Sept. 22, 1942. E. MARTIN ET AL 2,296,288

CONTROLLABLE-PITCH PROPELLER

Filed Sept. 7, 1938 2 Sheets-Sheet 1

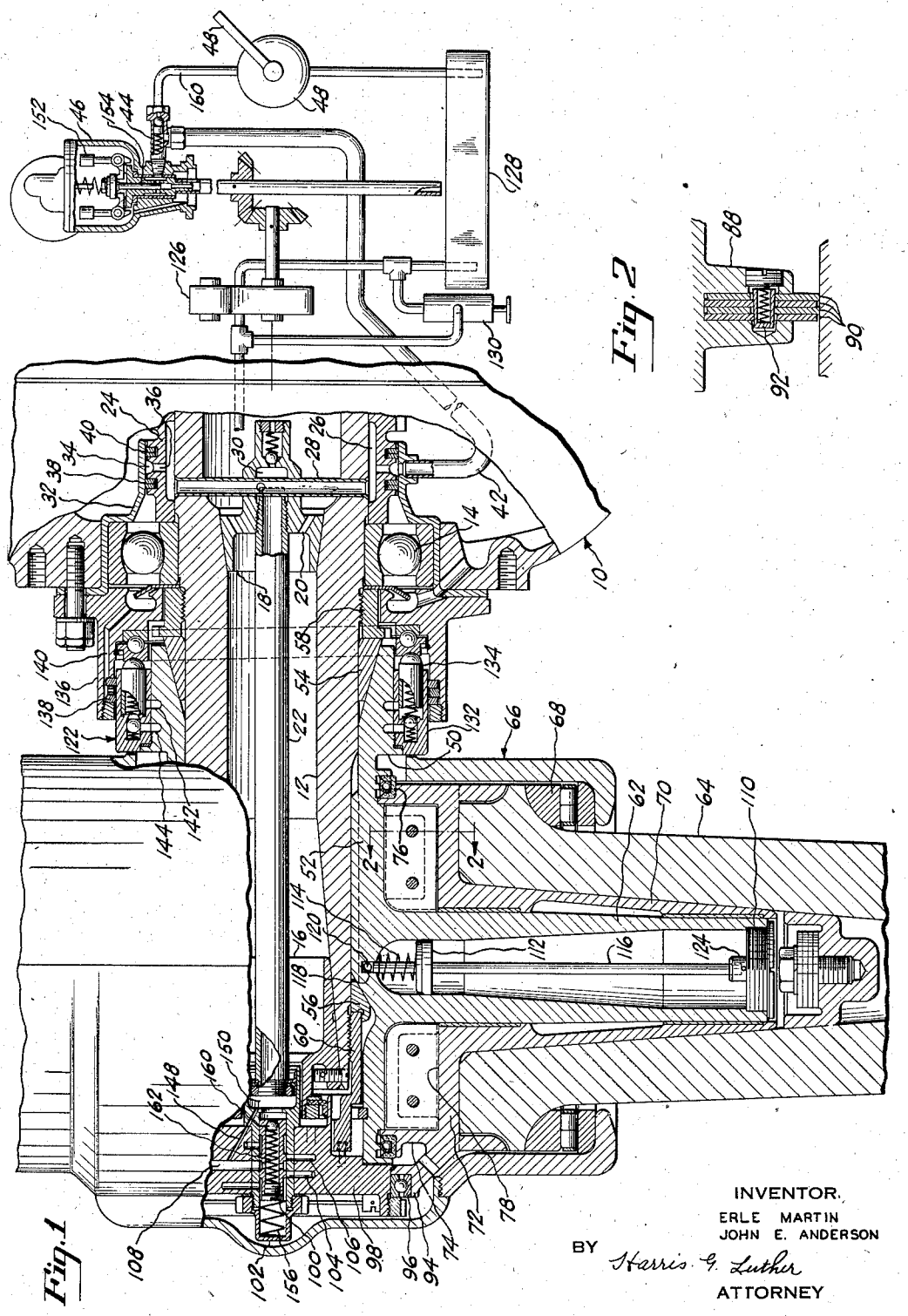


Fig. 1

Fig. 2

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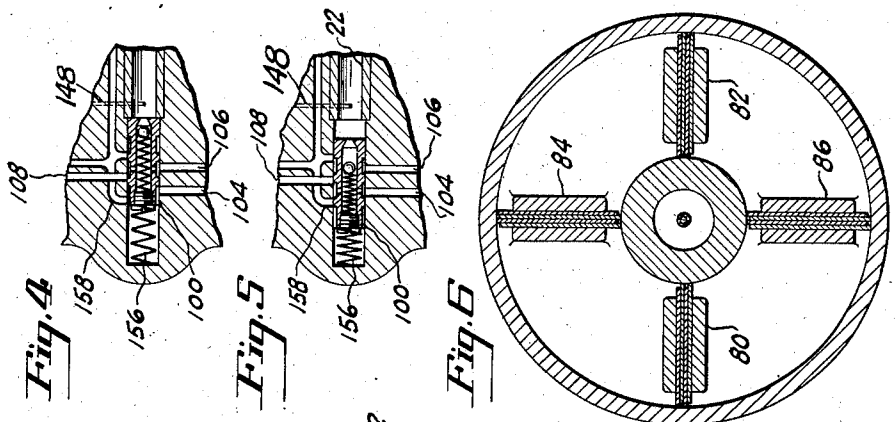


