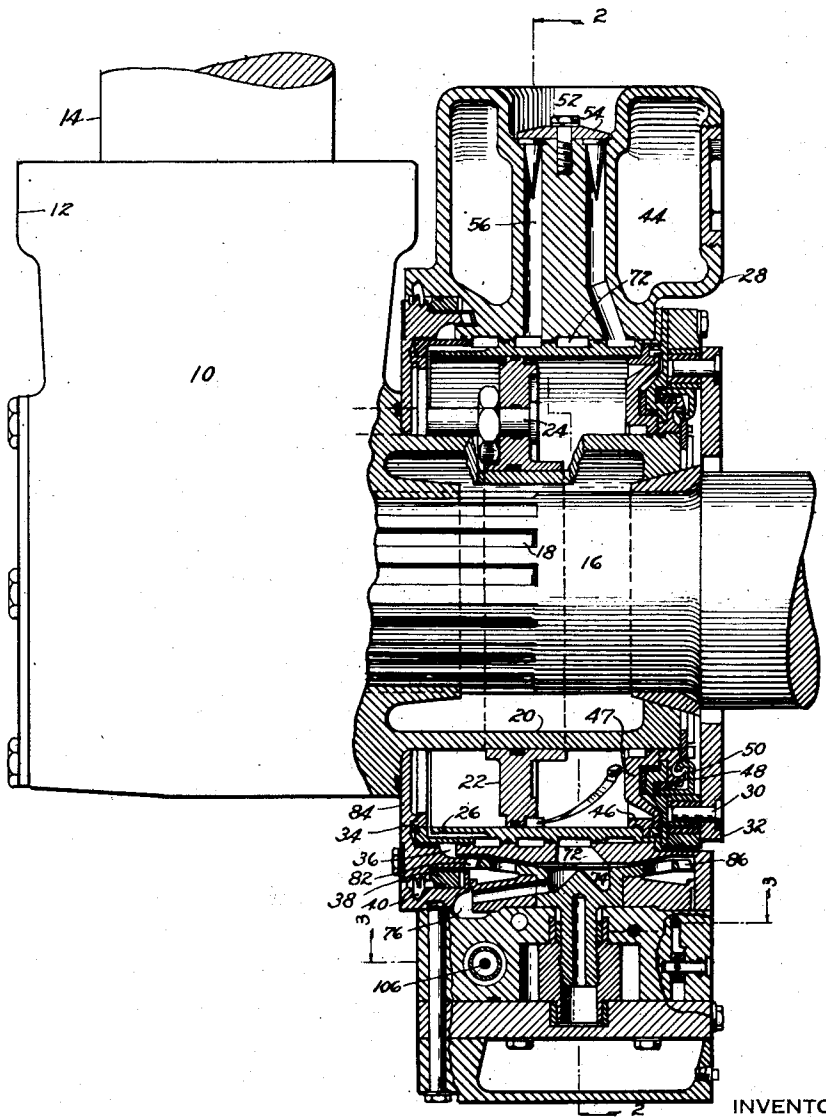
Nov. 3, 1953 M. E. CUSHMAN 2,657,755

VARIABLE PITCH PROPELLER

Filed Aug. 28, 1947 5 Sheets-Sheet 1

Fig. 1



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VARIABLE PITCH PROPELLER

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Fig. 2

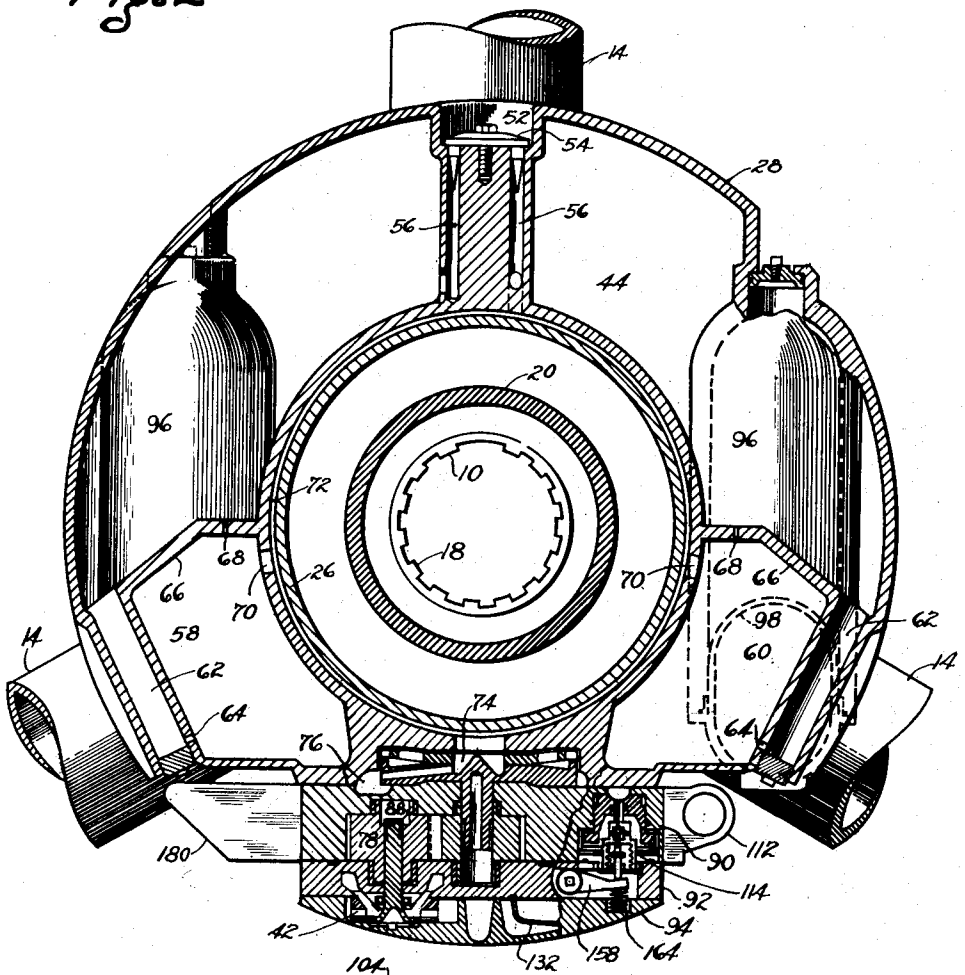
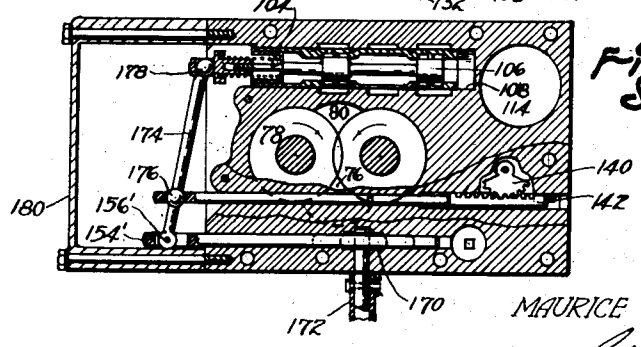


