Dec. 22, 1953 N. R. RICHMOND 2,663,373

REVERSIBLE PITCH PROPELLER

Filed Sept. 14, 1946 3 Sheets-Sheet 1

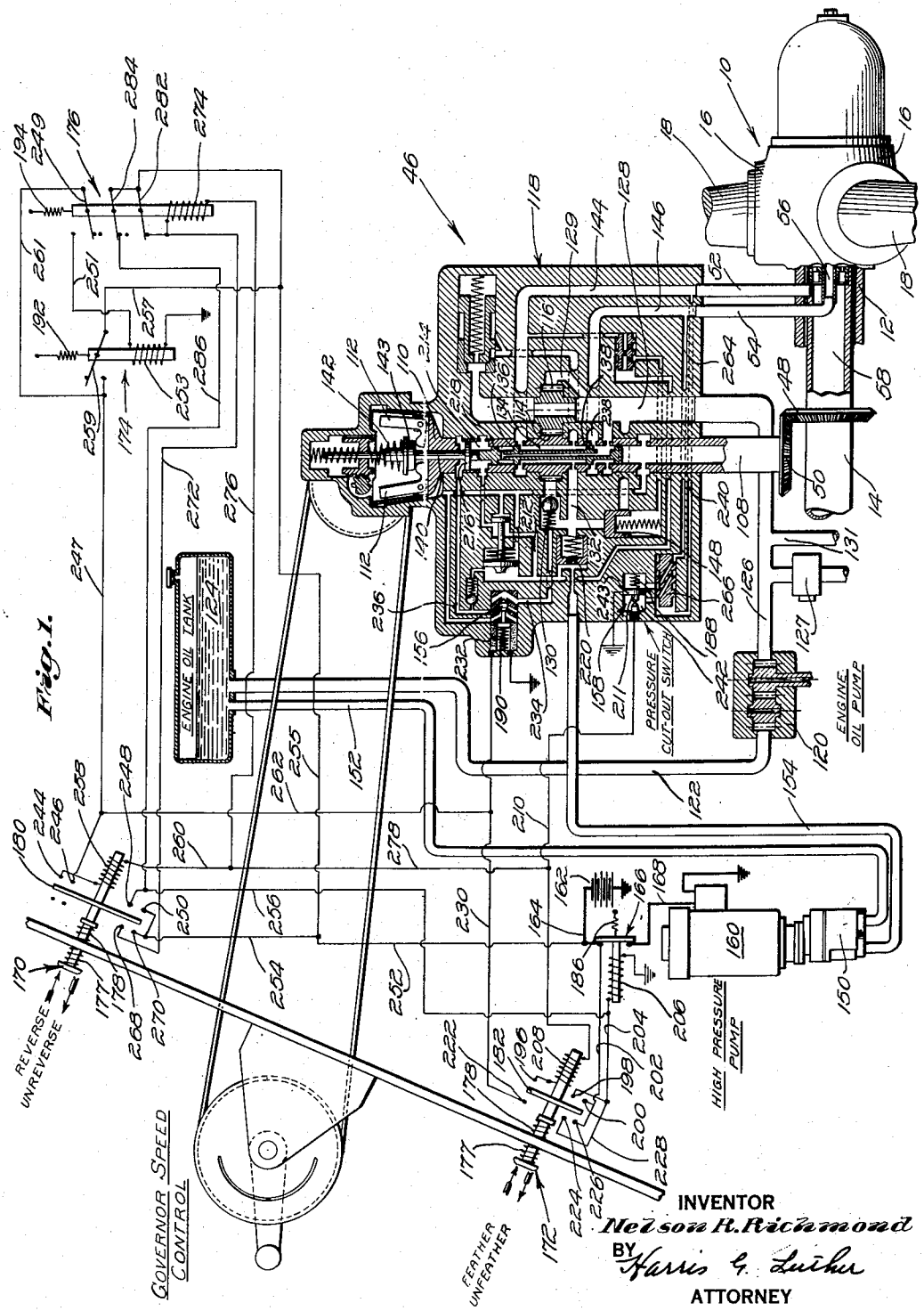


Fig. 1.

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REVERSIBLE PITCH PROPELLER

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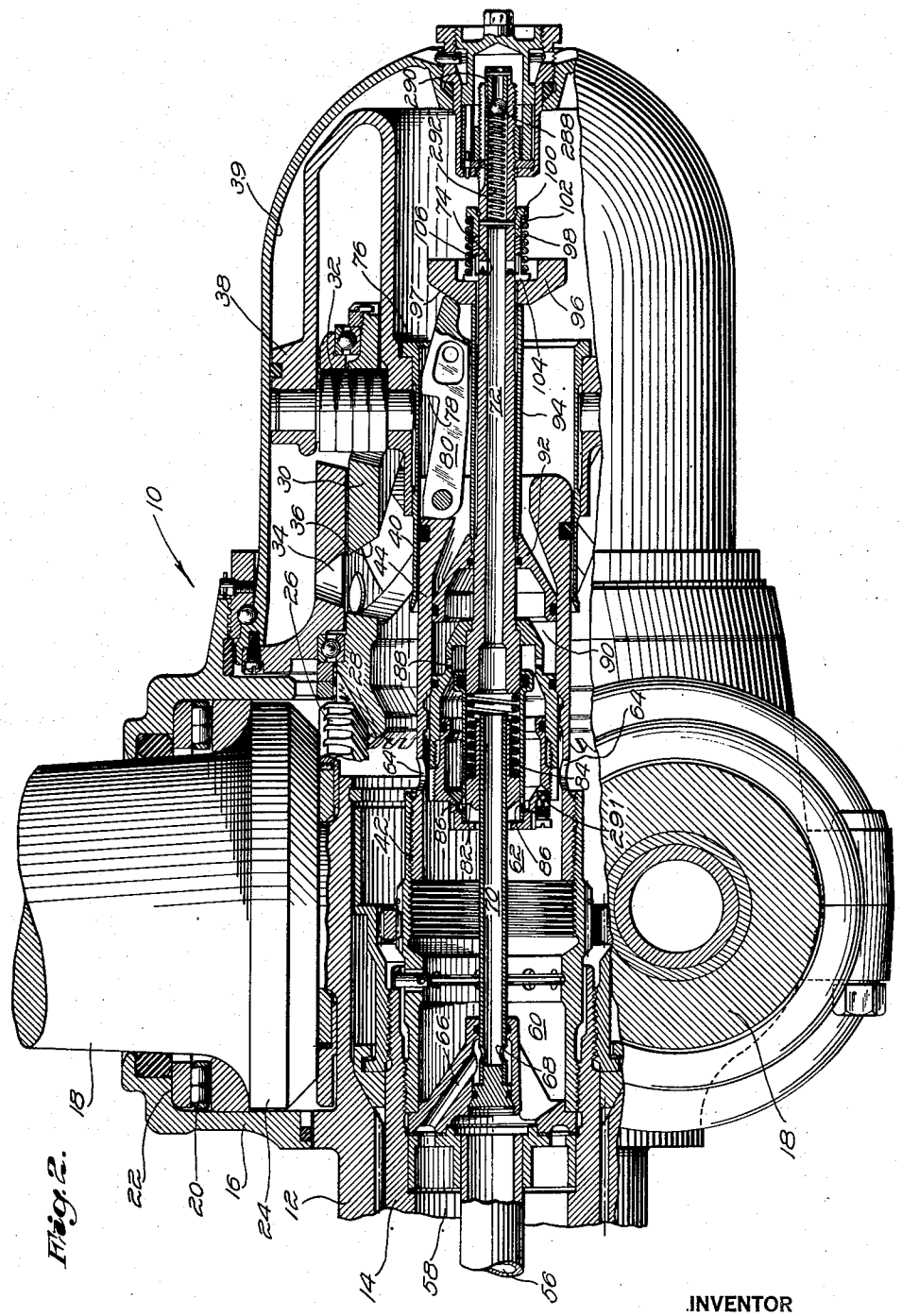


Fig. 2.