Fig. 4 Fig. 5 Fig. 6

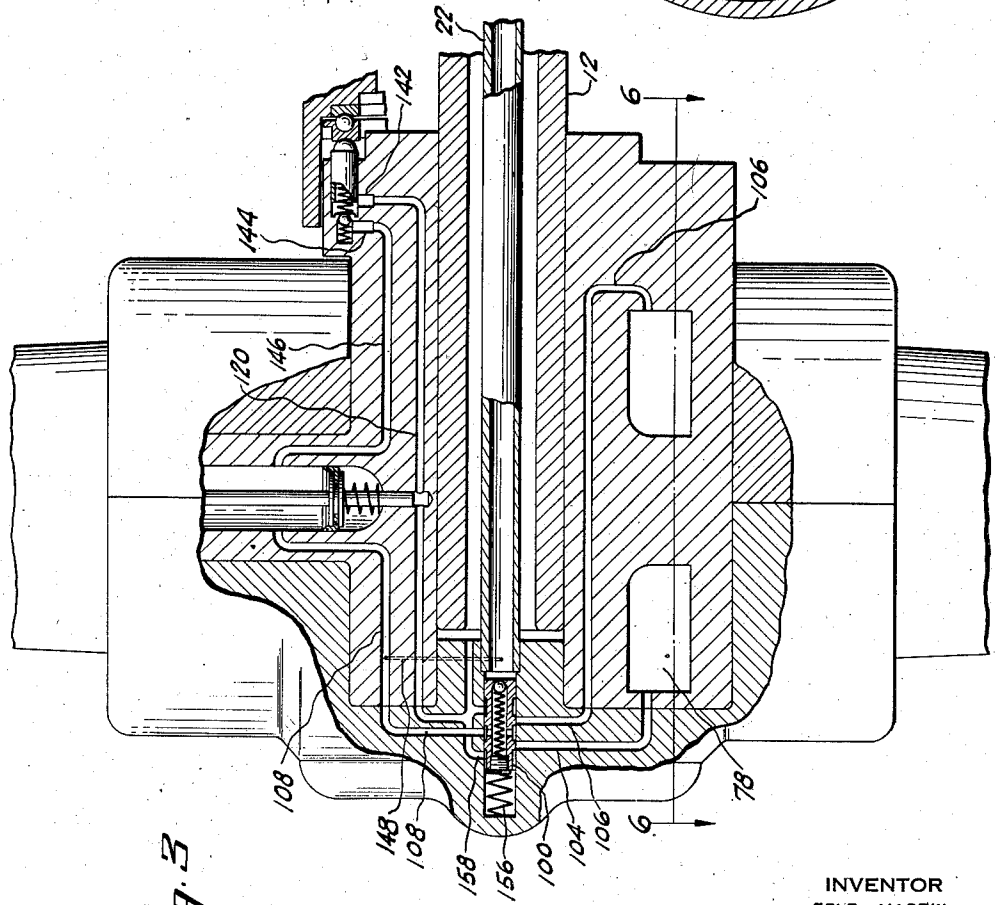


Fig. 3

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UNITED STATES PATENT OFFICE

2,296,288

CONTROLLABLE-PITCH PROPELLER

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Application September 7, 1938, Serial No. 228,772

19 Claims. (Cl. 170—163)

This invention relates to improvements in controllable-pitch propellers and has for an object the provision of an improved propeller of the character specified, so constructed and arranged that the propeller has a range of speed regulating pitch changing movements and a range of pitch changing movements beyond said speed regulating range in which the propeller is brought into and out of a feathered condition.

A further object resides in the provision of a controllable-pitch propeller of the character described having hydraulically actuated means for turning the propeller blades to change the pitch thereof, in which the pitch changing mechanism, fluid pressure accumulators and a fluid pressure pump are all in or closely associated with the hub portion of the propeller to reduce the probability of leakage of fluid under pressure and render the oil passages of a minimum length to thereby reduce the friction of the fluid in flowing through such passages.

A still further object resides in the provision of a controllable-pitch feathering-type propeller, of the character indicated, so arranged that hydraulic fluid under pressure may be supplied to the pitch changing mechanism with sufficient rapidity to substantially instantaneously change the propeller pitch from the operating range to a feathered condition.

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 designate similar parts throughout, there is illustrated, by way of example, a suitable mechanical embodiment of a propeller constructed according to the invention. The drawings, however, are for the purpose of illustration only and are not to be taken as in any way limiting or restricting the scope of the invention as set forth in the accompanying claims.

