April 21, 1942. E. MARTIN ET AL 2,280,713

FEATHERING PROPELLER

Filed June 12, 1937 4 Sheets-Sheet 1

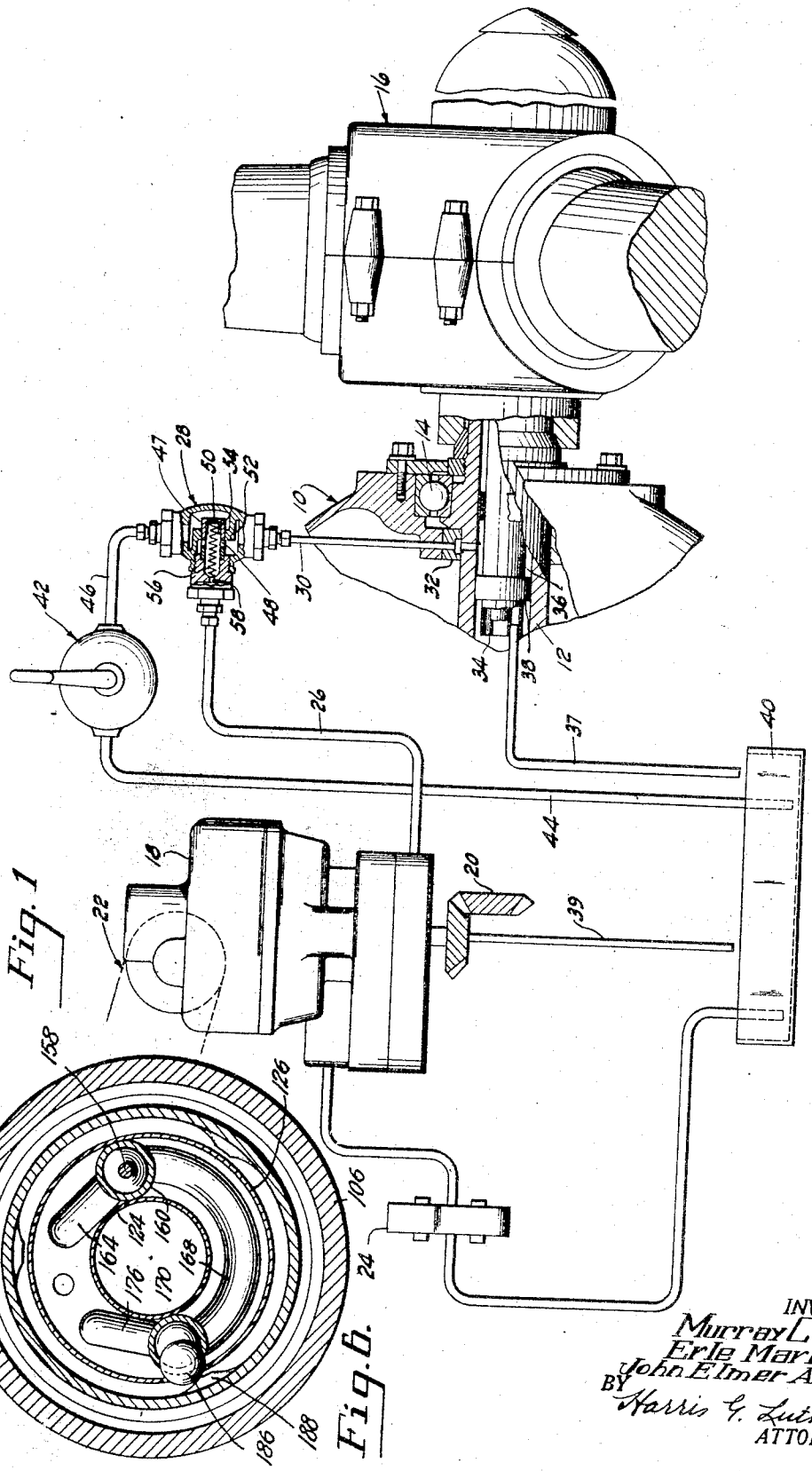


Fig. 1

Fig. 6.

INVENTORS
Murray C. Beebe
Erle Martin
John Elmer Anderson
BY Harris G. Luther
ATTORNEY

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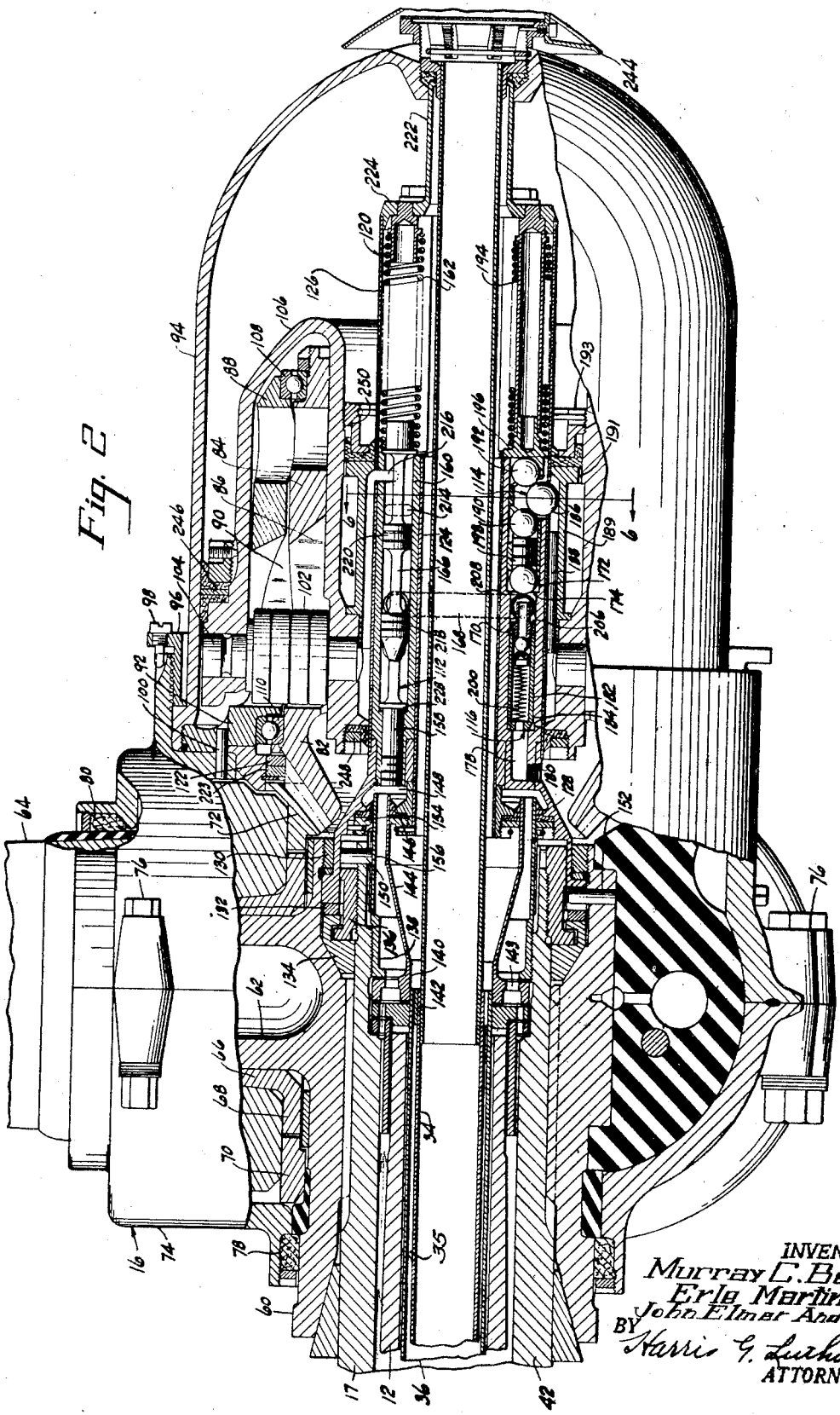
Fig. 2



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Erle Martin
John Elmer Anderson
BY Harris G. Luther
ATTORNEY