Fig. 3



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VARIABLE PITCH PROPELLER

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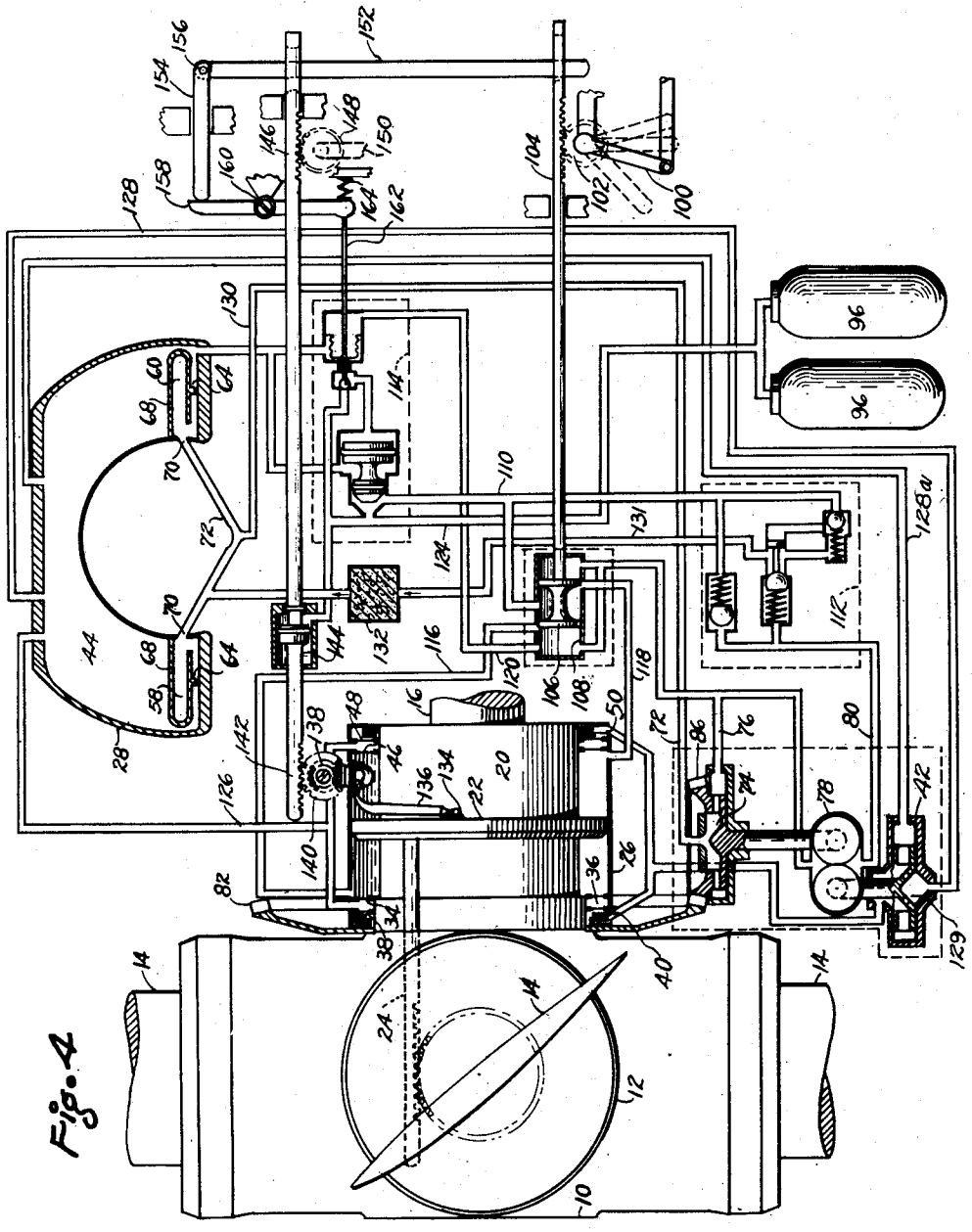