In the drawings,

Fig. 1 is a vertical sectional view of the hub portion of a propeller constructed according to the invention and a schematic arrangement of a governor and feathering control pump for controlling the pitch of the propeller.

Fig. 2 is a sectional view of a pitch changing motor vane, taken on the line 2—2 of Fig. 1.

Fig. 3 is a schematic sectional view of the hub portion of the propeller shown in Fig. 1 showing the arrangement of the various fluid passages and connections.

Fig. 4 is a sectional view of a fragmentary portion of the propeller illustrated in Fig. 1 showing the propeller pitch controlling valve in an operative position different from the position illustrated in Fig. 1.

Fig. 5 is a sectional view similar to Fig. 4 of a fragmentary portion of the propeller construction illustrated in Fig. 1 showing the propeller pitch controlling valve in an operative position different from the positions shown in Figs. 1 and 4 and

Fig. 6 is a sectional view of the propeller blade turning mechanism taken on the line 6—6 of Fig. 3 looking in the direction of the arrows.

Referring to the drawings in detail, the numeral 10 generally indicates a propeller driving engine, only a fragmentary portion of the engine nose piece being illustrated. A propeller drive shaft 12 projects from the nose piece of the engine and is rotatably supported therein by suitable anti-friction means such as the ball bearing 14. The drive shaft 12 is hollow and closed at its outer end by a tapered plug 16 and the hollow interior is divided by a second tapered plug 18 located in the interior of the drive shaft adjacent to the plane of the bearing 14. This plug is provided with holes or apertures 20 connecting the two portions of the interior of the drive shaft and receives the rear end of a tube 22 which is substantially coaxial with the drive shaft and projects forwardly to a location adjacent to the forward end of the plug 16. Immediately within the bearing receiving portion of the nose piece of the engine the drive shaft 12 is surrounded by a bushing 24 having an internal annular groove 26 connected by means of a transverse, apertured tube 28, with a chamber 30 in the plug 18 into which the rear end of the tube 22 extends so that the tube 22 is hydraulically connected with the channel 26. An oil collector ring or transfer bearing 32 is rigidly attached to the engine nose piece and provided with a cylindrical portion closely surrounding the exterior of the bushing 24. The bushing is provided with an exterior annular groove 34 connected to the interior channel 26 by apertures, as indicated at 36, and two pairs of sealing rings, as indicated at 38 and 40, are disposed one pair on each side of the external groove 34 between the bushing 24 and the bushing surrounding portion of the oil collector ring 32, to provide a suitable means for transferring fluid under pressure from the interior of the hollow drive shaft to a relatively fixed member outside of the drive shaft. A fluid channel 42 is connected at one end through the oil collector ring to the groove 34 and extends at its opposite end to a check valve 44 one side of which is hydraulically connected with a speed responsive governor 46 and the other side of which is hydraulically connected with a high-pressure fluid pump 48 which may be operated by a manually controlled motor or by hand as may be convenient or desired.

A spider member, generally indicated at 50, has a generally cylindrical portion 52 mounted upon the splined end of the drive shaft 12 and retained

thereon by suitable means such as the cones 54 and 56 and nuts 58 and 60; and a plurality of integral hollow blade carrying arms, as indicated at 62, projecting radially from the cylindrical shaft receiving portion. A propeller blade, as indicated at 64, having a hollow flanged root or base end is rotatably mounted upon each spider arm 62 and retained thereon by a barrel member, generally indicated at 66, and respective anti-friction thrust bearings, as indicated at 68. A bushing fixed to the base end of the blade 70 is disposed between the hollow base end portion of each propeller blade and the respective spider arms and each bushing is provided at its inner end with an outwardly extending radial flange portion 72 underlying the base end of the blade and an integral annular flange portion 74 which extends inwardly from the periphery of the flange 72 to an annular fluid seal 76 mounted in a circular groove in the shaft receiving portion of the spider immediately surrounding the root end of each respective blade carrying arm 62. This arrangement provides an annular space 78, of substantially rectangular cross section, immediately surrounding the base end of each blade carrying arm. Respective blade turning motors are provided by disposing relatively movable vanes in the annular spaces 78. As is particularly shown in Fig. 6, two diametrically opposed vanes, as indicated at 80 and 82, are secured to the flanged portion 72 of each bushing 70 and two similar diametrically opposed vanes, as indicated at 84 and 86 in Fig. 6, are secured to the portion of the spider 50 within the groove for the annular seal 76. With this arrangement the blade may be made to rotate in either direction by applying hydraulic fluid under pressure between appropriate sides of adjacent sleeve carried and spider carried vanes in a manner well known to the art. In order to minimize leakage past the vane and increase the efficiency of the vane type motors each vane comprises a slotted extension integral with the sleeve flange or spider, as indicated at 88 in Fig. 2, supporting a plurality of wiper blades, as indicated at 90, said blades being provided with apertures somewhat out of registry with each other and being urged toward the four corners of the rectangular cross section of the corresponding space 78 by a spring pressed tapered plug 92 extending through said apertures.