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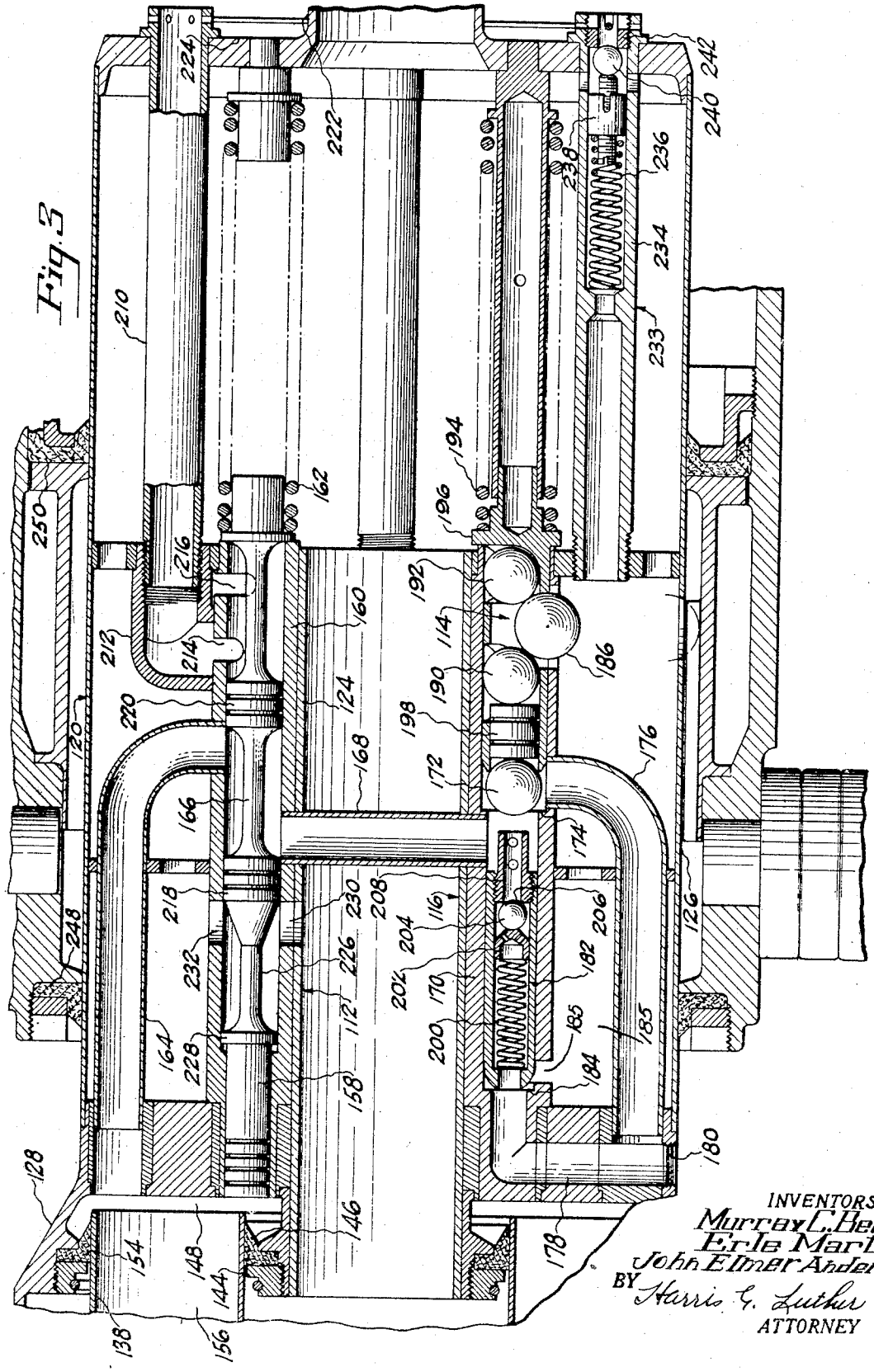
Fig. 3

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Earle Martin
John Elmer Anderson
BY Harris G. Luther
ATTORNEY

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Fig. 4

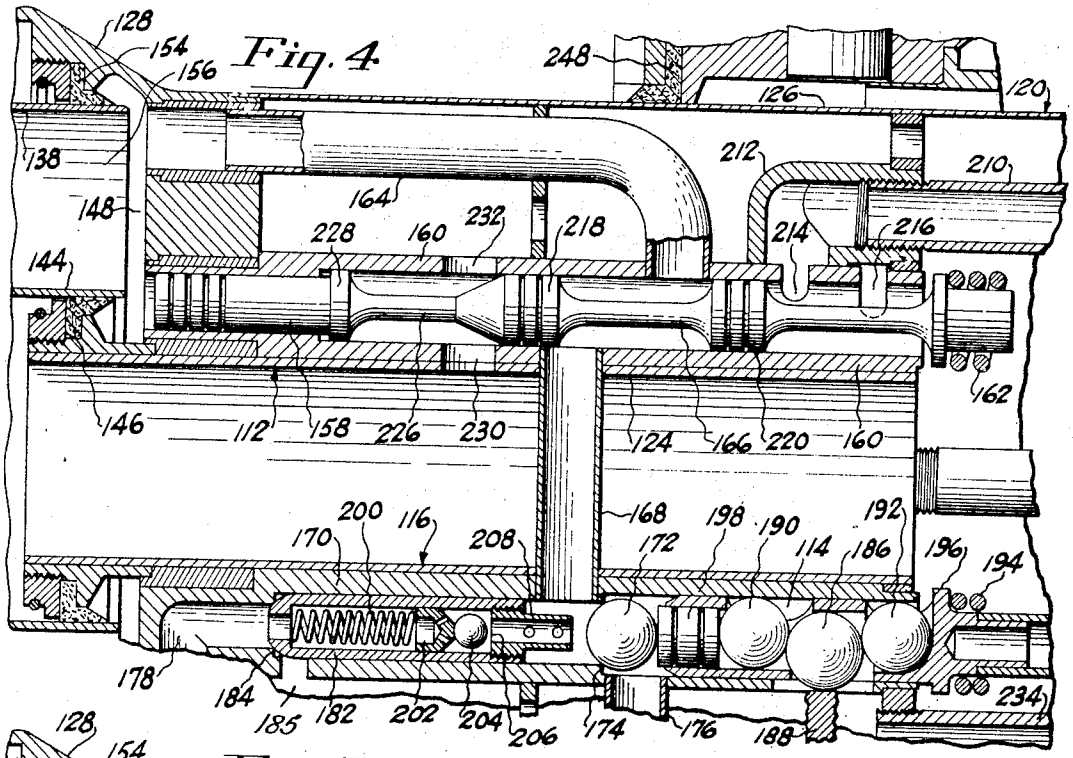
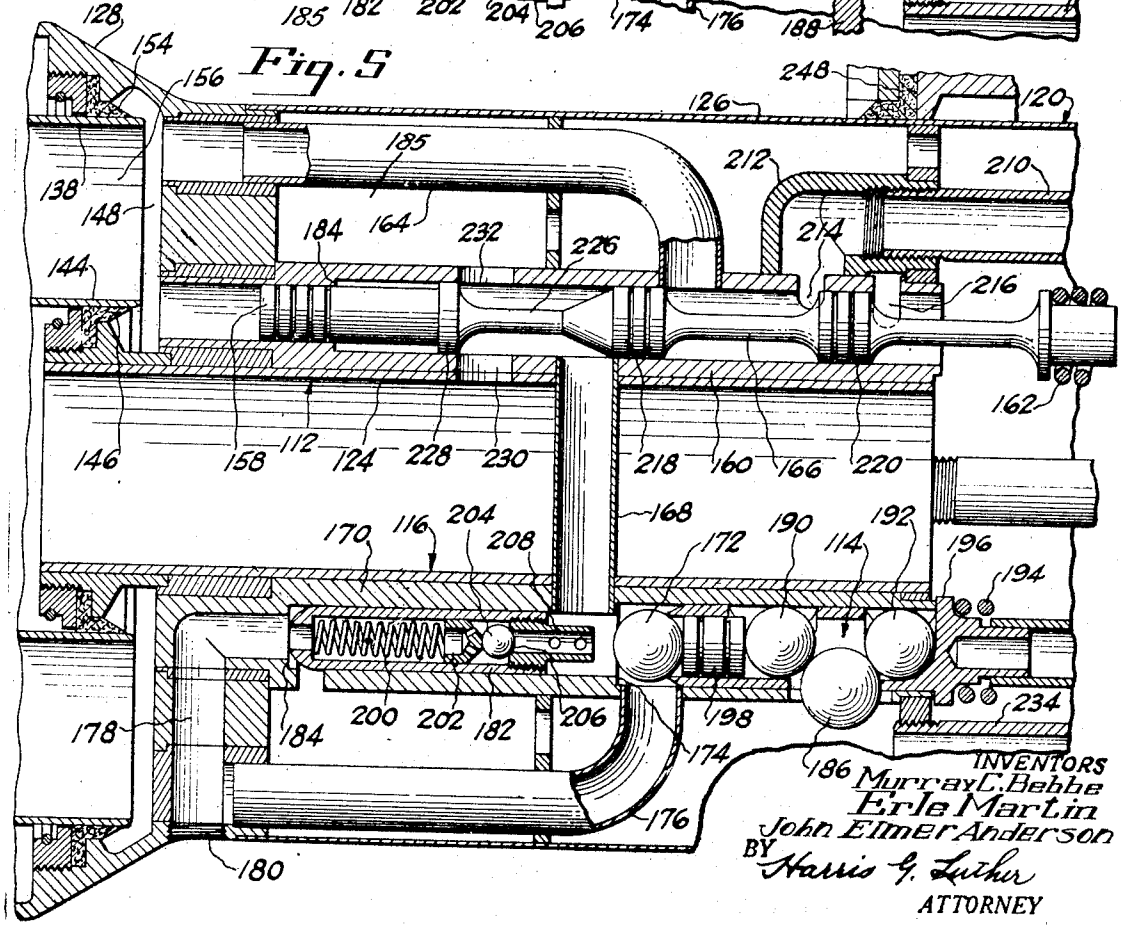



Fig. 5




INVENTORS
Murray C. Bebbe
Erle Martin
John Elmer Anderson
BY Harris G. Luther
ATTORNEY

Patented Apr. 21, 1942

2,280,713

# UNITED STATES PATENT OFFICE

2,280,713

## FEATHERING PROPELLER

Erle Martin, West Hartford, John Elmer Anderson, Portland, and Murray C. Beebe, South Glastonbury, Conn., assignors to United Aircraft Corporation, East Hartford, Conn., a corporation of Delaware

Application June 12, 1937, Serial No. 147,972

28 Claims. (Cl. 170—163)

This invention relates to improvements in controllable pitch aeronautical propellers and has particular reference to a hydraulically operated controllable pitch propeller which may be feathered.

