one chamber to the other. Housing **210** contains a return oil outlet at **226** for returning said oil to sump **266** for further use. The most forward end of control rod **144** extends into oil chamber **218**, which is supplied with oil by conduit **282**, and has three openings in the outer end thereof, one of such openings being indicated at **228**, for supplying oil through the control rod to pistons **104** and **118** for changing the pitch of the propeller blades. Forwardly of these openings, the control rod is sequentially reduced in diameter to form a first reduced portion **230** and a second reduced portion **232**. Mounted on the second reduced portion **232** are two ball bearing races **234** comprising inner and outer bearing shells **236** and **238** respectively, with ball bearings **240** secured therebetween. The ball bearing races **234** are held in place by a nut **242** which presses the races into engagement with the flat forward surface of first reduced portion **230**, and the after end

of control rod extension **216** is hollowed out to form an opening for nut **242** and said extension threaded on its outer exterior end. Threadably secured to said extension is a differential servo-motor piston **244** provided with oil seal rings **246** on its outer periphery and having a lip or flange **248** which aids in holding the bearing races in position. Nut **250**, which forms the other end of piston **244**, serves to position control rod extension **216** in housing **214**, and locks the piston **244** to said extension. The hollow central portion of second housing **214** forms with the control rod extension **216**, an oil chamber **252**, which is closed at its outer or forward end by a plug **254** secured to housing **214** by bolts **257** or other similar securing means, such as screw threads or a force fit. The plug **254** is equipped with oil seal rings at **256** and **258** for preventing leakage of the high pressure oil from chamber **252**. The control rod extension reciprocates within the plug opening and attached to the forward end thereof is an indicating rod **260**, which mechanically indicates the exact pitch to which the blades are set.

There are therefore, three oil containing chambers located in the differenial servo-motor section of this invention, namely, chambers R, **218** and **252**, chamber R being the low pressure return from the hub to sump **266** and pump **268** while chamber **218** serves to supply oil to the hub pistons by way of the control rod and to exert a force on differential servo-motor piston **244** for moving the control rod in a forward direction, and chamber **252** serves to house the oil for exerting a moving force against nut **250**, which in effect acts as a piston, for moving the control rod in an after or rearward direction.

There is also shown schematically for the purposes of illustration a three-way pilot valve **270** having a chamber port **272** connected to the chamber **252** by conduit **264**. An inlet port **273** is connected to the oil line **282** through the chamber **218** and conduit **262**, and an exhaust port **274** which is connected by conduit **278** to the oil sump **266** through the oil flow regulator valve **280**. A piston **276** in the pilot valve **270** serves to seal the chamber port **272**, interconnect the chamber port **272** and inlet port **273**, or to interconnect the chamber port **272** and the exhaust port **274**, as hereinafter explained. The means for controlling operation of pilot valve **270** is not a part of this invention but it may be noted that the pilot valve is controlled by electrical selsyns operated from the bridge of the ship.

The oil pressure in chamber **218** is substantially constant, and therefore exerts a susbtantially constant forward thrust on the servo-motor piston **244**. However, the servo-motor piston **244** exposes an area to oil chamber **252** which is substantially larger than its area exposed to oil chamber **218**, whereby a lower pressure in oil chamber **252** will overcome the higher pressure in oil chamber **218** to produce an aft movement of the servo-motor piston **244**.