The pitch changing movements of all of the blades are synchronized and equalized by means of a rotatable bevel gear 94 rotatably mounted, by means of a suitable anti-friction bearing 96, on the periphery of a circular supporting member 98 and provided with gear teeth which mesh with corresponding gear teeth provided on a portion of the periphery of the flanged portion 72 of each of the bushings 62.

The application of hydraulic fluid under pressure to the vane motors connected with the respective propeller blades is controlled by a slide valve 100 slidably mounted in a valve casing 102 secured in a coaxial aperture in the annular member 98 which member is carried by the nut 60 at the outer end of the propeller drive shaft 12. A pair of fluid channels, as indicated at 104 and 106 respectively, connect each of the vane motors with the slide valve casing 102 and a fluid pressure line 108 leads to the valve casing 102 from fluid pressure accumulators provided in the hollow spider arms 62. The outer end of each hollow spider arm is stopped by a suitable plug, as indicated at 110, and in the inner portion of each hollow arm there is provided a piston member 112 which works against a compression spring 114 set for the pressure which it is desired to maintain in the accumulators. A stem 116 projects through the piston member 112 and spring 114 into a chamber 118 which intercepts a fluid channel 120 connecting the engine oil supply in the hollow drive shaft 12 with the pressure pump, generally indicated at 122. The arrangement of these parts is such that when the pressure in the accumulators has reached the desired value the respective pistons 112 are moved to force the ends of the stems 116 into the receptacles 118 and thereby cut off the supply of oil at the desired pressure in the pressure accumulators at all times during operation of the engine. In order to facilitate operation of the above described valves the stems 116 may be extended along the axes of the arms 62 to a sliding connection with the end plugs 110, as indicated at 124, to maintain the stems at all times in perfect alignment with the respective pistons 112 and receptacles 118.

Hydraulic fluid, such as engine lubricating oil, is continuously supplied to the interior of the hollow drive shaft 12 at all times during engine operation by a lubricating oil pump 126 which draws the oil from the engine oil sump 128 and forces it into the engine lubricating system. The pressure of the engine lubricating oil is maintained at a preselected value by an oil pressure relief valve 130 which by-passes excess oil supplied to the lubricating system by the pump 126, back to the sump 128.

The pump 122 is in the form of a wobble pump having a plurality of small cylinders and pistons arranged in an annular member 132 disposed around the rearward portion of the spider 50 and the adjacent portion of the drive shaft 12 between the propeller hub and the front end of the engine nose piece. The annular member 132 is carried around with the spider when the propeller rotates and the ends of the piston, as indicated at 134, bear against a slightly skewed ball thrust bearing, one race of which is secured in an annular member 136 which is rigidly secured to the front end of the nose piece 10 and surrounds the rearward portion of the annular member 132. An oil seal 138 having a vent connection 140 with the interior of the engine casing is provided between the members 136 and 132 to prevent leakage of oil past the pump to the exterior of the engine. The pump supply channels 120 lead to pump intake ports, one for each pump cylinder, as indicated at 142, and the pump outlet ports, as indicated at 144, are connected with the several accumulators by suitable fluid channels, as particularly illustrated in Fig. 3 and indicated by the numeral 146. The several accumulators are preferably connected together by suitable channels so that the pressure in all of the accumulators will be equalized at all times. A bleed line 148 leads from the fluid pressure lines 108 to a chamber 150 connected with the front end of the tube 22. As has been explained above drainage from the tube 22 is controlled by the governor 46.

When the oil supply to the pump is cut off by the pressure actuated valves 116, as explained above, the pump pistons are held inwardly in the respective pistons by the suction thus produced, and the pump is rendered inoperative whenever the pressure of the fluid in the accumulators is at the selected value.

In the automatic constant-speed controlling action of the governor there may be said to be

three governor conditions, viz: a condition in which the engine speed is above the speed for which the governor is set in which case the governor fly balls 152 move outwardly to raise the valve member 154 and open the drain from the tube 22; a second in which the engine is operating at the speed for which the governor is set in which case the valve stem 154 may occupy a position diminishing the valve area to an extent such that the fluid drained from the tube 22 just balances the fluid entering the tube 22 through the bleed channel 148; and a third condition in which the engine speed is below the speed for which the governor is set and the flyweights 152 are moved inwardly to lower the valve stem 154 and cut off the drain from the tube 22. The pressure in the chamber 150 is controlled by the condition of the drain from the tube 22 and this pressure acts on the rearward end of the slide valve 100 against the compression spring 156 to control the position of the slide valve. When the tube 22 is connected with drain, incident to an overspeed condition of the engine, the spring 156 will move the slide valve to its limiting right-hand position, which position is particularly illustrated in Fig. 4. In this position of the slide valve the pressure conduit 108 is connected through the valve with the channels 106 leading to the vane motors, the channels 106 being connected with the motors in a manner to rotate the propeller blades toward a higher pitch condition. At the same time the channels 104 are connected by the slide valve 100 with the double ported drain channel 158 which vents to the interior of the hollow drive shaft 12 against the engine lubricating oil pressure, the pressure in the accumulators being sufficiently above the engine oil pressure so that the channel 158 serves as a drain under the conditions described.