Fig. 4

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VARIABLE PITCH PROPELLER

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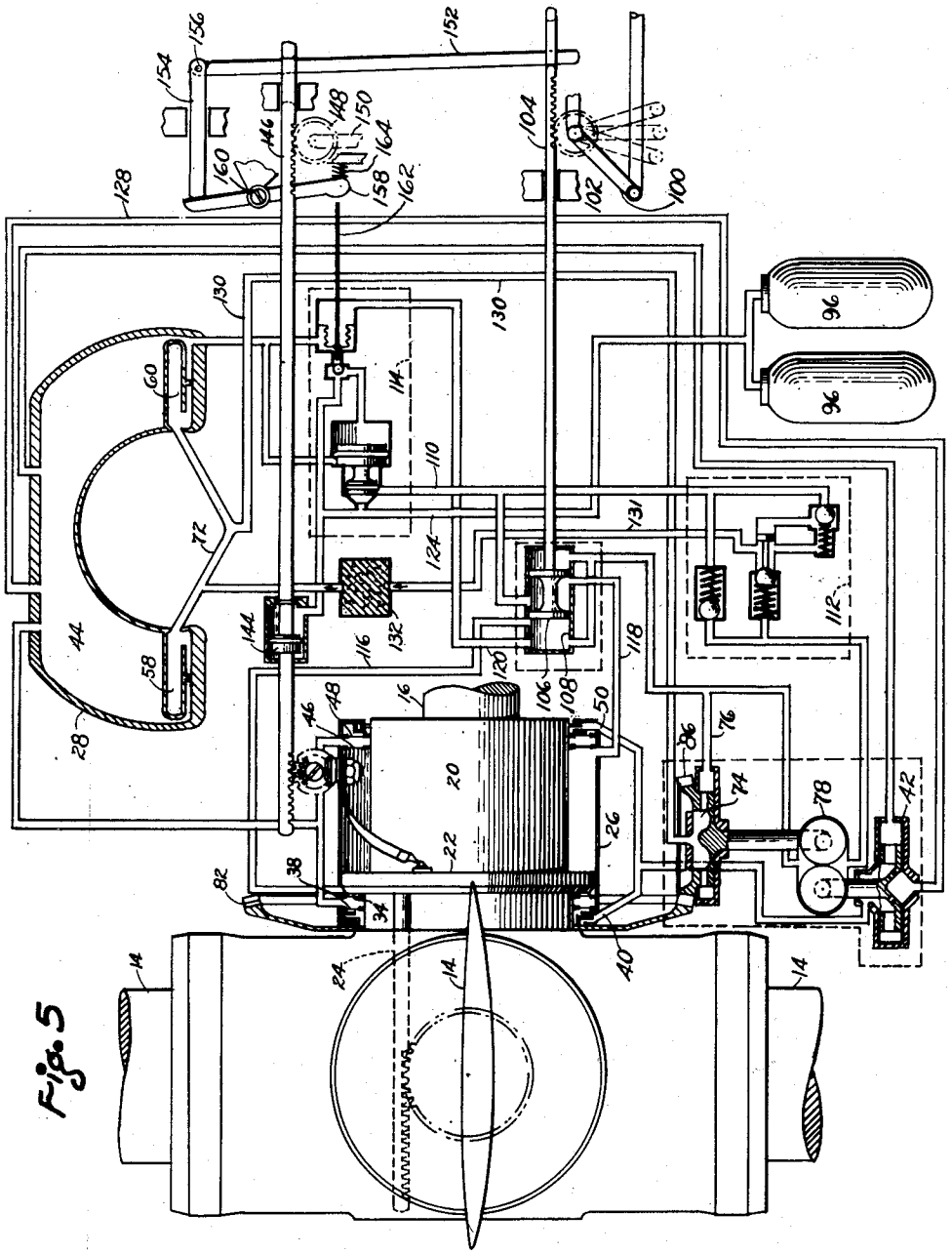


Fig. 5

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VARIABLE PITCH PROPELLER

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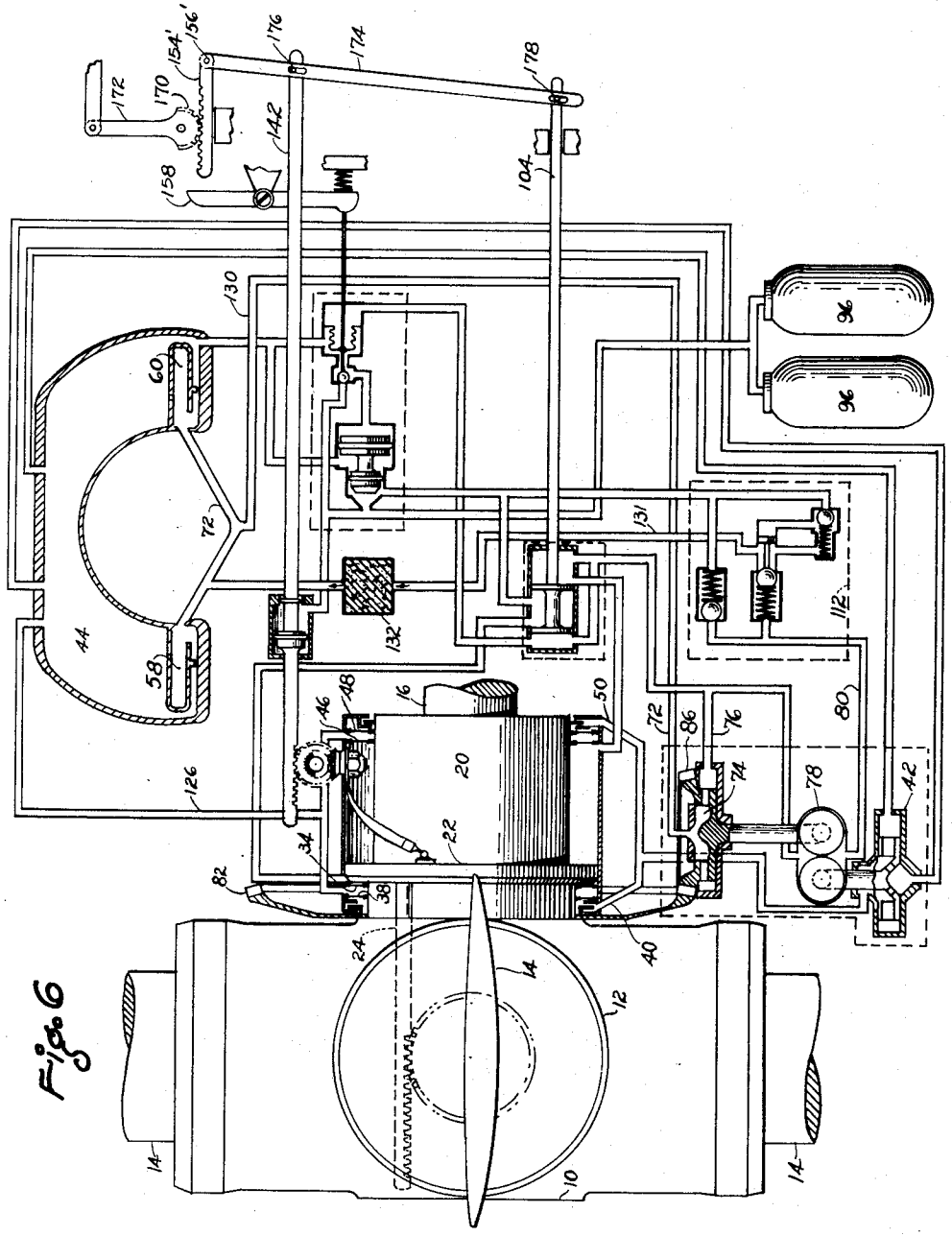