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REVERSIBLE PITCH PROPELLER

Filed Sept. 14, 1946 3 Sheets-Sheet 3

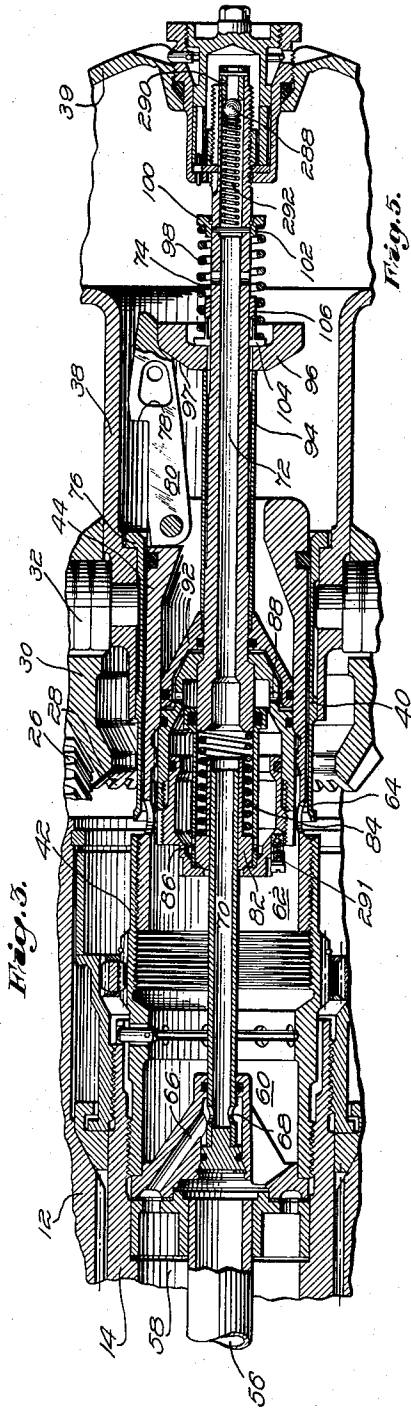


Fig. 3.

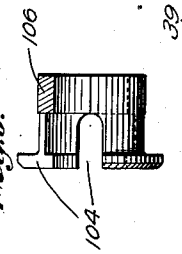


Fig. 5.

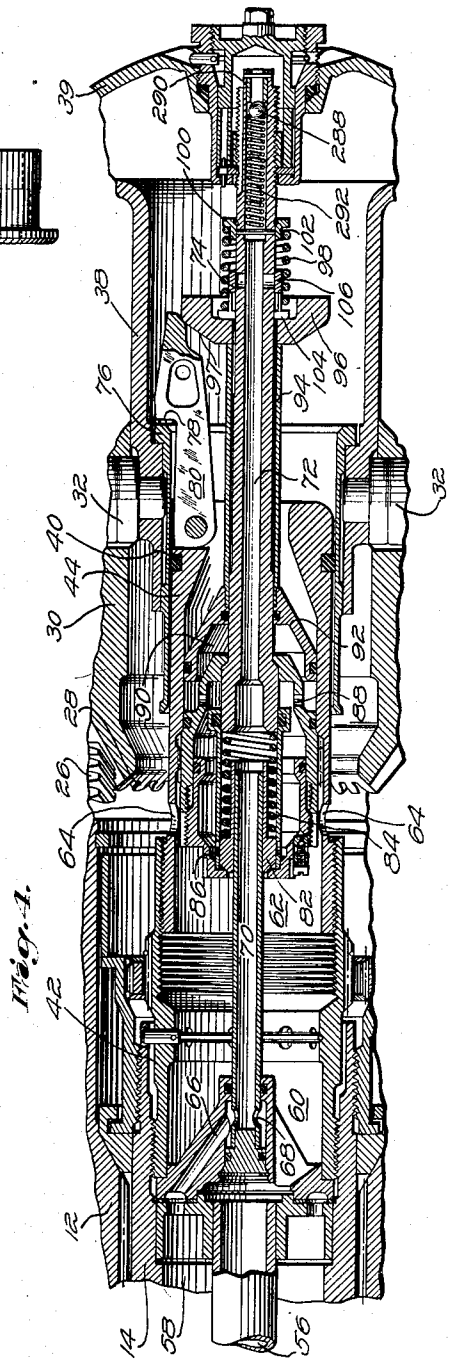


Fig. 4.

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Patented Dec. 22, 1953 2,663,373

UNITED STATES PATENT OFFICE

2,663,373

REVERSIBLE PITCH PROPELLER

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Application September 14, 1946, Serial No. 697,065

25 Claims. (Cl. 170—160.2)

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This invention relates to hydro-controllable propellers, and particularly to propellers of this type which may be feathered or reversed, and to improved control mechanism operative during unreversing of the propeller blades.

In propellers having pitch changing means capable of turning the blades beyond the normal operative range, in which their pitch angle is usually automatically controlled by a governor, into extreme or special purpose ranges such as feathered or reverse pitch positions, it is usual to operate the propeller blades in the normal range by a relatively low fluid pressure which is adequate to overcome the aerodynamic and centrifugal twisting moments exerted against the blades in this range, and to operate the blades into and out of the extreme positions thereof by a higher fluid presure to which the propeller pitch changing mechanism is subjected only while the propeller is in or being changed to or from these extreme special purpose ranges.

It is an object of this invention to provide improved means for controlling the admission of the higher pressure fluid (hereinafter referred to as the high pressure fluid) to the propeller.

Another object of the invention is to provide improved means operative during unreversing for interrupting the admission of high pressure fluid to the propeller pitch changing mechanism when the propeller has returned to the governor controlled constant speed range.

A further object of the invention is to provide means in the high presure fluid system which is automatically actuated by return of the low pitch stops to operative position for creating a pressure surge in the system to interrupt the supply of high pressure fluid to the propeller.

A still further object of the invention is generally to improve the construction and operation of governor controlled pitch changing propellers.

These and other objects and advantages of the invention will be apparent from the specification and claims, and from the accompanying drawings which illustrate what is now considered to be a preferred embodiment of the invention.

