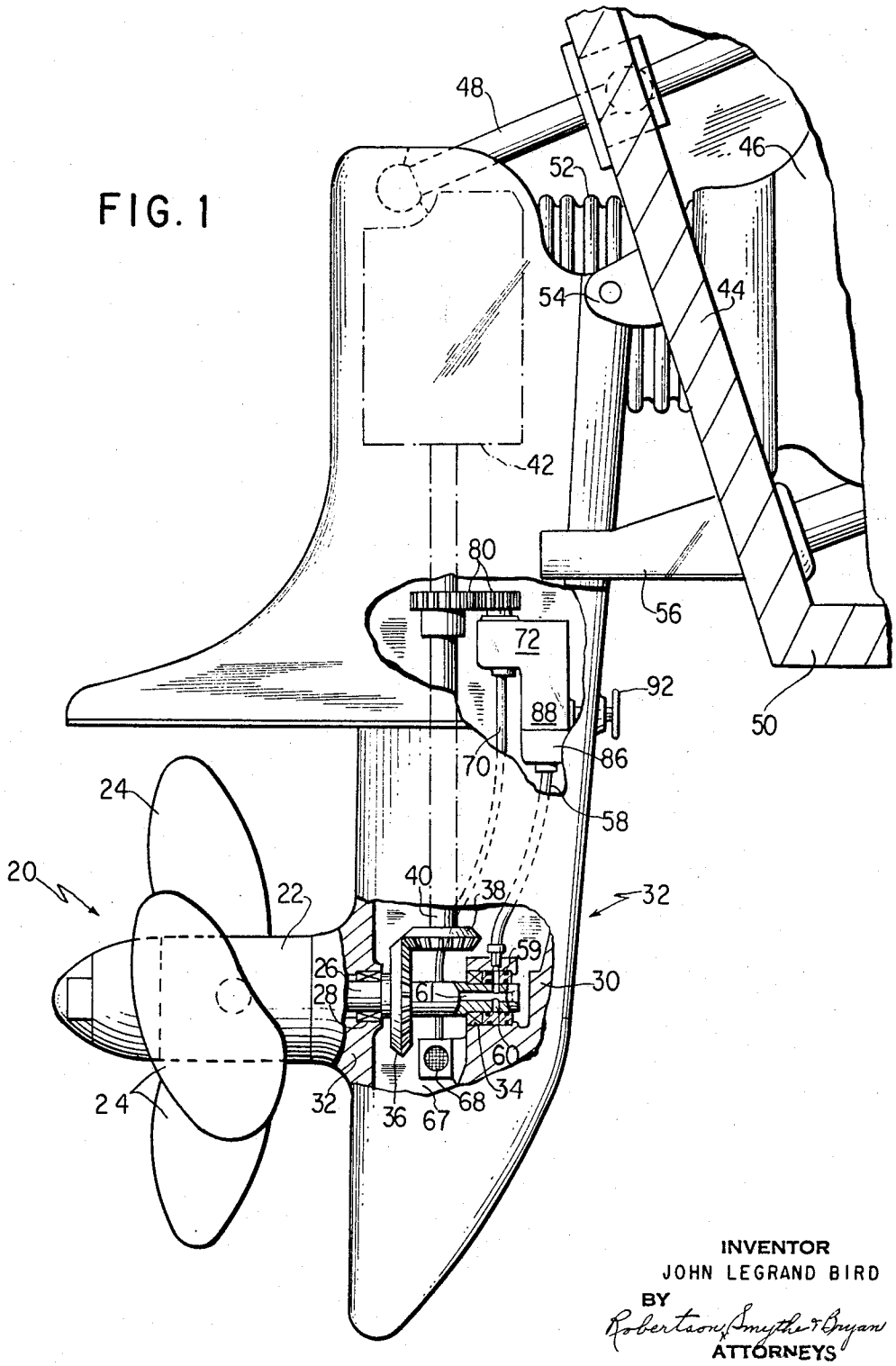
Sept. 20, 1966 J. L. BIRD 3,273,656

HYDRAULICALLY ACTUATED CONTROLLABLE-PITCH PROPELLER SYSTEM FOR OUTBOARD MOTORS AND OUTDRIVES

Filed June 30, 1964 4 Sheets-Sheet 1

FIG. 1



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FIG. 8

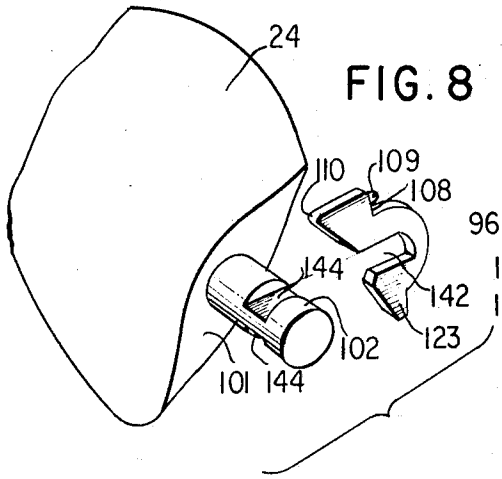