Fig. 6

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Patented Nov. 3, 1953

2,657,755

UNITED STATES PATENT OFFICE

2,657,755

VARIABLE PITCH PROPELLER

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Application August 28, 1947, Serial No. 771,022

6 Claims. (Cl. 170—160.37)

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This invention relates to aircraft propellers and is concerned particularly with improvements in hydraulically actuated propellers along with novel control systems therefor. The invention comprises certain improvements in the propeller disclosed in my co-pending application Serial No. 651,264, filed March 1, 1946, now Patent No. 2,640,555, and further is associated with propellers including compensated blade mountings to overcome the pitch flattening effect due to centrifugal force disclosed in my co-pending applications Serial Nos. 598,791 and 598,792, both filed June 11, 1945, now Patents 2,514,477 and 2,533,358, respectively, and Serial No. 722,253, filed January 15, 1947, now Patent No. 2,566,696.

Application Serial No. 651,264 discloses a propeller hub and blade pitch changing mechanism which includes an annular piston and cylinder assembly coaxial with the propeller shaft, wherein the external cylinder wall is stationary and the internal cylinder wall rotates with the propeller. With the stationary wall is associated a housing containing the hydraulic control system for the propeller and a speed sensitive governor. Propeller speed is controlled by changing blade pitch and hence, load on the prime mover, pitch change being initiated by the sensing of speed errors by the governor.

In the present invention, the pitch change mechanism and propeller hub is similar to that previously disclosed but, instead of the propeller incorporating its own speed responsive governor, it is provided with a blade angle control mechanism adapted to be associated with a separate control system, such as that of the power plant. Two blade pitch control arrangements are disclosed; one, called beta control, serving to adjust propeller pitch to a desired blade angle and the other, called rate control, serving to adjust the propeller mechanism to secure increased or decreased pitch at such rates of pitch change as may be called for by the separate control system.

Objects of the invention are: to provide a self-contained hydraulically actuated propeller; to provide, in a propeller assembly, a non-rotating housing forming a part thereof which carries all of the mechanism essential to attain the desired range and/or rate of operation of the propeller; to provide a unitary propeller assembly, wherein the blades are changeable in pitch through a servomotor system and wherein a control is provided for external operation which may be moved to effect increased pitch, decreased pitch, feathering, and reverse pitch; to provide a pitch indicating system which will, at all times, indicate the

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actual pitch position of the propeller blades; to provide a hydraulic propeller system whose pitch change is effected through a servomotor system which secures pitch changing power from propeller rotation; to provide an accumulator system as part of the unit propeller assembly by which pitch changes may be effected when the propeller is not rotating, or is rotating at such a low speed as to provide inadequate power to effect pitch change; to provide a pumping system in a self-contained hydraulic propeller wherein pressure levels in the propeller will be held at desired values for propeller operation and which will inhibit leakage of hydraulic fluid from the propeller; to provide a fluid supply sump as part of a unit propeller assembly which is insensitive to position or acceleration and which thereby will furnish the propeller mechanism with adequate operating fluid in all attitudes and conditions of operation of the airplane with which the propeller is associated; to provide a propeller which is particularly adaptable for use with gas turbines as distinguished from reciprocating engine power plants; and to provide a propeller having variable rates of pitch change in accordance with demands made upon the propeller by the aircraft and power plant combination.

Further objects of the invention will become apparent in reading the annexed detailed description in connection with the drawings. It is to be expressly understood, however, that the drawings and description are merely exemplary of one manner of accomplishing the teachings of the invention and the scope of the invention is only to be construed from the subjoined claims.

In the drawings, in which similar reference characters denote similar parts,

Fig. 1 is a side elevation of a unitary propeller assembly with the operating mechanism in longitudinal section;

Fig. 2 is a transverse section through the operating mechanism of the propeller substantially on the line 2—2 of Fig. 1;

Fig. 3 is a sectional plan of the portion of the propeller operating mechanism on the line 3—3 of Fig. 1;

Figs. 4 and 5 are schematic diagrams of one embodiment of the propeller operating mechanism, pertaining to a rate type of pitch change control, Fig. 4 showing the system in normal operating condition and Fig. 5 showing the system in feather position; and

Fig. 6 is a schematic diagram of an alternative propeller operating system adapted for pitch

angle or beta control, showing the system in the feathered blade position.

As stated, the invention includes two embodiments—a rate type of pitch change control and a pitch angle or beta type of pitch change control. The two systems are similar in most respects, and the differences between them will be pointed out in connection with a description of the schematic diagrams. The majority of the structural components of the propeller for both control arrangements are the same. Figs. 1, 2 and 3 include control provisions applicable to the beta control.

Referring first to Figs. 1, 2 and 3, I provide a propeller hub 10 having blade sockets 12 (one being shown) from which extend propeller blades 14. The mounting of the blades in the hub sockets is preferably in accordance with the teachings of the previously mentioned applications although any appropriate type of blade mounting may be used. The hub 10 is mounted upon a propeller shaft 16 through splines 18, the system utilizing the conventional form of propeller hub nut, not shown, by which the propeller is secured on the shaft. The propeller hub 10 carries a rearward integral extension 20 surrounding a portion of the propeller shaft and coaxial therewith and comprising an inner annular cylinder wall upon which an annular piston 22 is freely slidable. The piston 22 as well as the sleeve 20, closure 84 and rear partial closure elements secured to the cylinder 20, rotate with the propeller and the piston 22 is connected to the several propeller blades by rods 24 secured thereto and extending into the hub 10 for engagement with appropriate mechanism on the root ends of the propeller blades. Embracing the piston 22 is a stationary or non-rotating cylinder 26, non-rotatively secured to and within a housing 28 resiliently engaged with appropriate studs 30 springing from a power plant nose plate 32, the studs 30 serving to constrain the housing and its associated parts against rotation. The entire housing 28 and its contained and associated parts, however, is carried by and piloted on the propeller hub so that, while the housing does not rotate with the propeller, it is piloted on the propeller so that the propeller may rotate relative to it. The housing thus forms part of the propeller assembly and is removable with it as the propeller is removed from the shaft 16. On the left end of the cylinder assembly as shown in Fig. 1, a primary rotating seal 34 is indicated to minimize leakage from the leftward end of the annular cylinder and a rotating front closure 84 when the cylinder interior is exposed to fluid pressure. Fluid which may leak past the primary seal flows into a cavity 36 connected to a non-rotating sump at atmospheric pressure. Leakage from the cavity 36 is minimized by a secondary seal 38 between the rotating member 84 and the non-rotating housing elements, any leakage passing the seal 38 being caught in a labyrinth 40 in the non-rotating housing 28 whence it flows to a scavenger pump 42 (Fig. 2) and thence to a non-rotating sump 44 in the housing 28.