An object of the invention resides in the provision of a propeller of the character specified which has a normal operating range and a feathering range beyond the normal operating range.

A further object resides in the provision of a propeller of the character specified which may be controlled in its operating range and put into and brought out of its feathered condition by changing the pressure of the hydraulic fluid supplied to the controlling mechanism of the propeller.

A still further object resides in the provision of a propeller of the character specified which may be positively put into and brought out of its feathered condition by the application of hydraulic fluid under pressure to the propeller operating mechanism.

An additional object resides in the provision of a propeller of the character specified which may be controlled in its normal operating range, feathered, and brought out of feather by the application of hydraulic fluid at different pressures through a single hydraulic fluid supply line leading to the propeller operating mechanism.

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 a suitable mechanical embodiment of what is now considered to be the preferred form of the invention. The drawings, however, are for the purpose of illustration only and are not to be taken as limiting the invention the scope of which is to be measured entirely by the scope of the appended claims.

In the accompanying drawings

Fig. 1 is an elevational view of a fragmentary portion of an engine and aeronautical propeller and a schematic illustration of means for supplying and controlling the supply of hydraulic fluid to the propeller.

Fig. 2 is an elevational view of an improved controllable pitch feathering type propeller constructed according to the idea of this invention, certain portions being broken away and shown in section to better illustrate the construction thereof, and showing the positions of the parts when the propeller is in its normal operative range of pitch adjustment, and hydraulic fluid under pressure is being admitted to increase the pitch.

Fig. 3 is a somewhat schematic and expanded illustration on an enlarged scale of the propeller included mechanism for controlling the application of the hydraulic fluid and illustrates the positions of the parts when the propeller is in its normal operative range of pitch adjustment as shown in Fig. 2, and hydraulic fluid is being drained to allow centrifugal force to reduce the pitch.

Fig. 4 is a view similar to Fig. 3 and shows the positions of the parts when the propeller is at the upper limit of its operative range of pitch adjustment or is in transition between its ordinary operating range and the blade feathering range of pitch adjustment.

Fig. 5 is a view similar to Figs. 3 and 4 and shows the positions of the parts when the propeller is being brought out of its feathered condition and,

Fig. 6 is a cross sectional view taken on the line 6—6 of Fig. 2.

Referring to the drawings in detail and particularly to Fig. 1 the numeral 10 generally indicates a suitable propeller driving engine provided with a hollow power shaft or crank shaft 12 rotatably supported in the engine casing by suitable means such as the anti-friction ball-bearing 14 and projecting from the engine to support and drive an aeronautical propeller generally indicated at 16.

In the case of a geared engine, as illustrated in Fig. 2, a propeller shaft 17 is telescopically associated with the end of the crank shaft and is driven thereby.

The propeller 16, which constitutes the main portion of the subject matter of this invention, and which will subsequently be described in greater detail, is a controllable pitch propeller adapted to be used with a speed responsive device to provide a constant speed engine propeller combination, and is actuated in at least one direction by a suitable hydraulic mechanism to which hydraulic fluid is supplied from any suitable source of hydraulic fluid under pressure. In most installations pressure is applied to the hydraulic fluid by a suitable mechanism driven by the engine, and a suitable sump or reservoir is provided for receiving hydraulic fluid drained from the propeller operating mechanism.

In the arrangement illustrated in Fig. 1 a speed responsive device, such as the centrifugal governor 18, is provided and is driven by the en-

gine through a suitable driving connection 20 to control the supply of hydraulic fluid under pressure to the propeller controlling mechanism. The governor, which may be of any well-known design, may be manually controlled by a suitable device, such as is generally indicated at 22, to vary the governed speed.

Fluid under pressure may be supplied from any suitable source and in the arrangement illustrated in the drawings is supplied by a suitable engine driven mechanism such as the pump 24 and is led from the pump through a suitable conduit to a governor operated valve, the construction of which is well-known to the art, and from the governor operated valve, through suitable conduits and channels, to the propeller controlling mechanism.

In the construction illustrated, the hydraulic fluid, which may be engine lubricating oil or any other suitable fluid, is led from the governor controlled valve through the conduit 26 to a suitable pressure responsive valve, generally indicated at 28, and from the valve 28 through a conduit or channel 30 to the interior of the hollow power shaft 12 through a suitable bearing connection or slip ring 32. The valve 28 may be incorporated in the governor base or in some convenient fixed portion of the engine if desired. The shaft 12 contains two concentric tubes 34 and 36 of different diameters and the space within the shaft surrounding the outer tube 36 or between the shafts 12 and 17 in a geared engine, is blocked upon the rear side of the connection 32, as indicated at 38, so that the hydraulic fluid forced into the shaft flows through the channel between the interior of the outer shaft and the drain tube 36 or inner shaft, to the propeller controlling mechanism. Hydraulic fluid under the control of the governor controlled valve may move to and from the propeller through this channel as the valve connects the channel with the pump 24 or with the drain 39. The space between the tubes 34 and 36 constitutes a drain line which continues past the plug 38 and empties into the sump, generally indicated at 40, by means schematically shown as a conduit 37. The sump 40 itself, or a container connected therewith, constitutes a reservoir from which the hydraulic fluid is drawn by the pump 24 to supply the propeller controlling mechanism.

The pump 24, which may, if desired, be assisted by one or more booster pumps located in favorable positions along the fluid line leading from the pump 24 to the shaft 12, for example in the governor base, supplies hydraulic fluid to the propeller controlling mechanism at a substantially constant pressure, the pressure used in some installations being in the neighborhood of 200 pounds to the square inch. This pressure range will be hereinafter referred to as the working pressure.

In carrying out the idea of this invention means have been provided for supplying hydraulic fluid to the propeller at pressures other than the working pressure, for purposes which will presently appear. Such means may take the form of an auxiliary pump, generally indicated at 42, which may be either manually actuated, or power actuated under manual control. This auxiliary pump 42 has its inlet connected by means of a suitable conduit 44 with the sump or reservoir 40, and its outlet connected by a similar conduit 46 with the valve 28 which is in turn connected by the conduit 30 and the connection 32 with the interior of the outer shaft 12 or 17.

The valve 28 is provided interiorly thereof with a hollow cylindrical part 47, provided with ports 48 and 50, the ports 48 being located in the side of the part 47 on the valve outlet side of the valve diaphragm 52, while the port 50 is located in the end of the cylindrical part on the inlet side of the valve diaphragm 52. A plunger or piston member 54 is slidably mounted in the interior of the cylindrical part 47 and is urged, by suitable means such as the coil spring 56, to a position in which it closes the port 50.

When the auxiliary pump 42 is inoperative, hydraulic fluid flows from the pump 24 through the governor controlled valve, the conduit 26 and entrance aperture 58, to the interior of the cylindrical part 47 from which it discharges through the ports 48 into the outlet chamber of the valve 28 and flows from there through the conduit 30 to the connection 32. When the auxiliary pump 42 is operative to apply pressure to the hydraulic fluid greater than the working pressure, the piston member 54 is forced to the left, as viewed in Fig. 1, against the action of the spring 56, to a position in which the port 50 is connected with the ports 48 through the interior of the cylindrical member 47, and the entrance aperture 58 for hydraulic fluid at the working pressure is completely cut off from the ports 50 and 48 and the high pressure fluid. The hydraulic fluid will then flow from the outlet of the pump 42 through the conduit 46 to the inlet chamber of the valve 28, through the ports 50 and 48 to the outlet chamber of the valve and thence through the conduit 30 to the connection 32 and into the interior of the hollow power shaft. The spring 56 has a rate such that the plunger 54 will not be moved to connect the port 50 with the ports 48 until the pressure exerted by the pump 42 exceeds the working pressure by a preselected amount.