FIG. 7

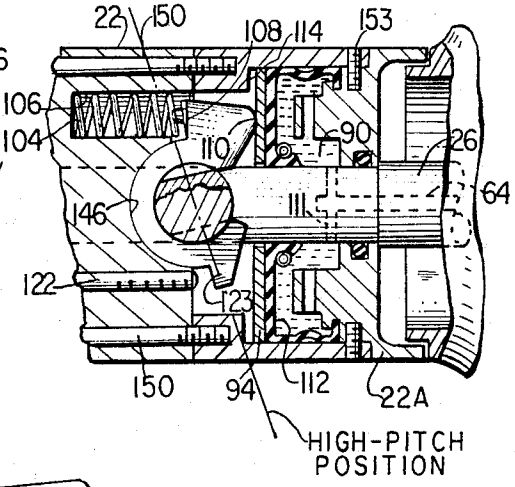


FIG. 2

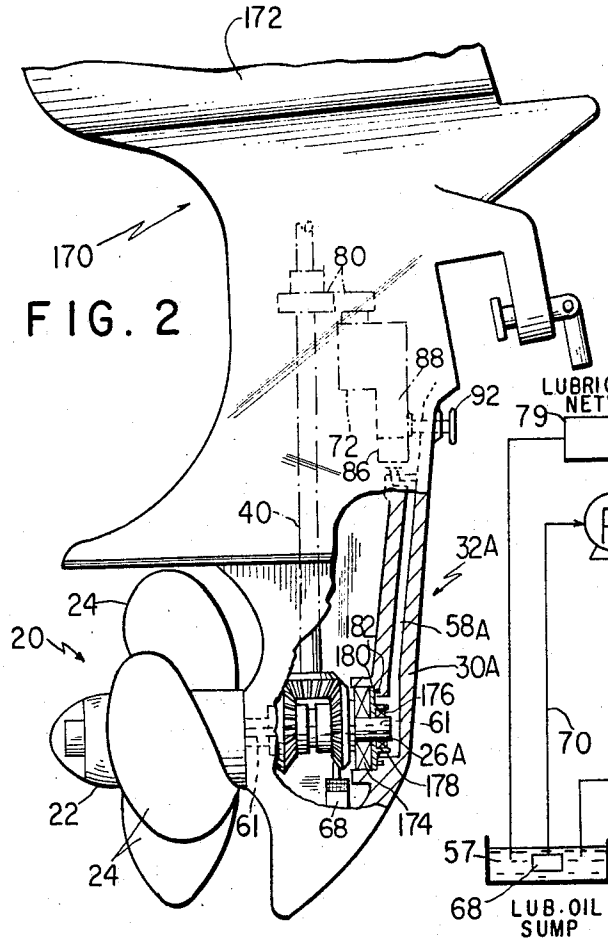
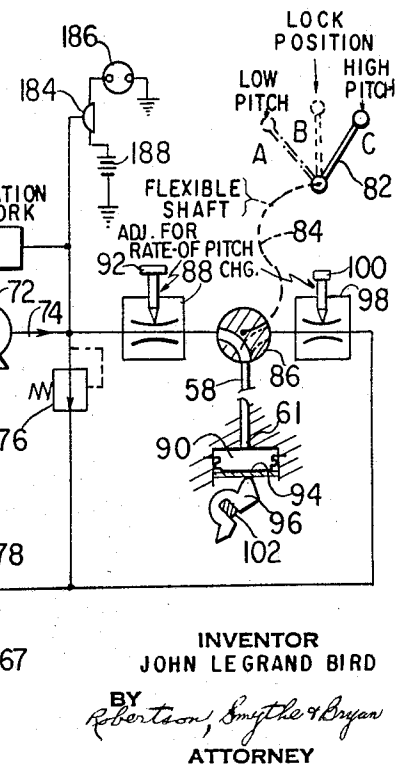


FIG. 3



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HYDRAULICALLY ACTUATED CONTROLLABLE-PITCH PROPELLER SYSTEM FOR OUTBOARD MOTORS AND OUTDRIVES