In somewhat the same fashion a primary seal 46 is arranged between the non-rotating cylinder 26 and a closure 47 secured to and rotated with the extension 20 toward the right hand end of the cylinder 26, such seal being backed up by a secondary seal 48, between rotating and non-rotating parts, the space between the seals being connected to the non-rotating sump 44 and the space downstream of the secondary seal 48 leading to a labyrinth 50 whence fluid bleed is scavenged by the pump 42 and returned to the sump 44.

Within the housing proper, the fluid sump 44, shown in section in Fig. 2, is contained, this sump including a filler opening 52 capped at 54 and leading to a plurality of passages such as 56, each opening into a different portion of the hydraulic system and one leading to the sump proper. The several filler passages 56 enable complete filling of the system when empty so that the hydraulic fluid does not have to be bled from the sump proper into the several portions of the system. The upper portion of the sump, occupying the upper portion of the housing 28, leads to left and right chambers 58 and 60 in the lower housing portion through passages 62 and restricted ports 64, the latter ports being disposed toward the bottom of the chambers 58 and 60 and the chambers being defined from the housing 44 by walls 66 integral with the housing 28. The uppermost portions of the chambers 58 and 60 are vented as at 68 to the upper sump 44 through small restricted openings. Fluid in the upper sump 44 flows through the passages 62 and the ports 64 to fill the chambers 58 and 60, the air in these chambers venting into the upper sump through the openings 68. Fluid from the chambers 58 and 60 is led through openings 70 into an annular passage 72 surrounding the cylinder 20 which passage forms a manifold from which the propeller mechanisms are supplied with fluid. In operation, the chambers 58 and 60 remain filled at all times so long as the level of fluid in the entire sump system is adequate for operation. Should the housing be inverted for a reasonable interval, the chambers 58 and 60 will remain full of fluid to a sufficient extent to feed the hydraulic system, although that fluid in the upper sump 44 may flow away from the passages 62. Upon restoration of normal attitude, the fluid in the upper sump 44 will again be available to feed the chambers 58 and 60 and any minor fluid withdrawal from said chambers will be made up from the normal fluid supply.

The annular passage 72 and its associated hydraulic parts are at atmospheric pressure. The fluid in the passage 72 feeds the eye of the impeller of a centrifugal booster pump 74 which discharges into a passage 76 leading to the inlet of a positive gear pump 78. The gear pump discharge 80 is connected through ports shown in the schematic diagrams to furnish pressure fluid to the annular cylinder in the propeller through the control mechanism to effect pitch change of the propeller. Working fluid in the system, after use in the propeller mechanism, is returned to the passage 76 so that there is no tendency to bleed the chambers 58 and 60 dry even when the aircraft attitude temporarily separates the chambers 58 and 60 from fluid communication with the upper supply sump 44.

The several pumps 42, 74 and 78 are housed in the stationary housing 28 and are driven as shown in Fig. 1, by a gear 82 integral with a back plate 84 secured to the propeller hub 10. Said gear 82 meshes with a pinion 86 forming a part of the impeller of the booster pump 74, the shaft of the latter being directly connected to one of the gears of the gear pump 78. The other gear of the gear pump carries a shaft 88 upon which is formed (as shown in Fig. 2) the impeller of the scavenger pump 42. The pump components of the assembly are contained within a sandwiched housing secured to a lower flat face of and form-

ing a part of the housing **28**, the elements of the lower housing comprising an upper member **90**, an intermediate member **92** and a lower member **94**. As will be clear in Fig. 2, these elements **90**, **92** and **94** are so designed as to lie within the circular envelope defined by the stationary housing **28**, the entire housing assembly having a diameter slightly greater than the circle defined by the outermost parts of the blade sockets **12** on the hub **10**.

The housing elements **90**, **92** and **94** further contain, or have attached thereto, components including valves and the like by which pitch change of the propeller is controlled. These components will be most clearly understood in connection with the description associated with the schematic views of Figs. 4, 5 and 6.

Disposed on substantially vertical axes along the side portions of the housing **28** is a pair of integral accumulator flasks **96**, these flasks containing dry inert gas under pressure and serving, as will be described, to provide power for normal propeller pitch change, and for final feathering and initial unfeathering of the propeller when the latter is rotating slowly or not at all. The flask walls are integral with the housing **28** and each flask contains an elastic diaphragm **98** serving as a floating piston to isolate the pressurized gas from hydraulic fluid contained in the flask. The passages leading hydraulic fluid to and from the accumulator flasks which are connected to the tops of the accumulators, are shown functionally in the schematic views and have been omitted in Figs. 1, 2 and 3 to minimize complexity of these figures. The two accumulators are preloaded with inert gas at different pressures, for instance, 100 and 500 pounds per square inch. The low pressure flask provides comparatively large fluid capacity, for unfeathering, in the low pressure range, while the high pressure cylinder provides large fluid capacity in the high pressure range between the loading and unloading pressure settings of the pump unloading valve **112**, to be described. The accumulators are parallel connected.

If hydraulic system pressure is in a low range between, say, 100 to 300 pounds per square inch, the low pressure flask will be partly full and will provide a substantial pressurized liquid supply for system operation, particularly for unfeathering the propeller. At this low system pressure, the high pressure flask will be empty of liquid since the gas pressure therein is higher than low system pressure.