In these drawings,

Fig. 1 is a diagrammatic view showing the propeller hub, the constant speed control means and associated control apparatus for feathering, unfeathering, reversing and unreversing the propeller with the parts shown in the position assumed during unreversing, the constant speed control means and part of the propeller hub being shown in section;

Fig. 2 is a view partly in section showing the propeller hub on an enlarged scale with the parts in the reverse pitch position;

Fig. 3 is a sectional view of a portion of the hub structure of Fig. 2 with the parts in the feathered position;

Fig. 4 is a sectional view of the hub structure of Fig. 3 with the parts in the position in which the retractible low pitch stops are being returned to operative position at the end of the unreversing movement of the blades; and

Fig. 5 is an enlarged detail of a sleeve in the pitch changing motor.

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As herein shown, Fig. 1 illustrates diagrammatically the principal elements of a controllable pitch, reversing and feathering type propeller embodying the invention. Such a propeller, as generally indicated by the numeral 10, includes a hub 12 splined to a propeller drive shaft 14 provided with a plurality of radially disposed blade receiving sockets 16, one of which is indicated in section in Fig. 2. The propeller also includes a plurality of blades 18 one of which is mounted in each socket in the usual manner including suitable anti-friction bearings 20 interposed between a socket abutment 22 and flange 24 on the inner end of the blade so that the blades are freely rotatable about their longitudinal axes in pitch changing directions. Each blade 18 is provided on its inner end within the hub member 12 with a gear sector 26 all of which gear sectors mesh with a master gear 28 journalled in the hub member 12 and rotatable about the axis of shaft 14. Master gear 28 is integral with a rotatable cam 30 rotated through a cam and follower mechanism including movable piston carried cam followers, one of which is shown at 32, and cooperating opositely directed stationary and movable cam slots 34 and 36. The cam followers 32 are carried by an annular piston 38, reciprocable in a cylinder 39 having a dome-shaped outboard end, the piston having a tubular hub provided with a sleeve 40 mounted for reciprocation on a tubular shaft extension formed by the telescoping threaded tubes 42 and 44 carried by shaft 14. The piston 38 is shown as sealed at the cylinder 39 and at the tubular extension 44 by the usual O-ring seals. From the above descrption, it will be evident that a preponderance of oil pressure upon either side of piston 38 will cause the piston to move and change the pitch of all of the propeler blades 18 in unison.

Oil is conducted from a control unit, generally indicated at 46 (Fig. 1), and driven by gears 48 and 50 in timed relation to the propeller, to cylinder 39 through two fluid conduits 52 and 54 and

communicating channels 56 and 58 leading into the propeller hub. The unit 46 acts to selectively connect one of the lines 52, 54 to governor pressure and to connect the other line with drain in order to move the piston 38 and change the pitch of the propeller blades the required amount to maintain constant speed of the engine and propeller. Thus when the unit supplies fluid, for example oil, under pressure to conduit 54 the oil flows through channel 56, chamber 60 within tubular extension 42, chamber 62 within tubular extension 44 and holes 64 to the rear of piston 38. When the unit supplies oil under pressure through conduit 52 oil flows through channel 58, oblique passages 66, holes 68 through an axial conduit 70, through a communicating axial conduit including conduit 72, through radial passages 74 in the side wall of conduit 72 to cylinder 39 on the front or outboard side of piston 38. It will be understood that when one side of the piston is connected to pressure fluid through one of the above fluid lines the fluid on the other side of the piston is connected to drain through the other line in the usual manner.

The piston 38 when under the constant speed control of the unit moves in an intermediate range of its full stroke in which it is prevented from moving in the outboard direction beyond a low pitch position determined by the engagement of the forward end 76 of sleeve 40 with the abutment shoulders, or low pitch stops, 78 on a plurality of latches 80 which are pivotally mounted on the outboard end of shaft extension 44. The inboard movement of the piston 38 in the constant speed range is limited by the shape of the cam slots in which the follower members 32 move, the pitch of these slots increasing so abruptly at the high pitch end of the constant speed range that the oil pressure supplied by the pump 114, 116 (hereinafter described) is insufficient to overcome the friction, aerodynamic and centrifugal loading on the blades.

The piston 38 can be moved beyond the constant speed governor controlled range in either direction whenever the high pressure fluid is admitted to the propeller hub through conduit 52 or 54. This high pressure fluid, when supplied to the outboard side of piston 38 through conduit 52, is sufficient to overcome the loading on the blades at the full pitch end of the constant speed range to move the blades into the feathered position thereof. The piston is stopped in the feathered position of the blades either by the end walls of the cam slots or by positive mechanical limit stops provided on the rotatable member 30 and the hub structure and described in Patent No. 2,280,713.

When the high pressure fluid is supplied to the rear of the piston through conduit 54, this pressure acting on the piston 82 which is in communication with chamber 62 compresses the spring 84 which admits high pressure fluid through holes 86 and holes 88 to chamber 90. The pressure in chamber 90 acting on piston 92 moves the latter in an outboard direction and, through the action of a sleeve 94 the outboard end of which abuts a wedge ring 96, moves the wedge ring in an outboard direction against the action of spring 98 a suffiicient distance to permit the latches 80 to move inwardly at their outboard ends along the inclined faces 97 of wedge ring 96. This inward movement of the latches 80 is caused by the axial thrust of sleeve 40 of piston 38 acting on the latch shoulders 78 in an outboard direction eccentrically of the latch pivots. The inward movement of latches 80 permits end 76 of sleeve 40 to pass off latch faces 78 and over these latches, enabling the piston 38 to continue its movement in an outboard direction beyond these low pitch limit stops into the reverse pitch range shown in Fig. 2.

It will be noted that at its outboard end spring 98 bears against an abutment 100 on a sleeve 102 which is fixed to axial conduit 72. At its inboard end spring 98 engages interrupted flange 104 of a sleeve 106. As shown particularly in Figs. 3 and 4, the interruptions in the flange 104 extend into the adjacent end of sleeve 106. Sleeve 106 occupies the same position in both the constant speed and feathered ranges so that in Fig. 3 the sleeve 106 is shown in the position it occupies in the constant speed range. It will be evident that when governor pressure is supplied to either the inboard or the outboard side of piston 38, passages 74 are freely open into the outboard end of cylinder 39 since the fluid pressure supplied by the governor acting on piston 82 is not sufficient to overcome spring 84 and consequently the sleeve 106 remains wholly on the inboard side of passages 74. However, when fluid under high pressure is supplied through tube 52, piston 82 compresses spring 84 and the piston 92 compresses the spring 98 and moves the uninterrupted portion of sleeve 106 wholly on the outboard side of passages 74 as shown in Fig. 2. In either case, the pressure fluid is free to pass from the tube 72 through passages 74 into the portion of cylinder 39 which is outboard of piston 38.

The governor is shown diagrammatically in Fig. 1 to which reference is now made. The governor comprises a rotatable drive shaft 108 carrying gear 50 which meshes with the gear 48 carried by the engine driven shaft 14. A flange 110 which is fixed to the upper ends of shaft 108 pivotally supports a pair of governor fly weights 112. The shaft 108 may be made in a single piece, as shown, or if desired may comprise several sections connected together, as by splined joints.