The auxiliary pump 42 is effective to apply pressure to the hydraulic fluid in at least two ranges above the working pressure. In some installations the lower pressure applied by the auxiliary pump is in the neighborhood of 300 pounds to the square inch, which pressure range will be hereinafter referred to as the feathering high pressure. In the same installations the second pressure range imposed by the auxiliary pump 42 may be in the neighborhood of 600 pounds to the square inch, which pressure range will hereinafter be referred to as the restoring high pressure.

The controllable pitch propeller 16 is illustrated in detail in Figs. 2 to 6 inclusive. In the construction illustrated a hub member 60 is mounted upon the projecting end of the hollow power shaft 12 or propeller shaft 17 and suitably secured thereon against both axial and rotational movements with respect to the power shaft. The hub member is provided with a plurality of hollow radially extending arms, as indicated at 62, and upon each of these arms there is mounted a propeller blade, as indicated at 64, supported for rotating or oscillating movements about the axis of the respective arm. A sleeve, as indicated at 66, is disposed between the hollow base or root portion of each of the propeller blades and the respective arm on the hub member, the sleeves being inserted in the propeller blades in such a manner that they are relatively immovable with respect thereto. Each of the sleeve members 66 has a flange portion, as indicated at 68, extending between the inner end of the respective propeller blade 64 and a suitable bearing surface provided on the adjacent portion of the hub

member 60. A ring member 70 surrounds each of the flanges 68 and is resiliently connected therewith against relative rotation, and is provided at one side thereof with a gear sector as indicated at 72.

The propeller blades are retained upon the hub member 60 by a suitable barrel member 74, preferably formed in two portions and secured together by suitable means such as the clamp bolt 76. The barrel member 74 is provided with inwardly turned portions which overlie the flanged base ends of the propeller blades, suitable antifriction means being interposed between the inwardly turned portions of the barrel member and the flanged ends of the propeller blades, in a manner well-known to the art, to provide for relatively free rotation of the propeller blades about the respective arms 62. Suitable packing means, as indicated at 78 and 80, is interposed between the barrel member 74 and the hub member 60, and the barrel member and the base portions of the propeller blades 64, to constitute the barrel member 74 a leak proof receptacle for the reception of hydraulic fluid from the propeller operating mechanism.

The gear sectors 72 on the ring members 70 have gear teeth inclined at an angle to the axis of rotation of the propeller, which mesh with similarly disposed gear teeth on a ring gear 82 integrally associated with a cylindrical member 84 provided with spiral or diagonal cam slots 86. The cylindrical member 84 is rotatable in a relatively fixed cylindrical member 88 provided with spiral or diagonal cam slots 90 inclined in a direction opposite to the direction of inclination of the cam slots 86. The member 88 is rigidly secured to the barrel member 74 by means of the radially extending flange 92 thereon which has a peripheral screw threaded and shouldered engagement with the inner end of the cylindrical dome shaped cover member 94, which is secured to the barrel member by the nut 96 and locking screws 98. Preferably, dowel pins 100 are inserted through the flange 92 and into the adjacent portion of the barrel member 74 to positively restrain the member 88 against rotation relative to the barrel member.

A plurality of rollers form cam followers, as indicated at 102, which extend through each pair of cooperating cam slots 86 and 90. Each cam follower 102 is mounted upon a pin or axle, as indicated at 104, the opposite ends of which are received in suitable apertures provided in the walls of a double walled piston 106, which receives the cylindrical members 84 and 88 in the space between its inner and outer walls and cooperates with the cover member or cylinder 94 to constitute an expansible chamber hydraulic mechanism for turning the propeller blades about the arms 62.

Movement of the piston 106 in the cylinder 94, in an axial direction will move the cam followers through the cam slots 86 and 90 to impart rotational movement to the member 84 with respect to the member 88. As the member 84 is operatively connected with the propeller blades through the ring gear 82 and respective gear sectors 72, rotation of the member 84 incident to axial movements of the piston 106 rotates the propeller blades 64 about the axes of the respective arms 62, which axes preferably coincide with the longitudinal axes of the respective blades. Suitable antifriction means, such as the ball-bearings 108 and 110 are preferably interposed between the members 84 and 88 to insure relatively free rotation of the member 84 with respect to the member 88.

While rotation of the propeller blades 64 about the arms 62 has been referred to as an incident of the axial or longitudinal movement of the piston 106, it does not necessarily follow that movement of the piston is always the result of the application of hydraulic fluid under pressure thereto, since the piston may at times be moved by other forces such as the centrifugal forces of the propeller blades themselves acting through the cam and the cam followers.

The means for directing the application of hydraulic fluid under pressure to the piston 106 comprises three principal elements, namely, a pressure responsive valve, generally indicated at 112, an intermediate pitch limit stop device, generally indicated at 114, and a by-pass valve, generally indicated at 116, all disposed in a valve housing generally indicated at 120.

The action and cooperation of these various elements is such that when only the working pressure is applied to the hydraulic fluid, the propeller will function as a controllable pitch or constant speed propeller within a normal pitch range determined by the low pitch limit stop 122, which is secured indirectly to the barrel 74 and coacts with a lug on the movable cam 84, and the intermediate pitch limit stop 114. When the feathering pressure is applied to the hydraulic fluid, the propeller blades will be immediately turned to a feathered position in which they are disposed substantially parallel to the axis of the propeller shaft and hence provide a minimum drag resistance, and when the restoring pressure is applied to the hydraulic fluid, the blades are returned to their operative position and the propeller may again function as a constant speed propeller or may, if desired, be placed under the control of the operator of the vehicle. The feature of feathering the propeller blades has many advantages well-known to the art among which is the advantage of being able to cruise on less than the whole number of engines with which the airplane is provided without excessive drag forces due to windmilling propellers.

The valve housing 120 comprises an inner tubular member 124 and an outer concentric cylindrical member 126 slidably received in the piston 106, connected at one end to a flared bell-like member 128, the tubular casings for the valves 112, 116 and the intermediate pitch limit stop 114 in the annular space between the two members.

The bell-like member 128 is secured to the extreme end of the power shaft 12 by means of a nut 130 which is threaded into the end of the hub member 60 and clamps a radially extending flange on the extreme end of the member 128 between itself and a washer 132 which bears against the forward end of the cone 134 which, in turn, is secured on the end of the power shaft by the nut 136. A suitable packing is inserted between the nut 130 and the flange on the member 128 to provide a leak-proof joint between the member 128 and the forward end of the hub member 60.

A nut 138 screw threaded into the tubular end of the power shaft serves to clamp in place an apertured plug member 140 which supports the forward end of the drain tube 38 and also provides an intermediate support for the breather tube 34 which extends through the drain tube, the support for the breather tube being provided by the spacer members 142 which are separated

to permit the passage of hydraulic fluid therethrough. The plug 140 is provided with circumferential spaced apertures 143 extending therethrough for the passage of hydraulic fluid through the plug, and is in two parts of which the forward part is provided with a tapered extension 144 which has a fluid seal connection 146 with the rearward end of the inner tubular member 124 of the valve housing so that it effectively connects the high pressure fluid space between the drain tube 36 and the interior of the hollow shaft 12 through the apertures 143 with the space 148, connected with the valve 112 and separates the high pressure channel from the drainage channel between the drain tube 36 and the breather tube 34.

The nuts 138 and 136 are secured against rotation relative to the power shaft upon which they are screw threaded by suitable locking pins 150 and the valve housing is restrained against rotation relative to the hub member 60 by similar locking pins 152.

The nut 138 has an extension received within an annulus in the flared portion of the bell member 128, and a leak proof seal 154 is provided between the end of the extension and the annulus. This construction provides between the members 144 and 138 a channel 156 for leading high pressure fluid, without leakage to the space 148 within the member 128.

When the hydraulic fluid in the channel 156 and the space 148 is at working pressure, this pressure through acting upon the end of the valve plunger 158 facing the space 148 fails to move the plunger against the action of the spring 162. The spring 162 has a carefully calibrated spring rate so that the plunger 158 takes a definite position in the casing 160 for each of the three operating pressures imposed on the hydraulic fluid, the pressures being hereinbefore referred to as the working pressure, the feathering pressure and the restoring pressure.

An oil channel or conduit 164 (see Fig. 3) leads from the space 148 to the interior of the valve casing 160 and, when the valve is in the position incident to the working pressure of the hydraulic fluid, this channel is connected, through the reduced portion 166 of the valve stem, with a conduit 168 connected with the interior of the valve casing 160, leading around the tubular inner portion 124 of the valve housing, shown diagrammatically in Figs. 3 to 5 as extending through tube 124 for clearness of understanding, to the interior of the casing 170 of the by-pass valve generally indicated at 116. With the positions of the parts as illustrated in Figs. 1 and 2, the hydraulic fluid flows from the conduit 168 through the space between the ball 172 and the annular valve seat 174 formed in the casing 170, and through the conduit 176 to the channel 178, and out of the valve casing through the aperture 180 to the space at the rear of the piston.