If system pressure is in a normally high operating range of, say, 500 to 700 pounds per square inch, the high pressure flask will be partly full and will provide a highly pressurized liquid supply in amount adequate for system operation for pitch change in normal operation and for feathering. At this high system pressure, the low pressure flask will be substantially full of liquid at high pressure but will remain relatively unavailable while system pressure remains high due to the small amount of gas in the flask.

Charging of the flasks with liquid occurs in sequence; as the pump operates, pressure builds up and fills the low pressure flask. Continued pump operation further builds up pressure in both flasks and fills the high pressure flask until pressure reaches a value to unload the pump. This arrangement enables the accommodation of a large amount of liquid for system operation in the high pressure region, the liquid being predominantly in the high pressure flask which has a large

amount of gas therein. The fairly large amount of liquid for use in the low pressure region remains in the low pressure flask which has a small amount of gas therein. Inherently, the supply of liquid available between the high and low regions will be small, but much liquid is not needed in the intermediate region. Thus, an economy of material and bulk is secured by the two-flask arrangement. When liquid is withdrawn in high pressure operation, the majority of it comes from the high pressure flask, and a small amount only from the low pressure flask.

The arrangement may be compared to two compression springs in series, one a soft spring and the other a stiff spring. Initial force on the soft spring compresses it until it reaches solidity, and a large increment of force is then needed to compress the stiff spring. Upon expansion, the stiff spring provides considerable force over a substantial distance until it has extended; then the soft spring exerts its force over a further range of distance.

Reference is now made to Figs. 4 and 5 which show the hydraulic systems in schematic fashion, those components of the system which have already been described bearing the same reference characters as in Figs. 1, 2 and 3.

In this arrangement a control level **100** operable manually or preferably by a coordinated control mechanism exteriorly of the propeller is effective to change the rate or pitch change of the propeller either in a pitch increasing or a pitch decreasing direction. The lever **100** is normally disposed adjacent a portion of the stationary propeller housing **28**, **90**, and is mounted on a shaft which carries a pinion **102** engaging a rack rod **104** upon the leftward end of which is a control valve **106**. This valve is also shown in Fig. 3. The valve is disposed in a bore **108** (in the housing **90**) to which a plurality of passages are connected. One of these passages **110** supplies pressure fluid to the valve bore and leads thereto from an unloading valve assembly **112** and from an accumulator valve assembly **114**. The unloading valve assembly, known in the art and described in detail in my co-pending application Serial No. 651,264, is provided with pressure fluid on demand from the gear pump **78** through the conduit **80**. The accumulator shut-off valve **114** when open, connects the accumulators with the passage **110** and the unloading valve assembly **112**. The accumulator shut-off valve is automatic in its operation and is that type of valve which is disclosed in my co-pending application Serial No. 743,748 filed April 25, 1947, now Patent No. 2,556,719.

The valve bore **108** has a port and associated passage **116** leading to the leftward end of the propeller annular cylinder **26**, said valve bore having another port and passage **118** leading therefrom to the right hand end of the propeller annular cylinder. The outer ends of the valve bore are provided with ports and passages **120** connected on the one hand to a control portion of the accumulator shut-off valve **114** and on the other hand to the delivery side of the booster pump **74** and to the intake side of the gear pump **78** as at **76**. When the valve **106** is moved to the right, as shown in Fig. 4, pressure fluid is admitted through the passage **110**, the valve **106** and the passage **118** to the right hand end of the annular piston, urging pitch increase. Fluid in the left end of the annular cylinder is returned through the passage **116** and the valve **106** to the gear pump intake **76**. When the valve **106**

is moved leftwardly, the port 110 is connected with the port 116 whereby pressure fluid passes to the left end of the propeller annular cylinder to cause pitch decrease of the propeller blades. As pitch of the blade decreases, fluid at the right hand end of the annular cylinder 26 is discharged through the passage 118 and the valve 106 to the passage 76 for recirculation in the pump system. The rate of change of pitch is established by the degree to which the ports 116 and 118 are opened.

The turbine control or other control mechanism operating the valve lever 100 and valve 106 is so arranged as to call for pitch increase or pitch decrease at varying rates of pitch change and further is so arranged as to shut off the ports 116 and 118 when no pitch change is needed, thus providing a hydraulic lock. The control system operating on the lever 100 likewise is controllable to call for reverse pitch operation of the propeller and for feathering movement of the propeller. For reverse pitch, a pitch decrease is demanded and is carried to the point where the blade 14 rotates until reverse pitch positioning of the blade is attained. When feathering is called for, the mechanism operating on the lever 100 calls for feather and increased pitch as shown in Fig. 5 and remains in that position throughout feathered operation of the propeller.

Since the operation of the pump system of the propeller depends upon propeller rotation, a propeller pitch position will be reached during feathering where propeller rotation is low and where insufficient capacity may be available from the pump 78 to accomplish, without aid by the accumulators 96, the final phases of feathering. To this end, the accumulators 96 automatically provide the necessary power for final feathering, these accumulators having been charged during normal operation and having sufficient capacity not only to accomplish final feathering of the propeller but to accomplish unfeathering of the propeller when such a demand is made after the propeller has been feathered. After complete feathering, the accumulator shut-off valve 114 closes the pressure line 110 serving the control valve 106, from the accumulator conduit 124, whereby the accumulators are isolated from the system during inactivity of the propeller. Upon call for decrease in pitch after feathering, the accumulator shut off valve 114 is opened concurrently with a decrease pitch demand in the valve 106 whereby accumulator pressure passes through the lines 124 and 110 to the valve bore 108 whence the fluid pressure passes to the port and passage 116 to initiate pitch decrease. As propeller rotation starts due to windmilling action, the pump system begins to operate to provide pressure fluid necessary to recharge the accumulators, and, possibly bring propeller pitch to a normal operating level. The valve 114 remains open during normal or reverse pitch operation.