Operation

When the drain from the tube 22 is cut off by the governor 46 incident to an underspeed condition of the engine the fluid pressure in the chamber 150 forces the slide valve 100 to the left against the action of the spring 156 to the position particularly illustrated in Fig. 5, in which the pressure line 108 is connected through the slide valve 100 with the channels 104 and the channels 106 are connected with the drain channel 158 thereby causing a rotation of the propeller blades toward a lower pitch condition to decrease the load on the propeller driving engine and increase its speed.

When the governor is in the second or balanced condition mentioned above the slide valve 100 may assume an intermediate position, such as is particularly illustrated in Fig. 1 in which the channels 104 and 106 are both blocked by the valve pistons and the several vane motors are locked to resist any change in the pitch of the propeller.

When it is desired to bring the propeller blades from the automatic constant-speed control range, described above, to a feathered condition the pressure pump 48 is operated to draw oil from the sump 128 and force it into the channel 42 past the check valve 44. When the pump 48 is operated the check valve 44 will be moved to a position in which it connects the pump outlet conduit 160 directly with the channel 42 and blocks the outlet from the governor 46. The high-pressure fluid from the pump 48 enters the tube 22 through the collector ring 38 and bushing 26, transverse tube 28, and flows to the chamber 150 where it reacts against the rearward end of the slide valve 100. The slide valve 100 is hollow and contains a check ball 160 forced against its seat at the rear or right-hand end of the slide valve by a spring 162 which is more easily compressible than the spring 156. It is assumed that before the pump 48 is operated to feather the propeller the engine will have ceased operation or will have been reduced to an idling condition so that there is no continuous supply of fluid under high-pressure to the accumulators in the hollow spider arms. Under these conditions the pressure supplied by the pump 48 moves the check ball 160 off of its seat in the end of the slide valve 100, compressing the spring 162, but the valve 100 itself does not move appreciably against the force of the spring 156. The high-pressure fluid then flows from the tube 22 through the hollow interior of the slide valve 100 to the channels 106 to turn the propeller blades to their limiting high-pitch position.

If, after the blades have been moved to their limiting high-pitch condition or have been feathered, the pump 48 is again operated to apply hydraulic fluid at a still higher pressure to the valve 100, the slide valve will be moved against the force of the spring 156 until the ports leading through the wall of the valve from the hollow interior thereof register with the channels 104, as is shown in Fig. 5. The high-pressure oil then flows through the channels 104 to the vane motors to return the blades toward a low-pitch condition and the oil in the portions of the motors supplied by the channels 106 drains back through this channel and the drain channels 158 to the interior of the hollow drive shaft 12.

From the above description it will be seen that there has been provided an improved controllable-pitch propeller in which the high-pressure pump and all of the high pressure fluid channels and connections for automatic constant-speed control are located entirely within the propeller hub to reduce the friction losses and time intervals for the flow of hydraulic fluid from the pump to the pitch changing motors, and avoid the danger of leakage from the high-pressure lines, and in which the only high-pressure pump connected with the propeller through a connection having relatively rotatable parts is the feathering and unfeathering pump which is used only on rare occasions and when the engine is not rotating at high-speeds; and also an improved propeller construction having a range of blade positions for constant speed regulation and a blade feathering position outside of the constant-speed range to which position the blades may be rapidly moved from the normal operating or constant-speed range.

While a particular mechanical embodiment 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 in no way limited to the particular construction and arrangement so illustrated and described, but that such changes in the size, shape and arrangement of parts may be resorted to as come within the scope of the sub-joined 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:

What is claimed is:

1. In a controllable-pitch propeller having a hub structure and a plurality of blades supported

by said hub structure for pitch changing rotational movements, a reversible vane type hydraulic motor operatively associated with the hub supported end of each blade for rotating the same, a source of hydraulic pressure within said hub structure adjacent to said motors, a drain leading from said hub structure, fluid passages wholly within said hub structure between said pressure source and said motors and between said motors and said drain, a fluid pressure operated valve also disposed within said hub structure intercepting said fluid passages to control the application of pressure fluid to said reversible motors, means for applying the pressure of hydraulic fluid to operate said valve and hydraulic means operatively associated with said pressure applying means for controlling the operation of said valve to regulate the pitch of said propeller.