If the ball valve 172 is unseated at the time that the flow from the passage 176 to the passage 168 begins, the action of the fluid against the face of the ball adjacent to the seat will maintain the ball in a position away from the seat. If the ball is seated at the beginning of the flow, or becomes seated during the flow, the pressure in the passage 176 will back up in the connected channel 178 and open the valve 182 permitting the fluid to flow from the valve seat 184 to the drain 185–35. The movement of the valve 182 will also bring the end of the member 208 in contact with the ball 172 to unseat the ball and again establish the flow from the passage 176 to the passage 168. As far as the operation of the device is concerned, it is not material whether the fluid from the back of the piston drains from the valve 172 or the valve 182. The hydraulic fluid acting against the rear end of the piston 106 tends to urge the piston forwardly to increase the pitch of the propeller blades. If at any time the pitch of the propeller blades is too high, the valve operated by the governor 18, or a manual control, cuts off the high pressure fluid from the pump 24 and connects the high pressure fluid channel within the power shaft 12 with the sump 40, through the drain 39. When this occurs, hydraulic fluid under pressure in the space behind the piston drains through the conduit 176 past the ball 172, through the conduit 168, past the reduced portion 166 of the valve plunger 158, and through the conduit 164, back to the space 148 and out through the pressure fluid channel in the power shaft. Some of this hydraulic fluid under pressure may also move the hollow plunger 182 of the by-pass valve 116 forwardly to open a space between the rear end of the plunger and the cooperating valve seat 184 provided at the forward end of the channel 178 so that the hydraulic fluid may flow into the space between the outer and inner concentric members 126 and 124 to the forward end of the member 124, particularly illustrated in Fig. 3, where it enters the drain channel between the tubular member 34 and the tubular members 124 and 36. The oil released by the valve 182 flows into the space between the members 124 and 126 not occupied by the valve casings 160 and 170. From this space the oil flows over the forward end of the member 124 to the interior of the tubular member 124 if a breather tube is not used, or to the space between the interior of the member 124 and the exterior of the breather tube 34 where such a breather tube is used. It will be noted that oil flow spaces are clearly indicated between the forward end of the member 124 and the adjacent surface of the breather tube in Fig. 2. When the space behind the piston is connected with drain, as indicated above, the propeller blades are turned toward their low pitch position by the action of centrifugal forces present in the blades themselves as they are rotated about the power shaft and the piston is forced rearwardly by the action of the cams 86 and 90 and the cam followers 102.

When hydraulic fluid under working pressure is applied to the rear of the piston 106 for a sufficient interval, the piston will be moved forwardly until the ball 186 of the intermediate pitch stop mechanism, generally indicated at 114, rides up on the piston carried cam 188 which is moved under the ball by the longitudinal movement of the piston and the rotational movement of the piston due to the angularity of the cam slots 90. When this occurs (see Fig. 4), the ball 186 is forced upwardly between the balls 190 and 192 thereby imposing the force of the spring 194, through the movable abutment 196, the balls 192, 186 and 190 and the spacer 198 against the ball 172 to force the same into valve closing contact with the seat 174 to prevent the flow of hydraulic fluid past the ball 172 from the conduit 168 to the conduit 176. At the same time the hydraulic fluid under pressure forces the plunger 182 of the valve member 116 into sealing engagement with the seat 184 at the end of the channel 178 and, as the working pressure of the

hydraulic fluid is not sufficient to compress the spring 200, which acts through the apertured abutment 202 against the ball 204, and move the ball 204 away from its seat 206 provided in the adjacent end of the tubular member 200 secured in the end of the hollow plunger 182, the flow of hydraulic fluid under working pressure to the space behind the piston will be stopped at the end of the conduit 168, and there will be no further admission of hydraulic fluid to the space at the rear of the piston to move the propeller blades beyond the limiting high pitch position determined by the relation of the cam 188 and the ball 186. Thus, when the hydraulic fluid is at the working pressure, the range of pitch changing movements of the propeller blades is limited by the low pitch limit stop 122 and the intermediate pitch limit stop 114. The cams 188 are formed on the interior surface of a sleeve member 189 having a splined connection 191 with the piston. This sleeve may be inserted in the piston at any selected relative rotational position to determine the pitch angle at which the intermediate pitch limit stop will function and is secured in the piston by suitable means such as the nut 193.

When hydraulic fluid under feathering high pressure, which may be supplied by the pump 42, is applied to the space behind the piston, the piston is first moved forwardly in the manner described above for the working pressure, until the ball 186 of the intermediate pitch limit stop device rides up on the cam 188 in the manner described above. While only one cam 188 is operative at a time, since the barrel may be mounted in any one of three different rotational positions, three cams have been provided so that one cam will be in a position to operate the pitch limiting valve regardless of the rotational position of the barrel with respect to the propeller hub the cams being adjustable to provide any desired pitch angle for the intermediate stop. At the same time the valve plunger 158 is moved slightly forward but not sufficiently to close the connection of the conduit 164 with the conduit 168 past the reduced portion 166 of the valve plunger so that hydraulic fluid under feathering high pressure flows through the conduit 164, the casing 160, the conduit 168 to the interior of the casing 170 of the valve 116. Although the ball 172 closes the passage to the conduit 176 when the ball 186 is on the cam 188, the pressure of the hydraulic fluid at feathering high pressure is sufficient to compress the spring 200 and open the valve passage between the ball 204 and the rear end of the member 208 as shown in Fig. 4. The hydraulic fluid then flows through the member 208, the apertured abutment 202, the hollow plunger 182 and the passage 178 to the space at the rear of the piston to continue the forward movement of the piston past the intermediate limit stop device. At the same time any hydraulic fluid that may have been trapped in the space between the front end of the piston and the interior of the forward portion of the cover member 94 may flow from that space through the conduit 210, the elbow 212 and the slot 214 into the interior of the forward portion of the valve casing 160, from which it escapes through the drain slot 216 to the interior of the outer wall 126 of the valve housing, and from this space around the forward end of the inner tubular member 124 of the valve housing and to drain through the inner tubular member and the space between the tubes 34 and 36.

Hydraulic fluid at the feathering high pressure may be injected into the space behind the piston until the piston has been moved to its furtherest forward position as determined by the limit stop 223 which is secured indirectly to the hub 14 and coacts with a lug in the movable cam member 84, and the propeller blades have been rotated to a position in which they present only their edges to the relative wind.

Hydraulic fluid, such as engine lubricating oil, injected at the working or the feathering pressure into the space at the rear of the piston backs up in the interior of the barrel member 14 and fills the same thereby lubricating all the working parts of the propeller. The packing means 78 and 80 between the barrel and the hub member and between the barrel and the base ends of the propeller blades, and sealing means between the two parts of the barrel, render the barrel leak proof for hydraulic fluid at pressures up to and including the feathering high pressure. Hydraulic fluid at pressures above the feathering high pressure is not permitted to flow into the barrel member.

When it is desired to restore the propeller from a feathered condition to an operative condition, the auxiliary pump 42 is operated to apply the restoring high pressure to the hydraulic fluid supplied to the propeller operating mechanism. When hydraulic fluid at the restoring pressure is supplied to the space 148, the valve plunger 158 is immediately moved forward to the position illustrated in Fig. 5 in which the valve piston 218 on the valve plunger 158 interrupts the connection between the conduit 164 and the conduit 168 and the second valve piston 220 closes off the drain slot 216.

With the valve in the position indicated, the hydraulic fluid at restoring high pressure flows from the space 148 through the conduit 164, past the reduced portion 166 of the valve plunger, and then through the slot 214, the elbow 212 and the conduit 210 into the space between the forward end of the piston 106 and the forward end of the cylindrical domed cover member 94, surrounding the forward end of the valve housing 120 and the extension member 222 which connects the forward end of the valve casing with the end of the cover member 94 and which is connected to the forward end of the outer wall 126 of the valve housing by the integral transverse flange 224, which constitutes the front end wall of the valve housing. The hydraulic fluid under pressure is then effective to act upon the forward end of the piston and force the piston rearwardly to restore the propeller blades to an operating condition.

While the piston is being forced rearwardly any hydraulic fluid which may have been trapped in the space at the rear of the piston flows through the conduit 176, past the ball valve 172 and through the conduit 168 into the valve casing 160 in a space occupied by a reduced portion 226 of the valve between the enlarged portion 218 and a piston member 228 and out of the valve casing through the apertures 230 and 232 to the interior of the valve housing 120 from whence it flows to drain through the space between the tubes 34 and 36. If, for any reason, the ball 172 seats against the shoulder 174, as when the piston is moving back past the intermediate pitch limit stop device 114, the drainage hydraulic fluid may alternatively flow through the channel 178, past the rear end of the valve plunger 182 into the interior of the valve hous-

ing and from there to drain in the manner specified.