In operation, with the pilot valve piston **276** blocking ports **272** and **274**, oil at a constant pressure of 1500 p. s. i. is supplied by pump **268** to oil chamber **218** which furnishes the oil to and through control rod **144** to the pistons located in hub A. This oil is further supplied through conduit **262** to pilot valve **270**, conduit **264** and oil chamber **252** being filled with oil. When it is desired to change the pitch of the propeller blades to, say, an ahead or forward pitch position, the pilot valve piston is operated, moving it to an ahead position, which position interconnects the chamber port **272** and the inlet port **273**. Oil now flows from chamber **218** to chamber **252**, thus increasing the pressure in chamber **252** to move the control rod **144** in an astern direction. Astern movement of the control rod uncovers ports **150** in hub A, causing oil to flow between pistons **104** and **118** for moving the blades to an ahead or forward pitch position. When the blades have reached the desired position (as remotely indicated on the bridge of the ship), pilot valve piston **276** is then moved to re-cover port **272**, thus blocking off the flow of oil to or from chamber **252**. A substantial reversal of this process occurs when the propeller blades are changed to a reverse pitch position, since the pilot valve **276** is then moved in a rearward movement to interconnect the chamber port **273** and exhaust port **274**. Oil pressure in chamber **218** then forces oil from chamber **252** to the sump **266**, and moves the control rod **144** in a forward direction. This rod action uncovers ports **152** allowing oil to flow to opposite sides of pistons **104** and **118** which moves the blades to a reverse pitch position, and when the desired blade angle is reached, the pilot valve piston is then caused to re-cover port **272** and the remaining oil in chamber **252** is trapped therein.

It should be understood that the foregoing disclosures relate to only a preferred embodiment of the invention and that numerous modifications or alterations may be made therein without departing from the spirit and the scope of the invention as set forth in the appended claims.

What is claimed is:

1. In combination, a controllable pitch propeller having blades and a hub, means for changing the pitch of said blades, said means comprising a pair of pistons in said hub, a guide connected to each of said pistons, a plurality of crank arms, means connecting said crank arms at one end to said guides and at the other end to said blades, a source of fluid supply, control means interconnecting said source of fluid supply with said pistons for regulating supply of fluid to said pistons, fluid pressure responsive means controlling said control means, said fluid responsive means comprising a housing, an actuating piston within said housing, means connecting said actuating piston with said control means, conduit means connecting said source of fluid supply with said actuating piston for exerting a constant fluid pressure against opposite sides of said actuating piston, and means in said conduit means for varying the fluid pressure acting against one side of said actuating piston so as to move said control means to provide fluid pressure to said pistons in said hub.

2. In combination, a controllable pitch propeller having blades and a hub, means for changing the pitch of said blades, said means comprising a pair of pistons in said hub, a common cylinder for said pistons attached to said hub, means connecting said pistons to said blades, a control rod, means movably mounting said control rod within a hollow shaft extending from one of said pistons to and through the central portion of the other of said pistons, passageway means in said cylinder interconnecting opposite ends of said pistons, valve ports in said shaft, valve lands mounted on said control rod for engaging said valve ports, a source of fluid supply, means connecting said source of fluid supply with said valve ports and thereby with said cylinder, fluid pressure responsive means for controlling the movements of said control rod, said fluid pressure responsive means comprising a housing, an actuating piston within said housing, means connecting said actuating piston with said control rod, conduit means interconnecting said source of fluid supply with said actuating piston, and pilot valve means in said conduit means for moving said actuating piston so that the movement of said actuating piston is imparted to said control rod for controlling the flow of fluid to said pistons.

3. In combination, a controllable pitch propeller having blades and a hub, means for changing the pitch of said blades, said means comprising a pair of pistons in said hub, a cylinder having closed ends attached to said hub for housing said pistons, means connecting said pistons with said blades, a source of fluid supply, control means in said cylinder for connecting said source of fluid supply with said pistons, a control rod connected at one end to said control means, fluid pressure responsive means adjacent said hub for controlling said control means, said fluid pressure responsive means comprising a first housing for supporting said control rod, a second housing, means forming a longitudinally hollow bore in said second housing, means securing said first housing to said second housing and forming therewith a fluid chamber, an actuating piston secured to the other end of said control rod extending through said fluid chamber and into said bore of said second housing, means connecting said source of fluid supply to said fluid chamber, a pilot valve, a first conduit connecting said pilot valve with said bore of said second housing, a fluid sump, a third conduit connecting said sump with said pilot valve, a pilot valve piston, and means adapted to move said pilot valve piston for controlling the flow of fluid through said conduits to said actuating piston.