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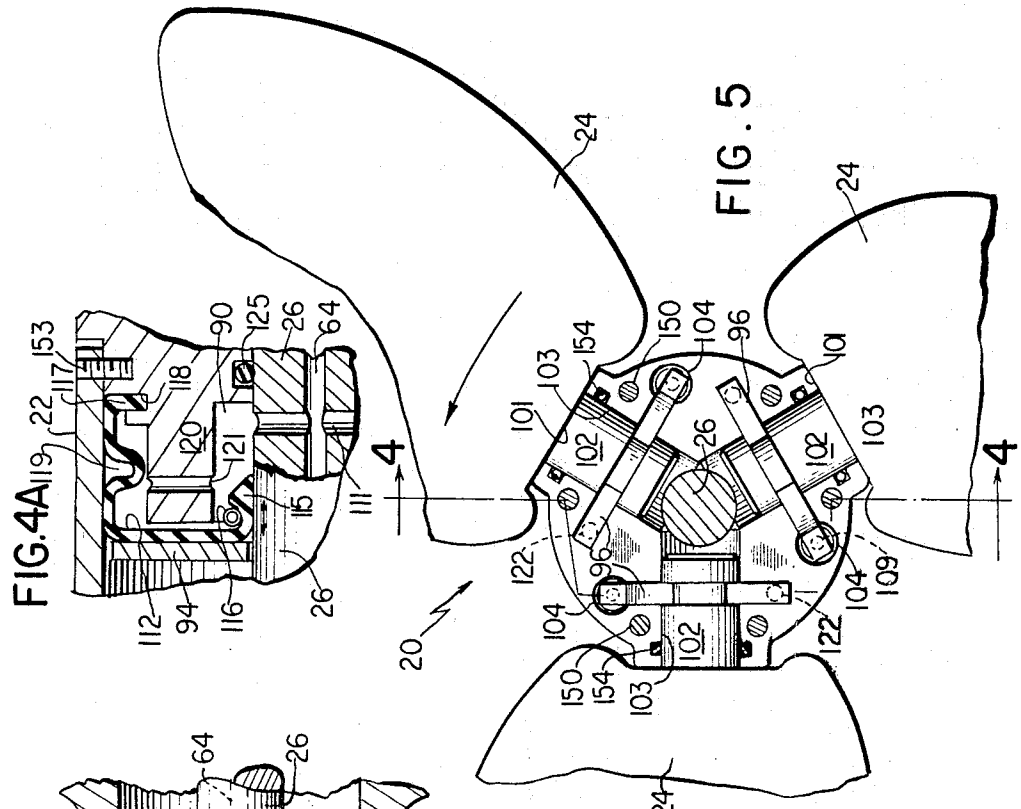