The pump 42 is capable of exerting a pressure greater than the pressure necessary to move the piston rearwardly to restore the propeller from a feathered condition to an operative condition and if the maximum pressure of the pump were imposed on the forward end of the piston and the adjacent end of the cover member 94 the stresses might become sufficient to endanger the parts. For this reason the relief valve generally indicated at 233 is provided between the space at the forward end of the piston and the interior of the valve housing. This valve, as particularly illustrated in Fig. 3, comprises a tubular casing 234 which contains a compression spring 236 acting against an abutment 238 which acts to force the ball 240 against the seat 242. The spring 236 is selected to maintain the relief valve closed until a predetermined pressure of the hydraulic fluid in the space at the front of the piston is reached after the valve will open to permit hydraulic fluid to drain from this space into the interior of the valve housing 126 and from thence to drain. When the piston 106 has been moved rearwardly a distance such that the intermediate pitch limit stop 114 has passed the cam 188, the limit stop device is restored to its operative condition and as soon as the restoring high pressure is removed from the hydraulic fluid, the propeller will again function as a constant speed or controllable pitch propeller within the range of pitch angle adjustment as determined by the limit stops 114 and 122.

In the form of the invention illustrated the tube 34 extends entirely through the propeller and the propeller operating mechanism and is connected with an annular vent between the nose plate 244, secured in spaced relation to the extreme forward portion of the cover member 94, and the adjacent portion of the cover member to provide a breather opening for the engine. It is to be understood, however, that the invention is in no way limited to this particular construction since the propeller may obviously be used with engines that do not utilize a breather opening through the power shaft and the propeller hub.

From the above description it will be observed that there has been provided a propeller that has two ranges of propeller blade pitch adjustment, that in one range the adjustment is accomplished by hydraulic fluid under pressure in one direction and by centrifugal action in the opposite direction, and in the second range of adjustment the adjustment is accomplished by hydraulic fluid under pressure in both directions, acting upon the opposite sides of the pitch controlling piston.

The area of the end of the valve stem 158 facing the space 148 and the strength of the spring 162 are so related that the valve stem 158 does not change its position upon the imposition of hydraulic fluid under working pressure or materially change its position upon the imposition of hydraulic fluid at feathering pressure into the space 148, but materially changes its position upon the imposition of hydraulic fluid under restoring pressure into the space 148. The piston portion 228 cooperates with the adjacent portion of the valve casing 160 to constitute a dash-pot to regulate the movements of the valve stem 158 and prevent sudden movement or chattering of the valve stem in the valve casing.

The piston 106 has a fluid seal connection 246 with the interior of the cover member 94 and fluid seal connections 248 and 250 with the external surface of the outer shell 126 of the valve housing, which are effective to prevent the leakage of oil in either direction past the piston from the pressure side to the drain side.

While there has been illustrated and described a suitable mechanical embodiment of what is now considered to be the preferred form of the idea of the invention, it is to be understood that the invention is not limited to the construction 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 subjoined claims.

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

What is claimed is:

1. In a controllable pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movements, a fluid pressure actuated power device for controlling the pitch changing movements of said blades, a positive low pitch limit stop and a positive high pitch limit stop for determining the entire range of pitch changing movement, and an intermediate pitch fluid controlling limit stop actuated by said power device to cut off the fluid pressure supply to said power device for normally limiting said pitch changing movements to the range of movement between one of said positive pitch limit stops and said intermediate pitch limit stop.

2. In a controllable pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movement, an expansible chamber fluid actuated mechanism carried by said propeller for controlling the pitch changing movements of said blades, a positive high pitch limit stop and a positive low pitch limit stop for determining the entire range of pitch changing movements of said blades, an intermediate pitch fluid controlling limit stop operatively associated with said mechanism and effective within a selected range of pressure of the hydraulic fluid supplied to said mechanism to limit the pitch changing movement to the range between one of said positive pitch limit stops and said intermediate pitch limit stop, and means operative at a pressure of said hydraulic fluid higher than said selected pressure to render said intermediate pitch limit stop ineffective to limit the pitch changing movements of said blades.

3. In a controllable pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movements, an expansible chamber hydraulic mechanism operatively connected with said blades for controlling the pitch changing movements thereof, a high pitch limit stop and a low pitch limit stop for determining the entire range of pitch changing movements of said blades, an intermediate hydraulic fluid controlling pitch limit stop operative under a selected pressure of the hydraulic fluid supplied to said mechanism to restrain said mechanism against moving said blades beyond a range determined by the operation of said intermediate pitch limit stop, means operative at a second selected pressure of said hydraulic fluid to render said mechanism operative to turn said blades to a pitch position beyond the limiting pitch position determined by the operation of said intermediate pitch limit stop, and means operative at a third selected pressure of said hydraulic fluid to render said mechanism operative to restore said blades

to the range of pitch changing movement as determined by said intermediate pitch limit stop.

4. In a controllable pitch propeller having blades rotatably mounted for pitch changing movement, an expansible chamber hydraulic mechanism having a relatively fixed part and a relatively movable part operatively connected with said blades and effective upon the application of hydraulic fluid under a selected pressure to one side thereof to turn said blades in one direction, an element movable by said movable part, a low pitch limit stop and a high pitch limit stop for determining the entire range of pitch changing movement of said blades, a valve operated by said element at a position intermediate the limits of said entire range of pitch changing movement to cut off the supply of hydraulic fluid to said one side of said relatively movable part, and a by-pass valve operative at a pressure of said hydraulic fluid higher than said selected pressure to supply hydraulic fluid to the same side of said relatively movable member.

5. In a controllable pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movement, an expansible chamber hydraulic mechanism having a relatively fixed part secured to said hub, and a relatively movable part operatively connected with said blades and effective upon the application of hydraulic fluid under pressure to one side thereof to turn said blades in a pitch increasing direction against the opposing force of the centrifugal action of the blades, an element movable by said relatively movable part, a low pitch limit stop and a high pitch limit stop for determining the entire range of pitch changing movement of said blades, a valve operated by said element at a position intermediate the limits of said entire range of pitch changing movement to cut off the supply of hydraulic fluid at a selected pressure to said side of said relatively movable part, a by-pass valve operative at a second selected pressure of said hydraulic fluid to continue the supply of hydraulic fluid to the same side of said relatively movable part through a range of pitch changing movement up to said high pitch limit stop, and a pressure responsive valve operative at a pressure of said hydraulic fluid higher than said second selected pressure to supply hydraulic fluid to the opposite side of said relatively movable part, and connect the space at the first mentioned side of said part with a drain.

6. In a controllable pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movement, an expansible chamber hydraulic mechanism having a relatively fixed part secured to said hub, and a relatively movable part operatively connected with said blades and effective upon the application of hydraulic fluid under pressure to one side thereof to turn said blades in a pitch increasing direction against the opposing force of the centrifugal action of the blades, an element movable by said relatively movable part, a low pitch limit stop and a high pitch limit stop for determining the entire range of pitch changing movement of said blades, a valve operated by said element at a position intermediate the limits of said entire range of pitch changing movement to cut off the supply of hydraulic fluid at a selected pressure to said side of said relatively movable part, a by-pass valve operative at a second selected pressure of said hydraulic fluid to continue the supply of hydraulic fluid to the same side of said relatively movable part through a range of pitch changing movement up to said high pitch limit stop, and a pressure responsive valve operative at a pressure of said hydraulic fluid higher than said second selected pressure to supply hydraulic fluid to the opposite side of said relatively movable part, and connect the space at the first mentioned side of said part with a drain and a pressure relief valve between said opposite side of said relatively movable member and said drain.

7. In a controllable pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movement, an expansible chamber hydraulic mechanism having a relatively fixed part secured to said hub, and a relatively movable part operatively connected with said blades and effective upon the application of hydraulic fluid under pressure to one side thereof to turn said blades in a pitch increasing direction against the opposing force of the centrifugal action of the blades, a valve operative at one selected pressure to limit the application of hydraulic fluid to said movable member to an intermediate pitch range, a valve operative at a second selected pressure to continue the application of hydraulic fluid to said movable member for the entire pitch range, and a valve operative at a third selected pressure to change the point of application of hydraulic fluid to said relatively movable member.

8. In a controllable pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movement, an expansible chamber hydraulic mechanism having a relatively fixed part secured to said hub, and a relatively movable part operatively connected with said blades and effective upon the application of hydraulic fluid under pressure to one side thereof to turn said bldaes in a pitch increasing direction against the opposing force of the centrifugal action of the blades, a valve operative at one selected pressure to limit the application of hydraulic fluid to said movable member to an intermediate pitch range, a valve operative at a second selected pressure to continue the application of hydraulic fluid to said movable member for the entire pitch range, and a valve operative at a third selected pressure to reverse the application of hydraulic fluid to said relative movable member and a pressure relief valve between the side of said relatively movable member to which said third mentioned valve applies hydraulic fluid and a fluid drain.