Intermediate its ends the shaft 108 carries a gear 114 meshing with a gear 116 supported on a hollow axle journalled in a governor base 118 to form a booster pump providing a source of fluid pressure. Hydraulic fluid is supplied to this pump from any convenient source, the source shown herein being the engine lubricating pump 120 which is supplied through a conduit 122 from the engine oil tank, or reservoir, 124 and discharges through conduit 126, duct 128 and branch passage 129 to the intake of the booster pump. A relief valve 127 limits the pressure in conduit 126 and in conduit 131 leading to the engine lubricating system. Oil from the booster pump flows through check valve 130 and channel 132, through ports in the hollow shaft 108 into annular pressure chamber 134 between annular lands 136 and 138 on a hollow piston rod of a governor pilot valve 140 which is vertically reciprocable in the hollow shaft 108 by the governor fly weights 112 and a governor speeder spring 142 which act oppositely on a flange 143 on the piston rod. When the pilot valve 140 is forced upwardly low pressure oil supplied by the booster pump 114, 116 flows from the chamber 134 through ports in shaft 108 to channel 144 which communicates with conduit 52, as shown in Fig. 1. When the low pressure oil is connected to conduit 52 the conduit 54 is connected through channel 146 and suitable ports in shaft 108 beneath the land 138 to the booster pump inlet channel 128,

thus establishing a vent through relief valve 127 of conduit 131 for oil on the inboard side of the pitch changing piston 38. The result of admitting governor pressure fluid through conduit 52 is, as previously described, to move the piston 38 inboard i. e. to increase the pitch of the blades with a resultant decrease in R. P. M. As the governor fly balls 112 slow down they permit the speeder spring 142 to depress the piston rod of valve 140 so that the land 136 cuts off the low pressure governor fluid passing from chamber 134 to channel 144 when the predetermined speed has been reached for which the governor is set.

If the governor speed falls below the predetermined value, pressure fluid in chamber 134 will be admitted past the land 138 to channel 146 and conduit 54 to move piston 38 towards low pitch position, while the fluid on the outboard side of piston 38 will be vented through conduit 52, channel 144 and the hollow stem of pilot valve 140 into the intake channel 128 of the governor booster pump. A constant pressure valve 148 is provided in the governor booster pump discharge as is usual in this type of governor.

High pressure fluid is supplied to the pitch changing mechanism in the propeller hub for moving the piston 38 beyond the intermediate constant speed range above described into the special purpose ranges in which the blades are feathered in one extreme position and reversed in pitch at the other extreme position thereof. To this end a high pressure pump 150 providing a separate source of fluid pressure is supplied from reservoir 124 through conduit 152 and discharges through conduit 154 into the governor base 118.

The admission of high pressure fluid from pump 150 to opposite sides of piston 38 is controlled in part by the valve mechanism, already described, in the propeller hub and by the governor pilot valve. A solenoid valve 156 controls the fluid pressure on the upper side of land 216 on the piston rod of valve 140 to position the governor pilot valve 140 to selectively admit high pressure fluid to either conduit 52 or 54 leading to the pitch control mechanism in the hub. A pressure cut-out switch 158 is also provided for interrupting the operation of the high pressure pump 150 as will later appear. High pressure pump 150 is driven by an electric motor 160 energized by a battery or other suitable source of power 162 through conductor 164, switch 166 and conductor 168. The electric control apparatus controlling the operation of switch 166, solenoid valve 156 includes cut-out switch 158 and also includes push-pull switch 170, push-pull switch 172, solenoid switch 174 and solenoid switch 176.

The switches 170 and 172 are normally biased by compression springs 177 and 178 into an intermediate, switch-open position in which their movable bridging contacts 180 and 182 are held between and out of contact with two sets of stationary contacts, one of which sets is engaged by the bridging member when the switch is pulled and the other of which is engaged when the switch is pushed. The movable contact member of solenoid switch 166 is constantly biased into open position by a spring 186, while the movable contact member of cut-out switch 158 is constantly biased into closed position by compression spring 188. Solenoid valve 156 is constantly biased to the right as viewed in Fig. 1 by compression spring 190, while the movable switch members of solenoid switches 174 and 176 are biased upwardly as viewed in Fig. 1 by tension springs 192 and 194.

To operate the propeller blades into feathered position the movable switch member of switch 172 is pushed to compress spring 177 and bridge one set of stationary contacts comprising contacts 196, 198 and 200. This completes a circuit from the positive side of battery 162 through conductors 164 and 202 to contact 200, through movable contact 182 to contact 198, through conductor 204 and solenoid 206 of switch 166 closing the circuit of motor 160 to start the high pressure pump 150. The above operation of switch 172 also establishes a circuit from battery 162 through conductors 164 and 202 contact 200, movable contact 182, contact 196, holding coil 208, conductor 210, and contacts of cut-out switch 156.

High pressure fluid will flow from conduit 154 through channel 212 and ports in hollow shaft 108 into chamber 214 between larger diameter land 216 and smaller diameter land 218 on piston rod of valve 140, thus moving the governor pilot valve upward (Fig. 1) so that high pressure fluid from conduit 154 can pass through holes 220 and channel 132 into chamber 134 within shaft 108 and thence to channel 144 and conduit 52. As previously explained, this fluid will act on the outboard side of piston 38 with sufficient force to move follower members 32 into the steeper-sloped, special-purpose range of the cam slots to feather blades 18. As piston 38 reaches the position shown in Fig. 3 in which the blades are feathered, it reaches the limit of travel in this direction either by the engagement of followers 32 with the ends of cam slots 34, 36 or by engagement of special stops which may be provided for this purpose. High pressure builds up on the discharge side of pump 150 and on the outboard side of piston 38 when the piston travel is stopped. This pressure acting through passage 240, which communicates with conduit 52, and chamber 242 of pressure cut-out switch 158 causes movable contact 211 of this switch which is carried by piston 243 to open the circuit for holding coil 208, allowing spring 177 to return switch 172 to its intermediate open switch position. This also interrupts the circuit through solenoid 206, resulting in stopping high pressure pump 150 with the propeller blades in feathered position. The engine cannot rotate the propeller in the feathered position of the blades and consequently the propeller and the governor will stop rotating and the blades will remain in feathered position until unfeathered.

In order to unfeather the blades switch 172 is pulled to compress spring 178 and move bridging member 182 into engagement with stationary contacts 222, 224 and 226, thus establishing a circuit from battery 162 through conductors 164 and 202, contacts 226, 182 and 224, conductors 228 and 204 and solenoid 206 to close switch 166 and start the operation of high pressure pump 150. A circuit is also completed from battery 162 through conductors 164, 202, contacts 226, 182 and 222, conductor 230 and solenoid 232 of valve 156. High pressure fluid now flows from conduit 154 through holes 220 and channel 234 through valve 156, this valve now being moved to the left as viewed in Fig. 1 to permit the fluid to pass from channel 234 through channel 236 to act on the upper surface of large diameter land 216. The high pressure fluid also flows as before through channel 212 into chamber 214 where it acts on the bottom surface of land 216 and also on the top surface of land 218. Since the fluid pressures

on land 216 are balanced, the pressure on the top surface of land 218 causes pilot valve 140 to be depressed into a position such that the high pressure fluid which passes through holes 220 and channel 132 into chamber 134 is now permitted to enter the annular passage 238 which communicates with channel 146 and conduit 54, leading to the inboard side of piston 38, to unfeather the blades.