2. In a controllable-pitch propeller having a hub structure and a plurality of blades supported by said hub structure for pitch changing rotational movements, a reversible vane type hydraulic motor operatively associated with the hub supported end of each blade for rotating the same, a source of hydraulic pressure within said hub structure, a drain leading from said hub structure, fluid passages wholly within said hub structure between said pressure source and said motors and between said motors and said drain, a pressure operated valve also disposed within said hub structure intercepting said fluid passages to control the application of pressure fluid to said reversible motors, speed responsive means for controlling said valve to regulate the pitch of said propeller, a hydraulic connection between said pressure source and said valve, and a hydraulic connection between said speed responsive means and said valve.

3. In a controllable-pitch propeller having a hub structure and a plurality of blades supported by said hub structure for pitch changing rotational movements, a reversible vane type hydraulic motor operatively associated with the hub supported end of each blade for rotating the same, a source of hydraulic pressure within said hub structure, a drain leading from said hub structure, fluid passages wholly within said hub structure between said pressure source and said motors and between said motors and said drain, a pressure operated valve also disposed within said hub structure intercepting said fluid passages to control the application of pressure fluid to said reversible motors, speed responsive means for controlling said valve to regulate the pitch of said propeller in an intermediate range of pitch adjustment, manual means for controlling said valve to move said propeller into and out of its extreme high-pitch condition, and a system of hydraulic conduits connecting said speed responsive means, said manual means and said valve.

4. In a controllable-pitch propeller having a hub structure and a plurality of blades supported by said hub structure for pitch changing rotational movements, a reversible vane type hydraulic motor operatively associated with the hub supported end of each blade for rotating the same, a source of hydraulic pressure in said hub structure, a drain leading from said hub structure, fluid passages wholly within said hub structure between said pressure source and said motors and between said motors and said drain, a pressure operated valve also disposed within said hub structure intercepting said fluid passages to control the application of pressure fluid to said reversible motors, speed responsive means operatively associated with said valve to regulate the pitch of said propeller in an intermediate range of pitch adjustment, and manually operable means for controlling said valve and supplying hydraulic fluid under pressure to said motors to move said propeller into and out of its extreme high-pitch condition.

5. In a controllable-pitch propeller having a hub structure and a plurality of blades supported by said hub structure for pitch changing rotational movements, a reversible vane type hydraulic motor operatively associated with the hub supported end of each blade for rotating the respective blades, a source of hydraulic pressure within said hub structure, a fluid drain leading from said hub structure, fluid passages wholly within said hub structure between said pressure source and said motors and between said motors and said drain, a fluid pressure operated valve also disposed within said hub structure intercepting said fluid passages to control the application of pressure fluid to said reversible motors, a pressure chamber operatively associated with said valve, and speed responsive means for controlling said valve by regulating the fluid pressure in said pressure chamber, and a hydraulic connection between said pressure chamber and said speed responsive means.

6. In a controllable-pitch propeller having a hub structure and a plurality of blades supported by said hub structure for pitch changing rotational movements, a reversible vane type hydraulic motor operatively associated with the hub supported end of each blade for rotating said blades to change the pitch of the propeller, a source of hydraulic pressure comprising pressure accumulators carried by said hub structure and an engine driven pump mounted on said hub structure and connected with said accumulators, means for supplying hydraulic fluid at a relatively low pressure to said pump from a fluid source outside of said hub, a drain connection leading from said hub structure, fluid passages wholly within said hub structure between said pressure accumulators and said motors and between said motors and said drain, a valve also disposed within said hub structure intercepting said fluid passages to control the application of fluid under pressure to said reversible motors, means outside of said hub for controlling said valve to regulate the pitch of said propeller, and means passing from the exterior of said hub to the interior thereof for operatively connecting said valve controlling means with said valve.

7. In a controllable-pitch propeller having a hub structure and a plurality of blades supported by said hub structure for pitch changing rotational movements, a reversible vane type hydraulic motor operatively associated with the hub supported end of each blade for rotating the same, a source of hydraulic fluid under pressure comprising pressure accumulators disposed within said hub and an engine driven pump carried by said hub and having inlet and outlet passages within said hub structure, passages for conducting hydraulic fluid to and from said hub structure, the inlet passage being connected with the inlet of said pump, fluid passages wholly within said hub between said pressure accumulators and said motors and between said motors and said drain, a fluid pressure actuated valve intercepting said fluid passages to control the application of fluid under pressure to said re-

versible motors, means for controlling said valve to regulate the pitch of said propeller, and a fluid channel between said valve controlling means and said valve.

8. In combination with a controllable-pitch propeller and a propeller driving engine, a hollow drive shaft supporting and driving said propeller, means supplying engine lubricating oil at lubricating oil pressure to the interior of said hollow drive shaft, a pump carried by said propeller arranged to withdraw oil from said drive shaft and increase the pressure thereof, a pitch changing hydraulic motor carried by said propeller and operatively associated with the propeller blades, fluid passages connecting said motor with the output of said pump, other fluid passages connecting said motor with the interior of said hollow drive shaft to return to said drive shaft oil withdrawn therefrom by said pump, a reversing valve in said propeller intercepting at least a portion of said fluid passages to control the application of high-pressure hydraulic fluid to said motor, means outside of said propeller for operating said valve, and a connection between said controlling means and said valve.