FIG. 5

FIG. 4A

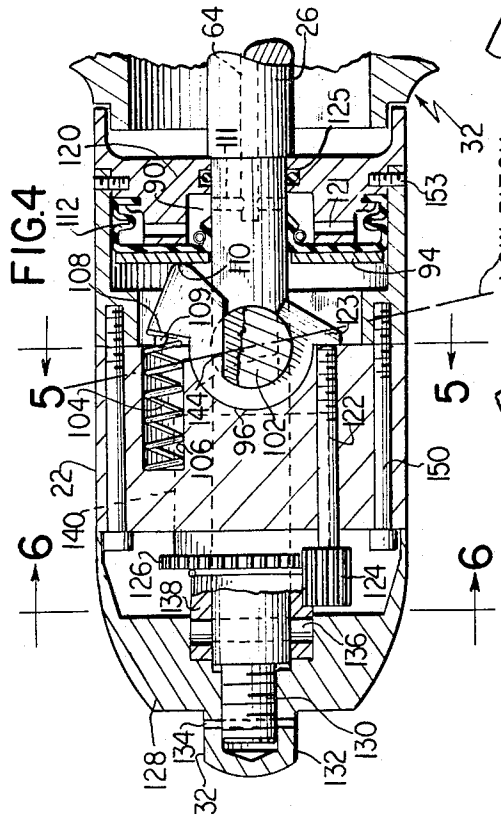


FIG. 4

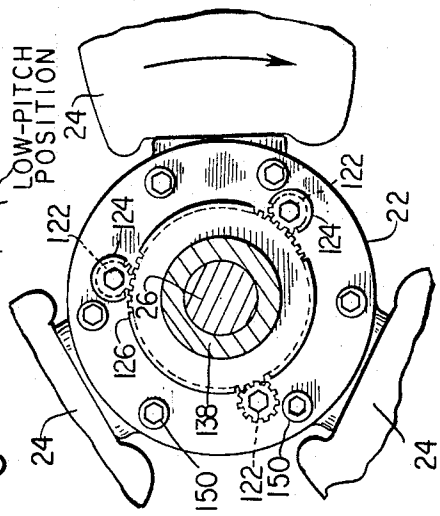


FIG. 6

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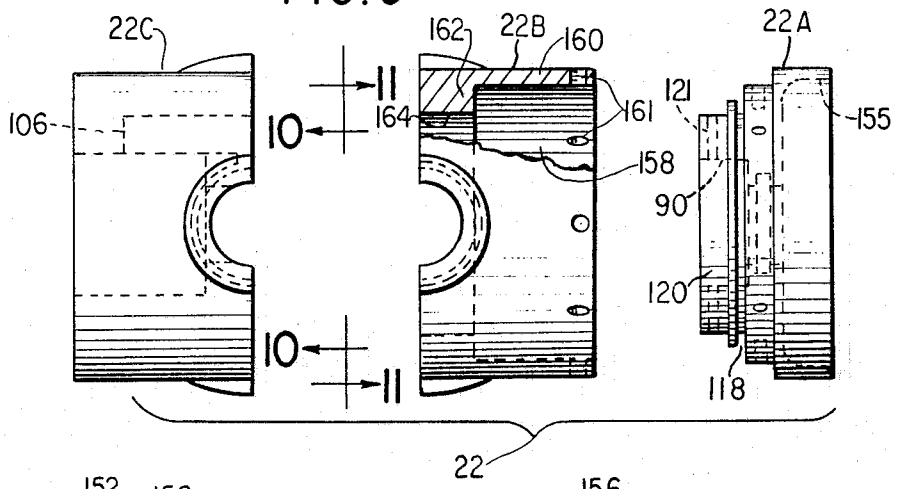
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HYDRAULICALLY ACTUATED CONTROLLABLE-PITCH PROPELLER SYSTEM FOR OUTBOARD MOTORS AND OUTDRIVES

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FIG. 9



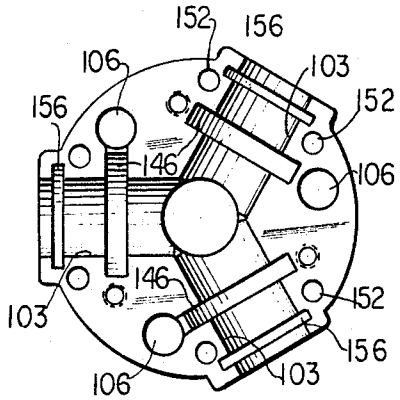


FIG. 10

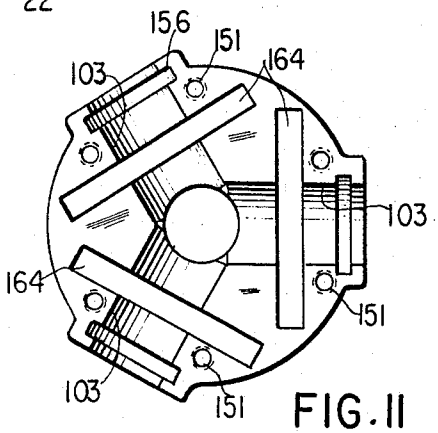
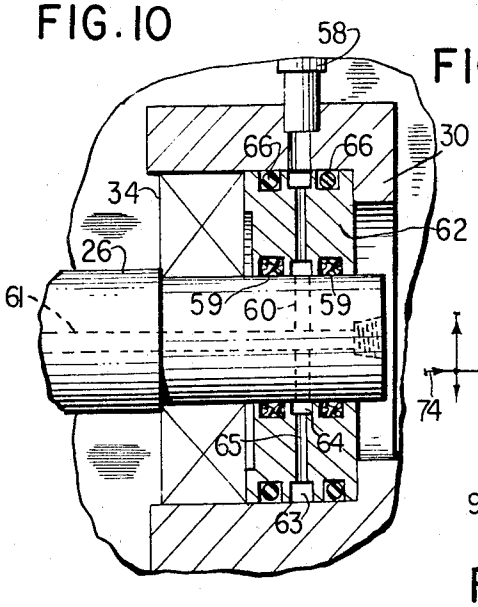