In carrying out the unfeathering operation during flight the switch 172 is held out manually while the piston 38 moves the blades from the feathered position, shown in Fig. 3, until the propeller starts to windmill. This can be determined by watching either the propeller or the engine speed indicator. The switch 172 is then released, the high pressure source 150 will be immediately shut off and the governor will take over.

To reverse the pitch of propeller blades 18 the pilot pushes switch 170 to bridge the stationary contacts 244, 246, 248 and 250. As a result four circuits will be established: (1) a circuit from battery 162 through conductors 164, 252 and 254, contacts 250, 180 and 248, conductor 256, solenoid 208 of switch 166 and pump motor 160 of high pressure pump 150; (2) a circuit from battery 162 through conductors 164, 252 and 254, contacts 250, 180 and 244 holding coil 258, conductors 260 and 210 and contacts of the pressure cut-out switch 158; (3) a circuit from the battery 162 through conductors 164, 252 and 254, contacts 250, 180 and 245, conductor 262 and solenoid coil 232 of valve 156; and (4) a circuit from battery 162 through conductors 164, 252 and 254, contacts 250, 180 and 246, conductors 247 and 261, normally closed switch 249 of solenoid switch 176, conductor 251 and coil 253 of solenoid switch 174. High pressure fluid is now supplied from conduit 154 through holes 220, valve 156 and conduit 236 to the upper side of land 216. High pressure fluid also passes through channel 212 to chamber 214 where it acts on the upper surface of land 218 and on the lower surface of land 216. Pilot valve 140 consequently moves downward to admit high pressure fluid from chamber 134 past the upper surface of land 138 into annular chamber 238 and communicating channel 146 and conduit 54.

The high pressure fluid flows as previously described through passage 56, chamber 60, and holes 64 to the inboard side of piston 38 to move the latter in an outboard direction, this pressure acting on piston 38 being sufficient to force the piston 32 to the right (Fig. 2), allowing access of the high pressure fluid to piston 92 which moves wedge ring 96 against the action of spring 98 and permits the sleeve 40 to override latches 80 as shown in Fig. 2. During this movement of piston 38 the fluid on the outboard side of the piston has been vented through ports 74, tubes 72 and 70, oblique passages 66, passage 58 and conduit 52 which is in communication through channel 144 and the hollow interior of the valve stem of governor pilot valve 140 with the low pressure fluid duct 128. This position of the parts in which propeller blades 18 are in reverse is shown in Fig. 2.

It will be noted that the sleeve 106 moves across the holes, or ports, 74 as the spring 98 is compressed during the reversing operation. A ball check valve 288 is provided in the outboard end of the passage in tube 72 which seats against the end of a tubular member 290 staked in position in tube 72. A compression spring 292 constantly urges the ball valve against its seat to maintain this end of tube 72 normally closed. However, during the movement of sleeve 106 from the left-hand side of ports 74 to the right-hand side thereof in the operation of moving the propeller blades to reverse pitch, ports 74 are blocked by sleeve 106. Check valve 288, however, then opens to permit fluid on the outboard side of piston 38 to flow from cylinder 39 into tube 72 so that the outboard end of cylinder 39 is connected throughout this operation to vent either through ports 74 or check valve 288.

When the cam followers 32 have reached the outboard ends of the cam slots, or when the reverse pitch stops have engaged, if such stops are employed, the pressure on the inboard side of the piston 38 and in the conduits leading thereto builds up to the full pressure developed by the high pressure pump 150. This pressure in conduit 54 is transmitted through the fluid in a channel 264 to act on the right-hand end of the valve 266 and move the latter to the left admitting fluid to the chamber 242 of pressure cut-out switch 158 and causing the switch to open its contacts and interrupt the holding coil circuit for switch 170. Switch 170 will therefore move to its normal intermediate position shown in Fig. 1 when the blades have reached reverse pitch position and as a result all four circuits which were completed by pushing in switch 170 will be opened.

Means is provided, however, for maintaining the coil 232 of solenoid valve 156 energized following the above described automatic return of switch 170 to its open position. It will be recalled that circuit (4) above described energized solenoid 253 of switch 174. The closing of switch 174 establishes a circuit from battery 162, through conductors 164, 252, 255 and 257, movable switch member 259, conductors 247 and 262 and solenoid 232 of valve 156. A holding coil circuit is also established for solenoid switch 174 from battery 162, through conductors 164, 252 and 257, contact 259, conductor 261, normally closed switch 249 of solenoid switch 176, conductor 251 and solenoid 253.

It will thus be evident that when switch 170 opens following a reversing operation, the valve 156 remains energized. As a result the low pressure fluid from the governor booster pump flows through check valve 130, channel 234, valve 156, channel 236 to the upper side of land 216 which will keep the governor pilot valve 140 in the down position and maintain the propeller in reverse pitch.

To unreverse the propeller blades the switch 170 is pulled out to cause the bridging member 180 to connect contacts 268 and 270. This establishes a circuit from the battery 162 through conductors 164, 252 and 254, contacts 270, 180 and 268, conductor 272, solenoid 274 of solenoid switch 176, conductors 276, 278, 210 and contacts of pressure cut-out switch 158 thus actuating solenoid switch 176 to open switch 249 and close switches 284 and 282. Opening of switch 249 breaks the circuit for holding coil 253 of solenoid switch 174 causing 259 to open and interrupt the circuit including solenoid 232 of valve 156, thus returning valve 156 to the position shown in Fig. 1. As solenoid switch 176 closes, a holding coil circuit is established for the coil 274 from battery 162 through conductors 164, 252 and 255, movable contact 282, coil 274, conductors 276, 278, 210 and cut-out switch 158. Closing of solenoid switch 176 also estab-

lishes a circuit to energize the solenoid 206 controlling energization of motor 160 of high pressure pump 150. This circuit includes the battery 162, conductors 164, 252 and 255, movable contact 284, conductors 286, 256 and solenoid 206.

The control apparatus is shown in Fig. 1 in the position which it occupies after switch 170 has established the above described circuits to unreverse the blades and has been released and spring 178 has returned it to its intermediate position. Since a holding coil circuit is immediately established for coil 274 of switch 176, it is not necessary to hold the switch 170 out manually. Accordingly, this switch is shown in its intermediate position which it would occupy following an initiation of the unreversing operation in which the pilot has pulled out on switch 170 and has then released it.