9. In a controllable pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movements, an expansible chamber hydraulic mechanism having a relatively fixed part secured to said hub and a relatively movable part operatively connected with said blades and effective upon the application of hydraulic fluid at pressures below a predetermined pressure to one side thereof to turn said blades in a pitch increasing direction against the opposing force of the centrifugal action of the blades, means for applying hydraulic fluid at said pressures below said predetermined pressure to said one side of said relatively movable member, means for continuously draining hydraulic fluid from the space at the opposite side of said relatively movable member while the pressure of said hydraulic fluid is below said predetermined pressure, means for supplying fluid at pressures above said predetermined pressure, and means operated by fluid at pressures above said predetermined pressure to reverse the relation of said hydraulic fluid apply-

ing means and said drain means with respect to the sides of said relatively movable member.

10. In a controllable pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movements, an expansible chamber hydraulic mechanism having a relatively fixed part secured to said hub and a relatively movable part operatively connected with said blades and effective upon the application of hydraulic fluid under a selected pressure to one side thereof to turn said blades in a pitch increasing direction against the opposing force of the centrifugal action of the blades and effective upon the application of hydraulic fluid under pressure to the opposite side thereof to turn said blades in a pitch decreasing direction, means for applying hydraulic fluid under said selected pressure to the blade pitch increasing side of said relatively movable member, means connecting the space at the opposite side of said relatively movable member with a drain, and a pressure responsive valve operative at a selected pressure above said first mentioned selected pressure to change the application of hydraulic fluid under pressure to the blade pitch decreasing side of said relatively movable member and to connect the space at the opposite side of said relatively movable member with a drain.

11. In a controllable pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movements, an expansible chamber hydraulic mechanism having a relatively fixed part secured to said hub, and a relatively movable part operatively connected with said blades and effective upon the application of hydraulic fluid under pressure to one side thereof to turn said blades in a pitch increasing direction against the opposing force of the centrifugal action of the blades and effective upon the application of hydraulic fluid under pressure to the opposite side thereof to turn said blades in a pitch decreasing direction, a valve comprising an intermediate pitch limit stop for limiting the operative range of pitch increasing movements of said relatively movable member, a pressure responsive valve operative when said relatively movable member is in said operative range of pitch changing movements to vent the blade pitch decreasing side of said member and connect said pitch increasing side with said fluid under pressure and operative under a selected pressure of the hydraulic fluid to apply hydraulic fluid under pressure to the blade pitch decreasing side of said relatively movable member and connect the space at the blade pitch increasing side of said relatively movable member with drain through said intermediate pitch limit stop valve, and a by-pass valve for connecting the space at the pitch increasing side of said relatively movable member with drain arranged in parallel with said intermediate pitch limit stop valve.

12. In a controllable pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movements, an expansible chamber hydraulic mechanism having a relatively fixed part secured to said hub and a relatively movable part operatively connected with said blades and effective upon the application of hydraulic fluid under pressure to one side thereof to turn said blades in a pitch increasing direction against the opposing force of the centrifugal action of the blades and effective upon the application of hydraulic fluid to the opposite side thereof to turn said blades in a pitch decreasing direction, means responsive to selected pressures of the hydraulic fluid supplied to said mechanism to render said mechanism operative to maintain the pitch changing movements of said blades within an operating range, to turn said blades to a feathered position and to restore said blades from said feathered position to said operative range, a single channel for the flow of hydraulic fluid in both directions when said mechanism is in said operative range and for the flow of hydraulic fluid under pressure to said mechanism when said blades are being moved to or from their feathered position, and a separate channel for draining hydraulic fluid from said mechanism when said mechanism is operating outside of said normal operating range.

13. In a controllable pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movements, an expansible chamber hydraulic mechanism having a relatively fixed part secured to said hub and a relatively movable part operatively connected with said blades and effective upon the application of hydraulic fluid under one selected pressure to one side thereof to turn said blades in a pitch increasing direction, through an operative range of pitch changing movements and upon the application to the same side thereof of hydraulic fluid at a second selected pressure to turn said blades to a feathered position, and operative upon the application of hydraulic fluid at a third selected pressure to the opposite side thereof to restore said blades from the feathered position to said operative range, a valve constituting an intermediate pitch stop for restraining said relatively movable part against exceeding said operative range under said one selected pressure, a by-pass valve for rendering said relatively movable part operative to exceed said operative range under said second selected pressure, and a pressure responsive valve for rendering said relatively movable member operative to restore said blades from the feathered position to said operative range under said third selected pressure, said pressure responsive valve, and said intermediate pitch limit stop valve being arranged in series in the fluid line leading to said hydraulic mechanism, and said intermediate pitch limit stop valve and said by-pass valve being arranged in parallel.

14. In a controllable pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movements, a cylinder secured to said hub, a piston in said cylinder operatively associated with said blades and operative upon the application of hydraulic fluid at one selected pressure to one end thereof to turn said blades through an operative range of pitch adjustment in a pitch increasing direction against the opposing force of the centrifugal action of the blades, and operative upon the application to the same end thereof of hydraulic fluid under a second selected pressure to turn said blades to a feathered position, and an intermediate pitch stop device for restraining said piston against exceeding said operating range of pitch changing movement under said one selected pressure, said device comprising, a tubular casing having a valve seat therein, a ball in said casing cooperating with said valve seat, a spring, a movable ball for applying the force of said spring to said first mentioned ball, and a cam on said piston for moving said movable ball

15. In a controllable pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movements, a cylinder secured to said hub, a piston in said cylinder operatively associated with said blades and effective upon the application of hydraulic fluid under one selected

pressure to one end thereof to turn said blades in a pitch increasing direction through an operative range of pitch adjustment, operative under a second selected pressure applied to the same end thereof to exceed said operative range and turn said blades to a feathered position, and operative under a third selected pressure applied to the opposite end thereof to restore said blades from the feathered position to said operative range, a fluid line and a drain line leading to said cylinder and a pressure responsive valve for reversing the application of hydraulic fluid under pressure from one end of said piston to the other and for simultaneously reversing the connection of said drain line from the spaces opposite the respective ends of said piston, said valve comprising a tubular casing provided with spaced ports therein, a valve plunger having a plurality of valve pistons cooperating with said ports and a piston at one end subject to the pressure of said hydraulic fluid, and a spring opposing movements of said plunger under the influence of the pressure of said hydraulic fluid, said spring having a rate such that no material movement is imparted to said plunger by said first and second selected pressures but a material movement is imparted to said plunger by said third selected pressure.

16. In a controllable pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movements, a cylinder secured to said hub, a piston in said cylinder operatively associated with said blades and effective upon the application of hydraulic fluid at one selected pressure to one side thereof to turn said blades in a pitch increasing direction against the opposing force of the centrifugal action of the blades and effective upon the application of hydraulic fluid at a second selected pressure to the same side thereof to turn said blades in a pitch increasing direction past said operative range to a feathered position, a limit stop device for restraining said piston against exceeding an operative range of movement under said one preselected pressure, and a by-pass valve for rendering said piston operative to exceed said operative range under said second selected pressure, said by-pass valve comprising a tubular casing, a valve seat in said casing, a hollow plunger, slidable in said casing cooperating at one end with said valve seat, a valve seat in said plunger, a ball in said plunger and a spring in said plunger for urging said ball into closing relation with said valve seat, said spring having a rate such that hydraulic fluid under said one selected pressure will not move said ball away from said valve seat but hydraulic fluid under said second selected pressure will unseat said ball and flow into the space adjacent to the end of said piston, said plunger cooperating with the valve seat in said casing to prevent the flow of hydraulic fluid into said space except past said plunger included valve.

17. In a controllable pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movements, a cylinder secured to said hub, a piston in said cylinder operatively associated with said blades and effective upon the application of hydraulic fluid at one selected pressure to one end thereof to move said blades in a pitch increasing direction through a normal operative range against the opposing force of the centrifugal action of the blades, effective upon the application of hydraulic fluid at a second selected pressure to the same end thereof to turn said blades past said normal operating range to a feathered position, and effective upon the application of hydraulic fluid at a third selected pressure to the opposite end thereof to restore said blades from the feathered position to said operative range, and pressure responsive means effective to change the application of hydraulic fluid from the blade pitch increasing side to the blade pitch decreasing side of said piston upon the application thereto of hydraulic fluid at said third selected pressure and to simultaneously provide a drain from the space at the blade pitch increased end of said piston.

18. In a controllable pitch propeller having a hub member adapted to be secured upon the end of a propeller shaft and provided with arms for rotatably receiving the propeller blades and a barrel member surrounding said hub member and the adjacent ends of said blades to secure said blades on said hub member, an expansible chamber hydraulic mechanism having a relatively fixed part secured to said barrel member and a relatively movable part operatively connected with said blades and effective upon the application thereto of hydraulic fluid at at least three graduated pressures to control the pitch of said blades in an operative range when subject to the lowest of said pressures, to turn said blades to a feathered position when subject to the intermediate pressure and to restore said blades from said feathered position to said operative range when subjected to the highest of said pressures, means for directing the application of hydraulic fluid at said low and intermediate pressures to a space in said hydraulic mechanism connected with the interior of said hub barrel and for directing the hydraulic fluid at the highest pressure to a space in said hydraulic mechanism separated from the interior of said barrel member by a hydraulic seal, whereby hydraulic fluid at only the lower pressures is permitted to enter the interior of said hub barrel.