9. In combination with a controllable-pitch propeller having a hub and a plurality of blades carried by said hub for pitch changing movements, and a propeller driving engine, a hollow drive shaft supporting and driving said propeller, means supplying engine lubricating oil at lubricating oil pressure to the interior of said hollow drive shaft, a pump carried by said propeller hub arranged to withdraw oil from said drive shaft and increase the pressure thereof, an oil pressure accumulator in said propeller hub connected with the output of said pump, pitch changing hydraulic motors within said hub operatively associated with said blades, fluid passages within said hub connecting said motors with said accumulator and with the interior of said hollow drive shaft to conduct oil from said accumulator to said motors and back to said drive shaft, a valve inside of said propeller intercepting said passages to control the application of high-pressure hydraulic fluid to said motors, and means for controlling said valve to regulate the pitch of said propeller.

10. In combination with a controllable-pitch propeller having a hub and a plurality of blades carried by said hub for pitch changing movements, and a propeller driving engine, a hollow drive shaft supporting and driving said propeller, means supplying engine lubricating oil at lubricating oil pressure to the interior of said drive shaft, a pump carried by said propeller arranged to withdraw oil from said drive shaft and increase the pressure thereof, a pitch changing hydraulic motor operatively associated with the hub carried end of each propeller blade, fluid pressure accumulators in said propeller hub connected with the outlet of said pump, fluid passages connecting said accumulators with said motors and said motors with the interior of said hollow drive shaft for conducting high-pressure oil to said motors and exhaust oil from said motors to the interior of said drive shaft, a valve intercepting said passages to control the application of hydraulic fluid to said motors, means for controlling said valve to regulate the pitch of said propeller, and means associated with said accumulators for cutting off the oil supply from said hollow drive shaft to said pump and rendering said pump inoperative when the pressure of oil in said accumulators reaches a predetermined value.

11. In combination with a controllable-pitch propeller having a hub spider adapted to be mounted on a drive shaft and provided with a plurality of hollow blade carrying arms, a blade rotatably mounted for pitch changing movement on each arm, and means for retaining said blades on said arms, means closing the ends of said arms to form closed chambers in said hollow blade carrying arms, a pitch changing motor operatively associated with each propeller blade, a fluid pressure pump, a drain, means connecting the outlet of said pump with said chambers to admit fluid from said pump into said chambers, resilient means in each chamber for applying pressure to fluid contained therein, means connecting said motors with said chambers and with said drain, and a valve intercepting said motor connecting means for controlling the application of fluid under pressure from said chambers to said motors and from said motors to said drain.

12. In a controllable-pitch propeller having a hub spider adapted to be mounted on a hollow drive shaft and provided with a plurality of hollow blade carrying arms, a blade rotatably mounted for pitch changing movements on each arm, and means for retaining said blades on said arms, at least one motor for turning said blades, a drain for said motor, a pump adapted to withdraw oil from said hollow drive shaft and increase the pressure thereof, means closing the end of said hollow spider arms to form closed chambers, means connecting said chambers with said motor and said motor with said drain, valve means in said connecting means for controlling said motor, means connecting the outlet of said pump with said chambers, a movable piston in the inner portion of each chamber, a spring opposing inward movement of each piston, and a valve stem actuated by each piston to control the supply of oil to said pump in accordance with the oil pressure in said chambers.

13. In a controllable-pitch propeller having a hub spider adapted to be mounted on a hollow drive shaft and provided with a plurality of hollow blade carrying arms, a blade rotatably mounted for pitch changing movement on each arm, and means for retaining said blades on said arms, a bushing in each blade and surrounding the respective spider arm, each bushing having a hollow annular base to provide annular spaces around the inner ends of the respective spider arms between the respective blade ends and said hub spider, a plurality of vanes in each annular space alternately connected to the respective bushing and to said spider and located entirely outside of said blades, and means for admitting hydraulic fluid under pressure to said annular spaces to rotate said bushings and said blades in either direction with respect to said spider arms to change the pitch of said propeller.

14. In a controllable-pitch propeller having a hub spider adapted to be mounted on a drive shaft and provided with a plurality of radially extending blade carrying arms, a blade rotatably mounted for pitch changing movements on each arm, and means for retaining said blades on said arms, a bushing in each blade end surrounding the respective spider arm, each bushing having a hollow annular base to provide an annular space of substantially rectangular cross-section around the inner ends of the respective spider arms, a plurality of vanes in each annular space connected alternatively to the respective bushing and to said spider, each vane comprising a slotted support and a plurality of plates loosely

carried in each slot and resiliently urged toward the four corners of the substantially rectangular section of said annular space, and means for admitting hydraulic fluid under pressure to said annular spaces to rotate said bushings and said blades in either direction with respect to said spider arms to change the pitch of said propeller.