High pressure fluid from the pump 150 discharged through conduit 154 acts on the lower face of land 216 to raise the pilot valve 140 in the governor shaft as previously described in connection with the feathering operation, it being noted that the solenoid 232 of valve 156, as in the feathering operation, is not energized to admit high pressure fluid to the top of land 216. Consequently the high pressure fluid flows through holes 220, passage 132, chamber 134 in governor drive shaft 108, past the lower edge of land 136, into conduit 144 and conduit 52 leading to chamber 58 in the propeller hub. The high pressure fluid passes through oblique passages 66 (Fig. 2), hole 68, tube 70 and tube 72, holes 74 and slots 104 in sleeve 106 to the right-hand, or outboard, side of piston 38 thus moving this piston inboard from the reverse pitch range into the normal, governor controlled range.

It will be noted that as the piston 38 moves inboard the latches 80 are prevented from moving outward by their engagement with sleeve 40 until the sleeve has reached the position shown in Fig. 4 in which it has moved inwardly beyond the latch faces 78. At this moment the latches, under the action of centrifugal force and also under the action of spring 98 acting on wedge ring 96, move outwardly about their pivots into the position shown in Fig. 4 in which their latch faces 78 again constitute low pitch limit stops to prevent outboard movement of sleeve 40 under governor oil pressure. At the same time that the latches 80 move outwardly sleeve 106 has moved inboard with wedge ring 96 and occupies the position shown in Fig. 4 in which it closes the holes 74 in tube 72 through which the high pressure fluid is being supplied to piston 38. As a result, a high pressure surge occurs in the high pressure fluid line including conduit 52 and channel 144 which is communicated through channel 240 to chamber 242 of the pressure cut-out switch, causing this switch to open its contacts and de-energize the holding coil 274 of switch 176. The de-energization of relay 176 immediately opens switch 284 and shuts down the high pressure pump 150. The piston is now inboard of latch faces 78, comprising the low pitch stops and the governor will take over and control the pitch of the blades to maintain the predetermined speed for which the governor is set.

When the high pressure pump 150 is cut off at the end of the reversing operation, the inboard side of piston 38 is connected to the outlet for the low pressure acting on piston 82 to maintain spring 84 compressed. Piston 82 consequently moves to the left (Fig. 2) and closes ports 86 leading to chamber 90. Piston 92, however, remains in the position shown in Fig. 2 because latches 80, being held in Fig. 2 position by sleeve 40, hold wedge ring 96 in the extreme outboard position thereof against the action of spring 98.

During the unreversing operation, movement of wedge ring 96 to the left in Fig. 2 moves piston 92 with it causing the fluid trapped in chamber 90 by the closing of ports 86 to be compressed. A ball check valve 291 is provided for permitting this trapped fluid to escape into chamber 62.

It will be evident that as a result of this invention a particularly simple and reliable means has been provided which is entirely automatic for returning the propeller to governor operation following initiation of the unreversing operation by the pilot. It will further be evident that the improved means above described insures that the propeller will be subjected to the high pressure fluid only during the short time that it is actually required for moving the blades in the special purpose ranges beyond the normal governor controlled range. It will further be noted that the improved means of this invention for returning the control to the governor does not require the attention of the pilot during unreversing, the only action of the pilot which is required being the pulling out of the switch 170 to initiate the unreversing operation.

While one embodiment of the invention has been shown and has been described and illustrated in the accompanying drawings it will be understood that this particular embodiment of the invention is shown for purposes of illustration only and that various changes in the construction and operation of the mechanism may be made without departing from the spirit and the scope of the invention as defined in the appended claims.

What it is desired to secure by Letters Patent is:

1. In combination, a propeller having variable pitch blades, a hydraulic pitch changing motor therefor, a governor controlling the admission of fluid to said motor in a normal operating range of pitch variation, a source of fluid pressure for operating said motor to move said blades beyond the governor controlled range, a fluid passage for connecting said source with said motor, pressure responsive means connected with said fluid passage for controlling said fluid pressure source, and means for creating a pressure surge in said fluid from said source to actuate said pressure responsive means when said propeller blades have been moved to feathered position or reverse position and also when in unreversing movement they have reached the normal governor controlled range, said surge creating means including a valve for temporarily altering the flow of fluid from said source to said motor incident to movement of said blades in unreversing movement past a predetermined position into said normal range.

2. In combination, a propeller having variable pitch blades, a hydraulic pitch changing motor therefor, a source of fluid pressure, a governor controlling the admission of fluid to said motor from said source in a normal operating range of pitch variation, means including a second source of fluid pressure for operating said motor to move said blades beyond said governor controlled range into feathered and reverse pitch ranges, hydraulically actuated means for disabling said second fluid pressure source, and means for automatically actuating said disabling means when

said blades have been moved by said motor to feathered position or reverse pitch position, a valve, a hydraulic connection between said valve, said source and said disabling means, and means for automatically actuating said valve to actuate said disabling means, when in the unreversing movement said blades have reached the normal governor controlled pitch range.

3. In a propeller having mechanism actuated by a pressure surge, a fluid line leading to said propeller, means for creating a pressure surge in fluid flowing in said line comprising a normally open valve in said line, mechanical stop means for limiting pitch changing movement of said propeller and means controlled by said stop means for closing said valve while fluid is flowing in said line to thereby create a pressure surge.

4. In a propeller, a plurality of variable pitch blades, a blade pitch changing motor, means for supplying operating fluid to said motor including a pump and a fluid line leading from said pump to said motor, means actuated by a pressure surge in said line to disable said pump, means for creating a pressure surge comprising a normally open valve in said fluid line, mechanical stop means for limiting the blade pitch changing movement of said propeller and means controlled by said stop means for closing said valve while fluid is flowing in said line to thereby create a pressure surge.

5. In combination, a propeller having variable pitch blades, a fluid operated pitch changing motor therefor, a source of fluid pressure, a governor controlling the admission of fluid from said source to said motor to vary the pitch of said blades in a normal operating range of pitch variation, means including a source of fluid at a pressure higher than the governor controlled fluid for operating said motor and moving said blades into and out of a special purpose range beyond said governor controlled range, pressure responsive means for interrupting said higher pressure source, and means governed by said fluid motor for actuating said pressure responsive means in special purpose position thereof and also when moving out of special purpose range said motor reaches said normal governor controlled range, said means for actuating said pressure responsive means including means for temporarily altering the pressure of said higher pressure fluid incident to movement of said blades out of said special purpose range past a predetermined position into said normal range.

6. In combination, a propeller having variable pitch blades, a fluid operated pitch changing motor therefor, a source of pressure fluid, a governor controlling the admission of said fluid to said motor to vary the pitch of said blades in a normal operating range of pitch variation, means including a source of fluid at a pressure higher than the governor controlled fluid for operating said motor and moving said blades into and out of a reverse pitch range beyond said governor controlled range, pressure responsive means for interrupting said higher pressure source, means connecting said pressure responsive means with said higher pressure source and means automatically operative during unreversing movement of said blades for creating a pressure surge in said connecting means for operating said pressure responsive means to cut off said higher pressure source and return said motor to governor operation.