19. In combination with a hydro-controllable propeller having blades rotatably mounted for pitch changing movements and a hydraulic mechanism for rotating said blades, and speed responsive means for controlling the pitch changing movements of said blades within a predetermined range of pitch adjustment, means for supplying hydraulic fluid at at least two different pressures to said hydraulic mechanism, a fluid passage in said propeller leading to said mechanism, and valve means responsive to movements of said pitch changing mechanism to close said fluid passage at a particular position of the movable element of said mechanism corresponding to a predetermined pitch angle and responsive to an increase in the pressure of the hydraulic fluid to reopen said fluid passage.

20. In combination with a hydro-controllable propeller having blades rotatably mounted for pitch changing movements and a hydraulic mechanism for rotating said blades, and speed responsive means for controlling the pitch changing movements of said blades within a predetermined range of pitch adjustment, means for supplying hydraulic fluid at at least two different pressures to said hydraulic mechanism, a valve actuated by said hydraulic mechanism to limit the pitch changing movements of said blades to said predetermined range, and a valve responsive to the higher of said pressures to bypass said mechanism actuated valve.

21. In combination with a hydro-controllable

propeller having blades rotatably mounted for pitch changing movements and a hydraulic mechanism for rotating said blades, and speed responsive means for controlling the pitch changing movements of said blades within a predetermined range of pitch adjustment, means for supplying hydraulic fluid at at least two different pressures to said hydraulic mechanism, and a combination of valves for providing said propeller with a range of constant speed pitch adjustment and a range of pitch adjustment outside of said constant speed range comprising, a valve for directing the hydraulic fluid through said speed responsive device when subjected to the lower of said two pressures and for bypassing said speed responsive device when subjected to the higher of said two pressures, a valve responsive to movements of said hydraulic mechanism to cut off the supply of hydraulic fluid from said responsive mechanism to said blade rotating mechanism when the mechanism reaches a predetermined point in its pitch changing movements, and a valve for opening a bypass around said cut off valve when subjected to the higher of said pressures.

22. In combination, a controllable-pitch propeller having a hub and blades rotatably carried by said hub for pitch changing movements, an expansible chamber mechanism for controlling the pitch changing movements of said blades, means for supplying fluid under pressure to said mechanism, means for regulating the pressure of said fluid to at least two different values, a pair of opposed limit stops for determining the entire range of pitch changing movements of said blades, and an intermediate pitch limit stop actuated by said mechanism operative at a predetermined pitch setting to cut off the supply of pitch changing fluid at one of said pressures to said mechanism but ineffective to cut off said fluid if the fluid pressure is increased to the other of said values.

23. In combination with a controllable-pitch propeller having a pitch changing mechanism operative to vary the propeller pitch through more than one range of pitch angles, means for supplying hydraulic fluid to said pitch changing mechanism at pressures within either of two different predetermined pressure ranges, a valve actuated by said pitch changing mechanism for restraining said mechanism against increasing the pitch of said propeller beyond a predetermined pitch angle when supplied with fluid at a pressure within the lower of said predetermined ranges, a pressure responsive valve for rendering said first mentioned valve ineffective to restrict the action of said mechanism when said mechanism is supplied with fluid at a pressure within the higher of said predetermined ranges, and manually controllable means for selecting the pressure range of the fluid supplied to said pitch changing mechanism.

24. In a controllable-pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movement, a fluid pressure actuated motor carried by said hub and having a movable portion operatively connected with said blades to change the pitch thereof, a conduit for conducting hydraulic fluid at pressures within different selectable pressure ranges to said motor, a positive high pitch limit stop and a positive low pitch limit stop carried by said hub for determining the entire range of pitch changing movement of said blades, valve means operatively associated with said conduit including a movable element movable to a valve opening position by pressure of said fluid acting thereon and effective upon movement thereof from a valve opening position to a valve closing position to interrupt the flow of fluid at pressures below a predetermined value to said motor and thus discontinue the operation of said motor by fluid from said conduit at pressures below said predetermined pressure, and means movable with the movable element of said motor operatively associated with the movable element of said valve means to close said valve and thus interrupt the flow of fluid from said conduit to said motor at a predetermined pitch angle between the pitch angles determined by said positive pitch limit stops.

25. In a controllable-pitch propeller having a hub and blades rotatably mounted in said hub for pitch changing movement, a hydraulic motor carried by said hub having a movable part operatively connected with said blades to change the pitch thereof, a positive low pitch limit stop and a positive high pitch limit stop carried by said hub for determining the entire range of pitch changing movement of said blades, and a conduit for conducting hydraulic fluid at pressures within different selectable pressure ranges to said motor to increase the pitch of the propeller blades and to vent exhaust fluid from said motor to permit the propeller blade pitch to decrease, valve means operatively associated with said conduit including an element movable to a valve opening position by the presure fluid in said conduit and movable to a position to block said conduit and interrupt the flow of fluid to said motor, and a check valve also operatively associated with said conduit to vent exhaust fluid from said motor when said conduit is blocked by said movable element, and a displacement element carried by the movable part of said motor and operatively engageable with the movable element of said valve to close said valve and thus interrupt the flow of fluid at pressures within a predetermined low pressure range through said conduit to said motor at a predetermined pitch angle between the limiting pitch angles as determined by said positive limit stops.

26. In the combination of a hydraulically actuated controllable-pitch propeller and means for supplying pitch changing hydraulic fluid to said propeller at pressures within any selected one of different pressure ranges, a propeller hub, a plurality of blades rotatably supported in said hub for pitch changing movements, a hydraulic motor carried by said hub and having a movable member operatively connected with said blades for changing the propeller pitch, a single conduit extending between said fluid supplying means and said motor, and a valve carried by said hub and hydraulically connected with said conduit and with said motor at opposite sides of said movable element, said valve including an element movable by the pressure of the fluid in said conduit normally blocking the connection between said conduit and said motor at one side of said movable member while providing a connection between said conduit and said motor at the opposite side of said movable member, whereby said movable member will move in one direction upon the application of fluid under pressure to said motor through said conduit and said valve, said valve element being movable in one direction by an increase in the pressure of the fluid in said conduit above a

predetermined pressure to connect said motor at said one side of said movable member with said conduit and block the connection between said conduit and said motor at said opposite side of said movable member and simultaneously open a fluid vent from said motor at said opposite side of said movable member, whereby said movable member will move in the opposite direction upon the application of hydraulic fluid at said increased pressure through said conduit and said valve to said motor.

27. In a controllable-pitch propeller having a hub, blades mounted in said hub for pitch changing movements, a double acting hydraulic mechanism operatively associated with said blades for changing the pitch thereof, means for supplying hydraulic fluid at different selectable pressures, and a single conduit extending between said fluid supply means and said hydraulic mechanism for conducting fluid at said different pressures, a valve having separate hydraulic connections, one with said single conduit and one with each side of said double acting mechanism, said valve including an element subject to the fluid pressure in said conduit resiliently urged to a position opening a fluid passage from said conduit to a predetermined side of said hydraulic mechanism and movable by a predetermined increase in the pressure of the fluid in said conduit to close said passage and open another passage from said conduit to the other side of said mechanism while simultaneously opening a vent from said predetermined side of said mechanism for venting hydraulic fluid from said predetermined side of said mechanism.

28. In a controllable pitch propeller having a hub, blades mounted in said hub for pitch changing movements, a double acting hydraulic mechanism operatively associated with said blades for changing the pitch thereof, means for supplying hydraulic fluid at different predetermined pressures to said mechanism, and a single conduit extending between said fluid supply means and said mechanism; a valve carried by said hub and disposed between said mechanism and said conduit, said valve having a pair of ports connected one with each side of said double acting mechanism, a fluid passage normally extending through said valve from said conduit to one of said ports, a vent normally connected with the other of said ports whereby the application of fluid under pressure to said hydraulic mechanism through said conduit will change the pitch of said propeller in one direction, said valve including a movable member having two operative positions effective to change the connection between said conduit, said vent and the respective ports upon moving from one of said operative positions to the other, a spring resiliently urging said movable member to one of said operative positions, and a piston operatively connected with said movable member and having its face exposed to the fluid in said conduit to overcome the force of said spring and move said movable member to the other of said operative positions when the pressure of the fluid in said conduit exceeds a predetermined value, whereby the application of hydraulic fluid at pressures in excess of said predetermined value through said conduit to said hydraulic mechanism will change the pitch of said propeller in the opposite direction.

ERLE MARTIN.
JOHN ELMER ANDERSON.
MURRAY C. BEEBE.