FIG. 11

FIG. 12



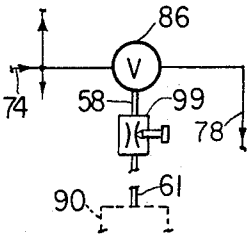


FIG. 14

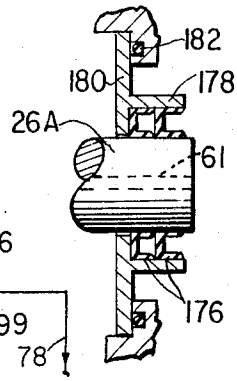


FIG. 13

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3,273,656

HYDRAULICALLY ACTUATED CONTROLLABLE-PITCH PROPELLER SYSTEM FOR OUTBOARD MOTORS AND OUTDRIVES

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Filed June 30, 1964, Ser. No. 379,180
17 Claims. (Cl. 170—160.32)

The present invention relates to hydraulically actuated controllable-pitch propeller systems for outboard motors and outdrives and more particularly to such systems which enable the pitch of the propeller to be changed from within the vessel as may be desired during operation of the vessel to provide improved performance under changing operating conditions. In addition, the present invention relates to hydraulically actuated controllable-pitch propeller systems for outboards and outdrives which enable the pitch of the propeller to be changed as may be desired regardless of whether the vessel is being steered straight ahead or being turned, that is, regardless of the fact that the propeller shaft may be swung about to various angles with respect to the vessel for steering.

The performance, efficiency and operating characteristics of marine vessels are markedly improved by the use of controllable-pitch propellers. The desirability of controllable-pitch marine propellers has been recognized for more than one hundred years, and the improvements in performance, efficiency and operating characteristics are thoroughly analyzed and various prior systems are explained in the study entitled "Controllable-Pitch Propellers" made by Commander Lewis A. Rupp and published in the Transactions of The Society of Naval Architects and Marine Engineers, volume 56, 1948.

There are various situations in which a controllable-pitch propeller system can be used to advantage, for example, in the event it becomes necessary to tow another vessel of substantial relative drag. During cruising such a system enables the operator to select a throttle setting and pitch setting for the most economic operation under the conditions being encountered. Also, in trolling, particularly when using a two-cycle engine, the engine becomes fouled if it is operated at low speed for any substantial period of time, and the systems described herein enable the engine to be operated at moderate speed without exceeding the desired boat speed for trolling. In situations where water skiers are being pulled, the transition period while the skier is being accelerated up to normal running speed is tiring on the skier because the skis must be held at a steep angle at slow speeds to provide sufficient lift, and accordingly the drag forces are quite large. The controllable-pitch systems described herein enable the skier to be brought up to the desired speed more quickly and smoothly so as to minimize the tiring transition period.

However, in spite of the many known advantages of controllable-pitch propeller systems wherein the pitch can be changed from within the vessel during operation, there is at the present time only a limited usage of such systems, which were available prior to the present invention. Many of the prior controllable-pitch propeller systems are complex and expensive and many require that the propeller shaft remain in a fixed alignment in a fore and aft direction, and the prior systems have involved complications or difficulties including large, bulky hub structures, so that in actual practice prior systems have found only very limited and specialized usage, which has generally been confined to certain larger vessels and to special naval craft.

Among the many advantages of controllable-pitch propeller systems embodying the present invention are those

resulting from the fact that they are adapted for use in outboard motors and for outdrives wherein steering of the vessel is accomplished by turning the propeller shaft away from its normal alignment in a fore and aft direction so that the thrust of the propeller provides a turning action on the vessel.

An advantage of the pitch control systems described herein as illustrative embodiments of the present invention is that the pitch of the propeller blades is continuously changeable while the vessel is under way from one limit of the pitch-change range to the other limit. The continuous change in pitch occurs at a predetermined rate which is adjustable as desired. In addition, the pitch may be held fixed at any desired position in the range for as long as may be desired by the operator. Thus, the pitch can be held fixed at either end of the range or at any intermediate value. For example, when a vessel equipped with a system embodying the present invention is first started under way the operator can set the manual pitch control handle at the low-pitch position so that the propeller blades are initially set at a low pitch. Thus, the engine is enabled to turn over at its rated r.p.m. so as to develop rated horsepower and maximum forward thrust from the propeller, even though the vessel is travelling through the water at low speed. Then, as the vessel is proceeding at a moderate speed, the manual pitch control handle is moved to its high-pitch position. This initiates an automatic progressive increase in pitch. As the speed of the vessel increases the pitch of the propeller blades is correspondingly increased so as to match their pitch with the increasing speed of the propeller through the water, and so the engine continues to operate at its rated speed and power. Under these conditions the vessel very quickly accelerates up to its full speed, at which time the highest pitch of the propeller is provided.