7. In combination, a propeller having variable pitch blades movable in extreme feathered and reverse pitch ranges and in an intermediate governor controlled range, a fluid operated pitch changing motor, a source of pressure fluid controlled by said governor for supplying fluid to said motor for moving said blades in said intermediate range, high pitch and low pitch stops defining the limits of said intermediate range, means including fluid at a pressure higher than the governor controlled fluid for supplying fluid to said motor to override said limit stops and move said blades into said feathered and reverse pitch ranges, means for supplying said higher fluid to said motor to move said blades from the feathered and reverse pitch positions into said intermediate range, means for controlling admission of said higher pressure fluid to said motor including pressure responsive means acted on by said higher pressure fluid, and means for automatically operating said pressure responsive means in the feathered and reverse pitch positions of said blades and also when in unreversing movement said motor has moved past said low pitch limit stop into said intermediate governor controlled range.

8. In combination, a propeller having reversible pitch blades, a fluid operated pitch changing motor therefor, a governor controlling the admission of low pressure fluid to said motor to vary the pitch of said blades in a governor controlled range, low pitch stop means limiting the movement of said blades by said governor controlled fluid, means including a fluid at a pressure higher than the governor controlled fluid for moving said blades past said stop means into reverse pitch position, and back into said governor controlled range, means for controlling the admission of said higher pressure fluid to said motor including a pressure responsive device subjected to said higher pressure fluid, and means governed by said motor during the unreversing movement thereof for creating a pressure surge in said higher pressure fluid after said blades have passed said low pitch stop means into said governor controlled range for actuating said pressure responsive device to interrupt the supply of said higher pressure fluid.

9. In combination, a propeller having variable pitch blades, a fluid operated pitch changing motor therefor, a governor controlling the admission of relatively low pressure fluid to said motor to vary the pitch of said blades in an intermediate governor controlled range, stop means limiting the movement of said blades by said governor controlled fluid beyond said range in either direction, means including a fluid at a pressure higher than the governor controlled fluid for moving said blades past said stop means into and from feathered and reverse pitch positions, means for cutting off the supply of said higher pressure fluid as said blades are moved into feathered position and as said blades are moved from reverse pitch position into said governor controlled range.

10. The combination claimed in claim 6 including a fluid line connecting said source and said motor and in which the means for creating the pressure surge comprises a valve in said fluid line.

11. The combination claimed in claim 4 in which the means for creating the pressure surge comprises a valve in the pressure line leading to said motor and said stop means defines the low pitch position of said blades and comprises an

element moved by said higher pressure fluid out of its blade pitch limiting position, and in which said valve is controlled in its movement into surge creating position by the return of said low pitch limit stop means to said limiting position.

12. In a propeller pitch control mechanism, a fluid operated pitch changing motor, a pump for supplying fluid under relatively low pressure, a speed governor for controlling the supply of low pressure fluid to said motor, retractible stop means for limiting the movement of the motor by said fluid beyond a predetermined position corresponding to a predetermined low pitch, means for constantly biasing said stop means into position to limit the movement of said motor, a pump for supplying fluid under a relatively high pressure, pressure responsive means acted on by said high pressure fluid for overcoming the bias of said stop means to permit the motor to retract said stop means and move into a position corresponding to reverse pitch, and means controlled by the unreversing movement of said motor for interrupting said high pressure pump when said motor has reached said predetermined low pitch position and returning said motor to governor control.

13. In a propeller, propeller blades, blade pitch control mechanism, a fluid operated blade pitch changing motor having a reciprocable member, a pump for supplying fluid under relatively low pressure to act on said member, a speed governor controlling the supply of fluid to said motor, a retractible low pitch limit stop, means for constantly urging said stop into position to limit the movement of said member under the action of said low pressure fluid, a second pump for supplying fluid under relatively high pressure to said motor for retracting said stop and moving said member beyond said stop means into a position in which the propeller blades are in reverse pitch, pressure responsive means in fluid communication with said high pressure fluid for controlling the operation of said high pressure pump, and means operative during unreversing movement of said motor when said member has moved past said stop means into the governor controlled range for creating a pressure surge in said high pressure fluid to actuate said pressure responsive means and stop said second pump.

14. In a propeller, propeller blades, blade pitch control mechanism, a hydraulic double acting propeller blade pitch changing motor, a pump for supplying fluid under relatively low pressure, fluid lines, one leading to one side of said motor and the other leading to the other side of said motor, a speed governor controlling the selective admission of fluid to said motor through said fluid lines, means for preventing the movement of said motor beyond a low pitch position of said blades while under control of said governor comprising a retractible low pitch limit stop, means for retracting said stop to permit said motor to move to reverse pitch position including a second pump for supplying fluid to said motor under pressure, pressure responsive means for controlling the operation of said pressure pump, means connecting said pressure responsive means with the line which is supplying high pressure fluid to said motor in the unreversing movement of said blades and means for creating an increase in pressure in said line for operating said pressure responsive means to interrupt the supply of high pressure fluid, said pressure increasing means comprising a valve in said line and operating means therefor controlled by said stop for closing said valve momentarily as said motor moves into the governor controlled range.

15. In a propeller pitch control mechanism, a double acting fluid operated pitch changing motor, a pump for supplying fluid under relatively low pressure, fluid pipe lines, one leading to one side of said motor and the other leading to the other side of said motor, a speed governor controlling admission of fluid to said motor, having a pilot valve for selectively admitting fluid to said lines, means for operating said pilot valve, a retractible stop for preventing movement of said motor by said low pressure fluid beyond a predetermined low pitch position, a high pressure fluid source for retracting said stop to enable said motor to move into reverse pitch position, a pressure responsive means connected into the high pressure fluid line into which fluid is admitted for unreversing said motor, said pressure responsive means controlling said high pressure source, means operative to create a pressure surge in said unreversing high pressure line, said last mentioned means being controlled by the return of said stop means to its normal operative position and such return of said stop means being controlled by the movement of said motor into its normal governor controlled operating range

16. In a propeller pitch control mechanism, a double acting fluid operated propeller pitch changing motor including a reciprocable fluid actuated member, a low pressure fluid source, a high pressure fluid source, a speed governor for controlling the admission of low pressure fluid to operate said motor over a normal pitch changing range, a retractible stop for limiting the movement of said motor in a predetermined low pitch position, fluid lines leading to opposite sides of said actuating member, said governor having a pilot valve selectively controlling the admission of fluid to said lines, means for controlling said source of high pressure including a pressure responsive device communicating with the unreversing fluid line, said pressure responsive means being responsive only to substantially the full line pressure of said high pressure source, and means in said unreversing line controlled by the movement of said stop means into operative position behind said fluid actuated member for obstructing the flow of fluid in said unreversing line to create a full line pressure surge therein.

17. In combination, a propeller having reversible pitch blades, a fluid operated pitch changing motor therefor, a source of low pressure fluid, a governor controlling the admission of said low pressure fluid to said motor to vary the pitch of said blades in a normal intermediate range of pitch variation, means including a fluid pump supplying fluid under a higher pressure than said governor controlled fluid for moving said blades beyond said normal range into reverse pitch position and from said reverse pitch position back into said normal range, and control mechanism for controlling said pump including an electric motor for driving said pump, manually operative means for energizing said electric motor for reversing and unreversing, means for maintaining the circuit for said electric motor energized following initiation of blade changing movement in either direction by said manual means, a cut-out switch in said electric motor circuit and means responsive to movement of said fluid motor into reverse pitch position and also, during unreversing movement of said fluid motor, into the governor controlled range for operating said cut-out switch to interrupt said electric motor circuit.