The accumulators, during normal operation, are held at a pressure level between high and low limits, and provide the power needed for normal propeller pitch increase and decrease. When the pressure level in the accumulators drops to the low limit, established by the setting of the unloader valve unit 112, the pump 78 is loaded and replenishes the accumulators to the high pressure limit. The unloader valve 112 loads and connects the pump 78 to the passage 110 when accumulator pressure is low and unloads and disconnects the pump 78 from the accumulator system (the passages 110 and 124) when the accumulator pressure has risen to the high pressure limit.

As will be seen from the schematic diagram, the zones between primary and secondary seals, 34, 38 and 46, 48 in the annular propeller cylinders are connected through a passage 126 to the sump 44. The sump 44 is maintained at atmospheric pressure by venting it through the line 128 to the impeller eye of the scavenger pump 42, said impeller having vent holes 129 therethrough to connect the vent with the scavenger pump inlet line leading from the labyrinths 40 and 50. Fluid in the labyrinths flows by gravity to the pump 42, which acts as a fluid-air separator, delivering fluid to the sump but allowing air flow in either direction for venting the sump 44. The scavenger pump further prevents loss of fluid from the sump when the airplane may be inverted, by pumping fluid through a vent line 128a back to the sump. Sump fluid may pass from the sump chambers 58 and 60 through the channel 72 and a passage 130 to the intake of the booster pump 74, the output of the latter pump charging the intake of the gear pump 78 and likewise maintaining a booster pressure, substantially less than the pressure delivered by the gear pump 78 or the accumulators 96, in that end of the propeller annular cylinder which is not being pressure fluid loaded by a call for pitch change, this connection being established through the ports and passages 120 from the booster pump discharge 76.

When the unloader valve 112 unloads the gear pump 78, the gear pump discharge, at low pressure, is directed through a passage 131 leading to a filter 132 and thence to the sump chambers 58 and 60 through the passage 72.

Positive indication of the pitch of the propeller blades is at all times available through the medium of a shoe 134 bearing on the propeller annular piston 22 and connecting through a flexible strip 136 to a bevel gear set 138 associated with the cylinder wall 26, the driven gear of said gear set carrying a pinion or sector 140 engaged with a rack formed on a rod 142. Some of these elements are shown in Figs. 1, 2 and 3 whereby their location in the propeller assembly is made clear. The rod 142 is translated to left and right in accordance with the actual pitch position of the propeller blades and is urged as shown in Fig. 4 in a leftward direction by a small piston-cylinder unit 144 which is fed from the accumulator conduit 124 so that the shoe 134 is at all times urged into contact with the annular piston 22. A rightward extension of the rod 142 carries a rack 146 engaged with a pinion 148 to which an arm 150 may be secured, said arm projecting from a portion of the propeller housing assembly for connection to pitch indication pickup devices in the propeller control system. Where a rate type of propeller pitch control is utilized in conjunction with a gas turbine, the control system normally requires a pitch signal for its coordinated operation in adjustment of propeller blade pitch. The pitch indicating arm 150 provides such a signal.

At the right hand end of Fig. 4 is shown a cross link 152 loosely engaging elongated slots in the right hand ends of the rack rod 142 and the valve actuating rod 104. At its upper end, the link 152 is hinged to a sliding member 154 as at 156, said member being engageable at times with a rocker arm 158 pivoted to fixed structure at 160, the other end of said arm being engageable with a rod 162 forming a part of the accumula-

tor shut-off valve system 114. Under all conditions except when the propeller is at or near feathering, the rod 162 is pressed leftwardly by a spring 164 whereby the accumulator shut-off valve 114 is constrained toward the open position as shown in Fig. 4.

When the control arm 100 is moved to the extreme left position as shown in Fig. 5, calling for feathering, the lower end of the link 152 is moved to the right by the rod 104. As the propeller pitch increases, the pitch indicator rod 142 moves leftwardly and prior to final feathering, through the member 154, rocks the arm 158 counter-clockwise as shown in Fig. 5, relieving the accumulator shut-off valve rod 162 of the spring pressure normally tending to hold it in a leftward position. When propeller feathering is finally completed, as when the piston 22 reaches the limit of its stroke, the accumulator shut-off valve 114 closes by the change in pressure relationships occurring when the system becomes inactive, in which position it remains while the propeller is feathered.

Upon a call for unfeathering, the control valve rod 104 is moved leftwardly thereby freeing the lower end of the link 152, the upper link end then moving to the right around the pivot of the rod 146 and unloading the rocker arm 158. The spring 164 then forces the accumulator shut-off valve control rod 162 to move to the left, which adjusts the pressure relationships in the shut-off valve 114 so that the latter opens, connecting the accumulator to the propeller to effect pitch decrease. As the pitch decrease continues, the propeller windmills, pump pressure can be built up in the system and the accumulators become recharged to operate in conjunction with the pump as previously described.

Reference should now be had to Fig. 6 which shows the propeller system adapted for beta control or pitch position control. The entire system is substantially identical with that previously described save for the right hand end of the schematic systems depicted. The sliding member 154' in this arrangement is provided with rack teeth engaged by a pinion sector 170 actuated by an appropriate control or arm 172. The rack member 154' serves the same purpose with respect to the accumulator shut-off valve and the rocker arm 158 as it did in the previously described embodiment. However, the member 154' serves the further purpose of establishing finite pitch positions of the propeller. A link 174 is pivoted at 156' to the sliding member 154' and is likewise pivoted as at 176 to the pitch indicator rod 142 and at 178 to the control valve rod 104. These elements are also shown in Fig. 3. When the sliding member 154' is moved to some new position from a previous position, say to the right, the link 174 will be swung clockwise about the pivot 176 as a center, moving the control valve rod 104 to the left thereby calling for pitch decrease. When the pitch decreases, the indicator rod 142 moves toward the right causing the link 174 to swing counter-clockwise about the pivot 156' whereby the valve control rod 104 is restored to a central position calling for no pitch change, as the preset pitch value has been attained. This in effect becomes a servo follow-up system so that any pitch position demands dictated by movement of the control arm 172 initiate pitch change at a rate which gradually becomes less as propeller pitch position approaches the desired value, finally cutting off pitch change as the value is reached. This provides a graduated type of control wherein initiation of pitch change in small amounts causes movement of the blades in pitch at a low rate, and wherein initiation of pitch change demands of large amount calls for high rate of pitch change at the beginning which gradually becomes less as the pitch approaches the desired value.