If it is desired to operate the vessel under conditions where a lower pitch than the maximum is desired, then the operator needs only to move the control handle back from the high-pitch into the low-pitch position. This initiates automatic progressive decrease in pitch. After a few moments, when the desired lower pitch is reached, then the operator moves the control handle to the center or pitch-locking position, and the hydraulic control system holds the propeller blades at the desired intermediate pitch. In other words the operator has stopped a decrease in pitch at the desired value by moving the control handle into the center position. Similarly, the operator can stop an increase in pitch at the desired value by moving the control handle into the high-pitch position to initiate an increase in pitch and then moving the handle into the center position when the desired increased pitch is obtained.

Another advantage of controllable-pitch propeller systems described herein as illustrative embodiments of the present invention is that the pitch is varied by changing the amount of pressurized hydraulic fluid in a control chamber which is located within the hub of the propeller. In the illustrative systems which are described herein it is the lubricating oil which is used as the fluid for controlling the pitch, and an oil pump is conveniently used as the pressure source.

In addition, controllable-pitch systems embodying the present invention are adapted for convenient manual adjustment of the range of pitch change for all of the blades simultaneously. The range limit stops for all of the blades in the propeller are ganged together for simultaneous movement. Thus, the user manually adjusts the low pitch position before the system is put into operation so that the minimum pitch value will provide the maximum rated engine r.p.m. when the vessel is proceeding at full throttle with the propeller blades set in the lowest pitch

position. In this way over-speeding of the engine during operation is prevented when the propeller is at the minimum pitch setting.

A further advantage of the illustrative systems is that they are fail-safe in operation. In the event the control fluid should leak or the hydraulic fluid pressure should fail, then the propeller returns to its low-pitch position.

Another advantage of the illustrative systems embodying the present invention is that they enable the use of a propeller hub which is no larger in diameter than conventional fixed pitch propellers for outboard motors and outdrives.

Among the many other advantages of the present invention are those resulting from the fact that it provides a dependable, compact, pitch-control system with only a few moving parts which is applicable to a wide variety of outboard motors and outdrives.

It is an object of the present invention to provide hydraulic actuated controllable-pitch propeller systems which are practical, dependable, economic to use, and suitable for outboard motors and outdrives for use with fishing boats, sport boats, family cruising boats, and the like.

As used herein the term "outboard motor" is intended to include the types of marine propulsion units in which the engine and propeller are both mounted on a frame which is adapted to be turned from side-to-side so as to change the direction of thrust of the propeller relative to the vessel for steering the vessel. The term "outdrive" is intended to include the types of marine propulsion systems in which the engine is inboard and the transmission from the engine to the propeller extends out of the vessel to a lower propeller drive unit which can be swung from side-to-side for steering and also can be swung up to an elevated position in which the entire lower unit and propeller are raised above the level of the bottom of the vessel for beaching.

In the specification and in the accompanying drawings are described and shown controllable-pitch propeller systems embodying the invention, but it is to be understood that these examples of embodiments of the invention are not intended to be exhaustive nor limiting of the invention. These examples of the invention are given in order that others skilled in the art may fully understand the invention and the ways in which it may be applied to the conditions of a particular use.

The various objects, aspects and advantages of the present invention will be more fully understood from a consideration of the following specification in conjunction with the accompanying drawings in which:

FIGURE 1 is a side elevational view of an illustrative embodiment of the invention in an outdrive installed in the stern of a vessel, the stern being shown in section with the engine broken away;

FIGURE 2 is a side elevational view of a further illustrative embodiment of the invention in an outboard motor;

FIGURE 3 is a diagram of a pressurized lubricating oil system for controlling the pitch of the propeller blades

FIGURE 4 is a sectional view taken longitudinally through the hub of a controllable-pitch propeller utilized in the embodiments of the invention shown in FIGURES 1–3. FIGURE 4 is a section taken generally along the line 4–4 of FIGURE 5 and it shows the low-pitch position of the parts;

FIGURE 4A is an enlarged sectional view of the flexible diaphragm and piston seen in FIGURE 4;

FIGURE 5 is a cross sectional view taken generally along the plane 5–5 in FIGURE 4;

FIGURE 6 is a rear elevational view with the protective hub cap removed to show the pitch limit adjustment for setting the minimum blade pitch;

FIGURE 7 is a partial sectional view of the hub corresponding with FIGURE 4 and showing the parts in their high pitch position;

FIGURE 8 is a partial perspective view to show the inner end of one of the propeller blades and the retainer arm for holding the blade in position in the hub. This retainer arm is actuated by the piston as shown in FIGURE 7 to change the blade pitch;

FIGURE 9 shows the front and rear halves of the hub casing in disassembled position;

FIGURE 10 is an end elevational view looking in the direction 10—10 in FIG. 9 to show the structure of the rear part of the hub;

FIGURE 11 is an end elevational view looking in the opposite direction along the line 11—11 in FIGURE 9;

FIGURES 12 and 13 are enlarged views of portions of FIGURES 1 and 2, respectively, to show the seals for the propeller shaft; and

FIGURE 14 is a diagram of a modified control system.