18. In a propeller pitch control mechanism, a double acting fluid operated propeller pitch changing motor including a reciprocable actuating member, means for supplying low pressure fluid to opposite sides of said actuating member including a pump and fluid lines connecting the discharge of said pump to opposite sides of said member, a speed governor selectively controlling the admission of fluid to said lines to control the pitch of the propeller in a normal range of pitch variation, a retractible low pitch limit stop for limiting the movement of said actuating member in a pitch decreasing direction, means for moving said actuating member beyond said low pitch limit stop including a high pressure fluid pump for supplying high pressure fluid to said motor, means associated with said governor for selectively admitting said high pressure fluid to said fluid lines, manually operable means for starting said high pressure pump and maintaining the latter in operation, pressure responsive means communicating with said lines for controlling the operation of said pump, and means for creating a pressure surge in said unreversing line to operate said pressure responsive means and stop said pump, said last mentioned means including a valve in said unreversing line for creating a pressure surge at a predetermined position of said actuating member for stopping said high pressure pump and returning said motor to governor control.

19. The combination as claimed in claim 15 in which the surge creating means comprises a valve in the line leading to one side of said motor which is momentarily closed during the retraction and the return movement of said stop means and in which a ball check valve is provided in parallel to permit flow of fluid in said line during the closure of said valve during reversing movement.

20. The combination claimed in claim 18 in which the low pitch limit stop includes a movable detent which normally limits the movement of said actuating member in a pitch decreasing direction and in which a spring biased member is provided to hold said stop means in position to prevent release of said stop when said low pressure fluid is acting in said lines, and piston means for moving said spring biased member against the action of its spring to permit said stop to be retracted when said high pressure fluid pump is started, a valve controlled by said spring biased member for momentarily closing, during both reversing and unreversing movement of said member, the line leading to the side of the said actuating member vented during reversing, and valve means parallel with said first mentioned valve for venting said side of said actuating member during reversing movement.

21. In combination, a propeller having reversible pitch blades, fluid operated pitch changing mechanism therefor including a reciprocable pressure responsive member and fluid lines communicating with opposite sides of said member, a governor controlling the admission of low pressure fluid to said lines to vary the pitch of said blades in a normal range of pitch variation, a pump for supplying fluid to said member at a higher pressure than said governor controlled pressure for moving said blades beyond said normal range into reverse pitch, a solenoid valve controlling the admission of said higher pressure fluid to said fluid lines, manually controlled switch mechanism for energizing said solenoid and starting said pump to supply fluid to said member and reverse the pitch of said blades, means for stopping said pump when said blades reach the limit of their reversing movement, and means which is energized by the closing of said switch to initiate a reversing operation for maintaining said solenoid energized while said blades remain in reverse pitch position.

22. In combination, a propeller having reversible pitch blades, fluid operated pitch changing mechanism therefor including a reciprocable pressure responsive member and fluid lines communicating with opposite sides of said member, a governor controlling the admission of low pressure fluid to said lines to vary the pitch of said blades in a normal range of pitch variation, a pump for supplying fluid to said member at a higher pressure than said governor controlled pressure for moving said blades beyond said normal range into reverse pitch, a solenoid valve controlling the admission of said higher pressure fluid to said fluid lines, manually controlled switch mechanism for energizing said solenoid and starting said pump to supply fluid to said member and reverse the pitch of said blades, means for stopping said pump when said blades reach the limit of their reversing movement, a second switch means for unreversing said blades including a manual switch for starting said pump, a relay energized by said second switch means, said relay having contacts for interrupting said solenoid circuit and for completing a holding circuit for said relay, a pressure responsive cut-out controlling said holding circuit communicating with the pressure fluid line for unreversing said blades, and means controlled by said member for creating a pressure surge in said unreversing line when said member has returned said blades to said normal range.

23. A propeller having controllable pitch blades and a pitch changing motor, a governor controlling the operation of said motor to control the propeller blade pitch within a predetermined range, limit stops cooperating with said motor to define said range and prevent movement of said blades under governor control beyond said range, manually controlled means having a connection with one of said stops and with said governor for disabling said one of said limit stops and said governor, and forming a connection with said pitch changing motor for manually controlling the pitch changing motor to move the blades outside of said predetermined range, and manually controlled means coacting with said first mentioned manually controlled means for forming a connection with said motor for controlling the pitch changing motor to return said blades to a position within said range from without said range, means connected with said last mentioned manually controlled means for inactivating said last mentioned manually controlled means, mechanism including means actuated by movement of said motor as said blades move to a position within said range from without said range, cooperating with said one stop to automatically restore said one stop and having a connection with said inactivating means to automatically actuate said inactivating means and thereby inactivate said last mentioned manually controlled means when said propeller blades in returning into said predetermined range pass the position determined by said one stop, and means responsive to inactivation of said last mentioned manually controlled means automatically restoring said governor to control.

24. In combination, a propeller having variable

pitch blades and having a normal pitch range, a reverse pitch range, a reverse pitch position at the extreme end of the reverse pitch range, a fluid operated pitch changing motor therefor, a source of fluid pressure, a governor controlling admission of fluid from said source to said motor to vary the pitch of the blades in said normal operating range, means connected with said governor for disabling the same, means connecting said source with said motor and said governor disabling means in said reverse pitch position including means directing fluid from said source to said motor to maintain said blades in said reverse pitch position, and directing fluid to said governor disabling means to disable said governor, a separate source of fluid pressure and means, including said disabling means, for directing fluid from said separate source to said motor to move said blades from said reverse pitch position into said normal range, and means actuated by the unreversing movement of said motor at a preselected point in said unreversing movement for automatically interrupting the supply of fluid from said separate source to said motor and automatically restoring control to said governor.

25. In combination, a propeller having variable pitch blades and having a normal pitch range, a reverse pitch range and a reverse pitch position at the extreme end of the reverse pitch range, a fluid operated pitch changing motor therefor, a source of fluid pressure, a first relief valve connected with said source to limit said pressure, a governor controlling admission of fluid from

said source at said limited pressure to said motor to vary the pitch of said blades in said normal operating range, means connecting said source at said limited pressure with said motor in said reverse pitch position including means directing fluid from said source at said limited pressure to said motor to maintain said blades in said reverse pitch position, a second relief valve connected with said source and set to relieve at a pressure higher than said first relief valve, means connected with said first relief valve disabling the same to thereby provide a second fluid pressure, and means, including means actuated by said second fluid pressure disabling said governor, for directing fluid at said second pressure to said motor to move said blades from the reverse pitch position into said normal range, and means actuated by the unreversing movement of said motor at a preselected point in said unreversing movement for automatically interrupting the supply of fluid at said second pressure to said motor and said governor disabling means and automatically restoring control to said governor.

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