15. In a controllable-pitch propeller having a hub spider adapted to be mounted on a hollow drive shaft and provided with a plurality of radially extending blade carrying arms, a blade rotatably mounted for pitch changing movements on each arm, and means for retaining said blades on said arms, a bushing in each blade end surrounding the respective spider arms and rigidly secured to the respective blades each bushing having a hollow annular base to provide an annular space of substantially rectangular cross-section around the inner ends of the respective spider arms, a plurality of vanes in each annular space alternatively connected to the respective bushing and to said spider, each vane comprising a slotted support, a plurality of plates loosely carried in each slot and each having a circular aperture therethrough so disposed with respect to the area of the respective plates that said apertures are excentric with respect to each other when said plates are assembled in said slots and disposed in said annular space, and a spring pressed tapered plug extending through said excentrically disposed apertures to urge said plate toward the four corners of the substantially rectangular cross-section of said annular spaces, and means for admitting hydraulic fluid under pressure to said annular spaces to rotate said bushing and said blades in either direction with respect to the respective spider arms to change the pitch of said propeller.

16. In combination with a controllable-pitch propeller having a hub and a plurality of blades carried by said hub for pitch changing movements, and a propeller driving engine, a hollow drive shaft supporting and driving said propeller, means maintaining a supply of engine lubricating oil at engine lubricating oil pressure in said hollow drive shaft, a pump carried by said hub and connected with the interior of said hollow drive shaft operative to withdraw oil from said drive shaft and increase the pressure of said oil, pitch changing motors and a control valve therefor also carried by said hub and connected through said hub with the outlet of said pump, a pressure chamber in said hub for operating said valve, a restricted connection between said pressure chamber and said pump outlet, means outside of said hub for controlling said valve by regulating the drainage of oil from said pressure chamber, and means including a slip ring around said drive shaft for hydraulically connecting said valve controlling means with said pressure chamber, whereby only drainage oil passes through said slip ring connection.

17. In combination with a controllable-pitch propeller having a hub and a plurality of blades carried by said hub for pitch changing movements, and a propeller driving engine, a hollow drive shaft supporting and driving said propeller, means maintaining a supply of engine lubricating oil at engine lubricating oil pressure in said hollow drive shaft, a pump carried by said hub and connected with the interior of said drive shaft operative to withdraw oil from said engine oil supply and increase the pressure thereof, pitch changing motors and a control valve therefor also carried by said hub and connected through said hub with said pump, a pressure chamber in said hub for operating said valve, a restricted connection between said pressure chamber and said pump, means outside of said hub for controlling said valve by regulating the drainage of oil from said pressure chamber, and a connection between said controlling means and said pressure chamber including a tube within said drive shaft connected at one end with said pressure chamber, and a slip ring on the outside of said shaft connected through said shaft with the opposite end of said tube.

18. In combination with a controllable-pitch propeller having a hub and a plurality of blades carried by said hub for pitch changing movements, and a propeller driving engine, a hollow drive shaft supporting and driving said propeller, means maintaining a supply of engine lubricating oil at engine lubricating oil pressure in said hollow drive shaft, a pump carried by said hub and connected with the interior of said hollow drive shaft to withdraw engine lubricating oil from said hollow drive shaft and increase the pressure thereof, pitch changing motors and a control valve therefor in said hub and connected through said hub with the outlet of said pump, a pressure chamber in said hub for operating said valve, a restricted passage connecting said pressure chamber with said pump outlet, speed responsive means outside of said hub for controlling said valve in an intermediate pitch range by regulating the drainage of oil from said pressure chamber, a connection between said speed responsive means and said pressure chamber including a tube within said drive shaft connected at one end with said pressure chamber, a slip ring on the outside of said shaft connected with the opposite end of said tube, and a conduit between the stationary portion of said slip ring and said speed responsive means, and a relatively stationary pressure pump connected with said pressure chamber through said slip ring to control said valve and supply fluid under high pressure to said pitch changing motors to turn said propeller blades to a feathered position beyond said intermediate range of pitch adjustment.

19. In a controllable-pitch propeller having a hub spider adapted to be mounted on a hollow drive shaft and provided with a plurality of hollow blade carrying arms, a blade rotatably mounted for pitch changing movement on each arm, and means for retaining said blades on said arms, at least one hydraulically actuated motor for turning said blades, a drain for said motor, a pump, means closing the ends of said hollow spider arms to form closed chambers therein, resilient means in said chambers compressible by fluid under pressure introduced into said chambers, means connecting said chambers with the outlet of said pump and with said motor and means connecting said motor with said drain, valve means intersecting said connecting means for controlling said motor, means supplying the inlet of said pump with hydraulic fluid, and valve means associated with at least one of said chambers to interrupt said fluid supply whenever the pressure of hydraulic fluid in said chamber reaches a predetermined value.

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