In the outdrive installation in FIGURE 1 the propeller **20** includes a hub **22** and blades **24** whose pitch can be changed over a range as will be described in detail further below. The hub **22** is driven by a propeller shaft **26** journaled in a bearing **28** in a frame **30** of the lower drive unit **32**. The forward end of the propeller shaft **26** is held by another bearing **34** seated in the frame **30**.

In order to drive the propeller shaft **26**, there is a set of bevel gears in the lower unit **32** including a bevel gear **36** secured to this shaft engaged by another bevel gear **38** on an upright drive shaft **40** of conventional construction which extends up to another set of bevel gears in a transmission generally indicated at **42**. This transmission **42** is of a conventional construction and includes a reversing gear and a clutch for disengaging the engine from the propeller and for reversing the direction of propeller rotation for backing the vessel. As will be understood, there is a main drive shaft of conventional construction extending forward from the transmission unit **42** through the stern transom **44** to the rear of the engine **46**, and this main drive shaft includes universal joints so as to permit the lower unit **32** to be turned from side-to-side for steering and to be swung up into a lifted position. Also, there is a conventional lift mechanism **48** for swinging the lower unit **32** up to a position above the level of the bottom **50** of the vessel for clearing underwater obstacles, for beaching the vessel, etc. The main drive shaft and universal joints are protected by a convoluted, flexible water-tight housing **52**.

It is to be understood that this outdrive installation may include all of the usual mechanisms for holding the lower unit down when operating in reverse, for disposing of exhaust gases, for water intake to cool the engine, and so forth. The thrust of the propeller is transmitted to the transom **44** through suitable conventional brackets **54** and **56** which permit the steering and elevating of the lower unit **32**.

In order to control the pitch of the blades **24**, a suitable controlled amount of hydraulic liquid **57** (see also FIG. 3) is fed into a control cylinder, as will be described. This liquid flows through a line **58** from a pressurized supply and is contained between seal rings **59** (FIGURES 1 and 12) and passes into a transverse passage **60** in the propeller shaft which connects with an axial passage **61**. As shown in FIGURE 12, the seal rings **59** have an X-shape as seen in cross section to accommodate rotation of the propeller shaft **26** while effectively providing a liquid-tight connection between the line **58** and passage **60**. The seal rings **59** are seated in spaced grooves in a metal ring **62** which includes exterior and interior liquid-passage grooves **63** and **64** joined by a radial passage **65**. A pair of O-rings **66** form a stationary seal with the mounting in the frame **30**. In this illustrative embodiment of the invention the hydraulic liquid **57** is lubricating oil which is being used to lubricate the moving parts in the lower unit **32**. This lubricating oil is contained in a sump chamber **67** adjacent to the bevel gears **36** and **38** and it is supplied and controlled by a system as shown in FIGURE 3 or by a modified system as shown in FIGURE 14.

In FIGURE 3 the oil is drawn from the sump **67** through an intake strainer **68** and an intake line **70** to a liquid-pressurizing pump, for example such as a positive-displacement gear-type oil pump **72**, for supplying oil at the required pressure to a high pressure oil manifold **74**. An overload pressure-relief valve **76** is connected from the high-pressure manifold **74** to a common line **78** returning to the sump **67**. The pump **72** as shown is of conventional oil pump construction which is connected to a conventional network **79** of lubrication passages in the drive unit **32** for lubricating the bearings, gears, clutch bearings and other moving parts. As shown in FIGURE 1, the oil pump **72** is driven by gearing **80** from the drive shaft **40**, and the oil is drawn up through the line **70** from intake strainer **68**.