4. In a controllable pitch propeller having blades and a hub, a hollow propeller shaft secured to said hub, means for changing the pitch of said blades, said means comprising a servo-motor mechanism in said hub, means connecting said mechanism with said blades, a hollow shaft secured to a forward end of said servo-motor mechanism and extending into the after section of said propeller shaft, emergency means for changing the pitch of

said blades, said emergency means comprising a stationary plate encircling said hollow shaft and rigidly mounted in said hollow propeller shaft, a cylindrical ring forming a piston secured to said hollow shaft; said hollow shaft, piston, plate and propeller shaft forming a fluid receiving chamber, a pair of conduits, a source of emergency fluid supply, said conduits respectively connecting said chamber with said source of emergency fluid supply and with the atmosphere and means for selectively closing said conduits so that the application of fluid pressure to said piston moves said servo-motor to effect a change in pitch in the blades mounted on said hub.

5. In a controllable pitch propeller having blades and a hub, means for changing the pitch of said blades, said means comprising a hub casting in said hub, a centrally hollow bore in said hub casting, a plurality of propeller blades radially extending from and secured to said hub casting, a servo-motor mechanism, said mechanism comprising a cylindrical housing attached to said hub, a first piston within said housing, a first hollow and longitudinally bored shaft movably mounted within said bore of said hub casting and secured at its one end to said first piston and adapted to extend into a propeller shaft at its other end, a first guide member having a plurality of arms and formed as an integral part of said first shaft, a plurality of crank arms, means connecting said crank arms at one end to said guide arms and at the other end to said blades, a second piston within said housing, a second shaft secured at its one end to said second piston and terminating at its other end in a second guide having a plurality of arms, means mounting said second piston and said second shaft in surrounding relation with said first shaft and adapted to reciprocate therealong, a plurality of second crank arms, means connecting said second crank arms at one end to said second guide arms and at the other end to said blades so that opposite movements of said pistons produce a cumulative turning torque on said blades, a hollow control rod having valve lands thereon, means mounting said control rod longitudinally within said first hollow shaft and adapted to be connected to an actuating piston remotely located from said hub, valve ports positioned in said first hollow shaft between said pistons and controlled by said control rod and means adapted to supply a fluid through said control rod and said ports to move said pistons in opposite directions.

6. In a controllable pitch propeller having blades and a hub, a hollow propeller shaft attached to said hub, means for changing the pitch of said blades, said means comprising a hub casting in said hub, a plurality of propeller blades secured to said hub casting, a servo-motor mechanism, said mechanism comprising a closed housing attached to said hub, a first piston in said housing having a first hollow shaft passing centrally through said hub casting and terminating in said propeller shaft, a second piston in said housing having a second hollow shaft mounted for reciprocating movement on said first hollow shaft, a pair of guides respectively secured to said hollow shafts, a plurality of crank arms, means connecting said crank arms at one end to said guides and at the other end to said blades, a hollow control rod reciprocatingly mounted within said first hollow shaft, a source of fluid supply connected to said hollow control rod, and means controlling said supply of fluid from said control rod to said pistons.

7. The combination according to claim 6 wherein each of said propeller blades is secured to said hub casting through means of a crank pin ring, said crank pin ring comprising a hollow cup-shaped member having a neck extending downwardly therefrom, means rigidly affixing said blade in said crank pin ring, said rigidly affixing means comprising a set of interrupted female threads on the inner portion of said crank pin ring, a set of interrupted male threads on the outer neck portion of said blade, a slot formed in each of said crank pin rings and said blades which are adapted to be aligned with one another, a key for said aligned slots, whereby said blades are inserted in said crank pin ring and rotated less than 180° into a fixed position prior to the insertion of said key in said slot.

8. The combination according to claim 6 wherein emergency means are provided for changing the pitch of said blades, said emergency means comprising an emergency piston attached to said first hollow shaft and positioned within said propeller shaft, stationary means in said propeller shaft forming a closed chamber with said emergency piston, and fluid pressure supply means connected with said chamber for moving said emergency piston in a rearward direction for changing the pitch of said blades.

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