The basic structure of the propeller herein described remains the same for both the rate and beta type of controls, the only essential change residing in substitution of one type of control linkage for the other. The propeller structure has been designed to permit comparatively simple change from one system to the other, the essential changes involving the substitution of the links 174 and 152 and associated control elements. These changes may readily be made by removing the auxiliary housing 180 (Figs. 2 and 3) which covers the link system, and substituting one set of links and associated parts for the other. In the case of the rate control propeller (Figs. 4 and 5), the rate control element 100 would be borne in the housing 180 and would carry a pinion engaging a rack extension of the control valve stem 104.

The unloader valve assembly 112 shown in the schematic view is disposed in an auxiliary housing, bearing the same number, secured to the right hand end of the lower attached housing portions shown in Fig. 2. The accumulator shut-off valve assembly 114 shown in the schematics is disposed in a cavity bearing the same reference character within the housing 90. Other associated parts of the control system, where it is feasible to do so without unduly complicating Figs. 1, 2 and 3, are shown and numbered with the same characters which are used for them in the schematic diagrams. It will be appreciated that the housing elements such as 28, 90, 92 and 94 may be cored and drilled to provide the various fluid passages shown in the schematic drawings, in all instances said passages being short and direct between the members and components which they connect. It is considered that the disposition and location of passages of the type described comes within the scope of those skilled in the art, and accordingly, a detailed showing of these passages has not been rendered in the drawings.

Though several embodiments illustrating the invention have been shown and described, it is to be understood that the invention may be applied in other and various forms. Changes may be made in the arrangements, without departing from the spirit of the invention. Reference should be had to the appended claims for definitions of the limits of the invention.

What is claimed is:

1. In a controllable pitch propeller comprising a rotatable hub having blades mounted therein for pitch change and a non-rotating housing journalled on the hub, said housing containing a hydraulic pitch change mechanism operably connected to said blades and including a motor, a pressure source, a feed conduit therefrom to said motor, a supply conduit to said pressure source, a discharge fluid conduit receiving fluid from said motor, a scavenging conduit connected in said mechanism to receive leakage and surplus fluid, and a fluid sump comprising two chambers normally superimposed and in restricted communication with one another, said supply and discharge conduits being connected to the lower-

most chamber and said scavenging conduit being connected to the uppermost chamber.

2. In a controllable pitch propeller comprising a rotatable hub having blades mounted therein for pitch change and a non-rotating housing journalled on the hub, said housing containing a hydraulic pitch change mechanism operably connected to said blades and including a motor, a pressure source, a feed conduit therefrom to said motor, a supply conduit to said pressure source, a discharge fluid conduit receiving fluid from said motor, a scavenging conduit connected in said mechanism to receive leakage and surplus fluid, and a fluid sump comprising two chambers normally superimposed and in restricted communication with one another, said supply and discharge conduits being connected to the normally lowermost chamber and said scavenging conduit being connected to the normally uppermost chamber, said sump forming a part of said housing and being non-rotatable whereby, in all propeller attitudes, the said normally lowermost sump chamber receives and discharges fluid for propeller operation.

3. In a controllable pitch propeller, a propeller-carried hydraulic motor operable to increase and decrease pitch of the propeller blades and comprising a piston element and a cylinder element within which said piston element is movable axially, a non-rotative housing carried by said propeller, embracing said motor, and to which one of said elements is secured for non-rotation, the other element of the motor being rotatable with the propeller, a part secured to said propeller for rotation therewith, a primary seal between said part and said non-rotating element, a secondary seal between said part and a portion of said housing, serially arranged with said primary seal, there being a space between respective primary and secondary seals, a fluid sump in said housing to which the said space between seals is connected, and a pump system driven by the propeller including a high pressure pump delivering operating fluid to the motor and a low pressure pump fed from said sump and delivering its output to the input of the high pressure pump.

4. In a controllable pitch propeller, a propeller-carried double-acting hydraulic motor operable to increase and decrease pitch of the propeller blades and comprising a piston element and a cylinder element within which said piston element is movable axially, a non-rotative housing carried by said propeller, embracing said motor, and to which one of said elements is secured for non-rotation, the other element of the motor being rotatable with the propeller, a part secured to and rotatable with said propeller, a primary seal between said part and said non-rotating element, a secondary seal between said part and a portion of said housing, serially arranged with the primary seal, there being a space between respective primary and secondary seals, a fluid sump in said housing to which the said space between seals is connected, and a pump system driven by the propeller including a high pressure pump delivering operating fluid to the motor and a low pressure pump fed from said sump and delivering its output to the input of the high pressure pump, and a scavenger pump delivering leakage fluid to said sump from the downstream side of said secondary seals.

5. In a controllable pitch propeller having a self-contained pitch change mechanism, an adjustable hydraulic motor drivably connected to said pitch change mechanism, and a pump driven by the propeller having its discharge connected to said motor; a propeller carried non-rotating sump comprising a first sump chamber, a fluid connection from said first chamber to the inlet of said pump, a fluid connection to said first chamber fed by fluid discharged from said motor, said first chamber being normally filled with fluid, said sump further comprising a second sump chamber normally disposed above the first chamber, said second chamber being normally partly filled with fluid, and a restricted conduit connecting said two chambers to enable fluid flow therebetween and to maintain said first chamber in primed condition.

6. In a controllable pitch propeller having a self-contained pitch change mechanism, an adjustable hydraulic motor drivably connected to said pitch change mechanism, and a pump driven by the propeller having its discharge connected to said motor; a propeller carried non-rotating sump comprising a first sump chamber, a fluid connection from said first chamber to the inlet of said pump, a fluid connection to said first chamber fed by fluid discharged from said motor, said first chamber being normally filled with fluid, said sump further comprising a second sump chamber normally disposed above the first chamber, said second chamber being normally partly filled with fluid, and a restricted conduit connecting said two chambers to enable fluid flow therebetween and to maintain said first chamber in primed condition, means to collect fluid leakage from said motor, and pump means to collect and pump leakage fluid to said second chamber.

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