In this illustrative system shown in FIGURE 3 a manual control handle **82** is moved from the low-pitch position A into the high-pitch position C and is allowed to remain in position C when it is desired to initiate a continuous, smooth change of the blade pitch from low to high. The handle **82** is located at a convenient point near the helmsman's position in the vessel and has a flexible mechanical connection **84** to a three-way valve **86** within the drive unit **32**. When the pitch-control handle **82** is in position C, then the pressurized oil flows through an adjustable orifice control **88**, through the valve **86** and through the supply line **58** and shaft passage **61** (FIG. 1) into a pitch-control cylinder **90** (FIG. 3) within the hub **22**. The adjustable orifice **88** serves to control the rate at which the cylinder **90** is filled, and thus it sets the actual rate of change of blade pitch. An adjusting screw handle **92** is accessible from the outside of the drive unit **32** (as seen in FIGURE 1) for presetting the rate at which the change from low to high pitch will be effectuated. The setting of the valve **88** which is chosen depends upon the horsepower-to-weight ratio of the vessel and its hull configuration, which in turn establish the rate of acceleration from low to top speed. In the case of a powerful engine and light-weight high-speed hull, then the orifice **88** is set in a more open position so that only a relatively few seconds are required to change from low to high pitch, because the vessel accelerates very rapidly, and vice versa in the case of a heavier hull and a relatively less powerful engine.

As the oil fills the cylinder **90** it pushes a piston **94** which moves the individual blade control arms **96** so as to turn each of the blades **24** from its lower into its higher pitch position, as shown in FIGURES 4–8 to which reference will also be made in the following discussion.

When the pitch control handle is moved back into position A, the valve **86** makes an interconnection between line **58** and a flow control orifice **98** for returning the oil from the cylinder **90** through line **78** to the sump **67**. The orifice control **98** includes an accessible adjustment screw handle **100** for setting the rate of change of pitch during the return of the blades from high to low pitch.

Thus, advantageously, the system of FIGURE 3 includes a first adjustable flow control valve **88** for controlling the actual rate at which the increase in pitch occurs, i.e., to control the length of time to change from the low to the high pitch position and a second adjustable flow control valve for controlling the actual rate at which the decrease in pitch occurs. Accordingly, these rates can be set independently.

The system of FIGURE 14 is identical to that of FIGURE 3 and corresponding reference numbers are used for corresponding parts, except that in FIGURE 14 only a single adjustable flow control valve **99** is included in the line **58**. Accordingly, this single valve **99** controls both the rate of pitch increase and the rate of pitch decrease.

When it is desired to lock the pitch at any value in the range of operation, then the helmsman first moves the control handle **82** into position "A" or "C" (depending upon the desired direction of pitch change) for a time interval sufficient to produce the desired change, and then he moves the handle into position "B." In position "B," the valve **86** closes off the passage **58** so as to trap the amount of liquid in the cylinder **90** which is present at the instant the handle **82** is moved into position "B."

As shown in FIGURE 5, this pitch control system is adapted for use with a multi-bladed propeller, for example such as the three-bladed propeller **20**. In these particular examples, as seen from FIGURES 1, 2 and 6, the propeller is a right-hand propeller, that is, it turns in a clockwise direction as seen from astern. In FIGURE 5 the view is from ahead, and so the direction of rotation appears counter clockwise. It is to be understood that the present invention is equally suitable for left-hand propellers. The base **101** of each of the blades **24** includes an inner stub shaft **102** (FIGS. 4, 5 and 8) which is rotatably mounted in a socket **103** in the hub **22**. Attached to each shaft **102** is the control arm **96**, as seen also in FIGURE 8. To urge each blade toward its low-pitch position, as shown in FIGURES 4 and 5, there is a compression spring **104** in an axially extending recess **106** in the hub **22**. This spring pushes against a seat **108** on the arm **96** surrounding a pin **109** for holding the end of the spring in place. These springs **104** push the operating lever end **110** of each arm **96** against a large annular plate **94** which serves as a piston head, as will be explained below. In FIGURE 4, the arm **96** and piston **94** are shown in the forward or low-pitch position.

When hydraulic fluid is supplied under pressure through the axial passage **61** in the propeller shaft **26**, this fluid passes out through a transverse passage **111** so as to enter the irregular shaped cylinder **90** adjacent to a convoluted flexible seal **112** which presses against the opposite side of the piston **94** from that which is engaged by the ends **110** of the control arms **96**. The hydraulic fluid moves the seal **112** and the piston **94** rearwardly in the annular cylinder in the hub **22** until the piston **94** touches a stop surface **114** as shown in FIGURE 7. This movement of the piston **94** turns each arm **96** and stub shaft **102** so as to turn each of the blades **24** into its high-pitch position. During manufacture, the position of the stop surface **114** is determined so as to establish the maximum pitch setting for any given propeller as desired. If it is wished to reduce the maximum setting after manufacture, then one or more shim washers are press fitted into the hub adjacent to the surface **114**.

In FIGURE 4A is shown the general shape of the flexible seal **112**. The inner edge **115** of this seal is held against the shaft **26** by means of an annular coil spring **116**. This coil spring resists the centrifugal force which might otherwise tend to deflect the inner edge **115** of the seal away from the shaft **26**. During the change of pitch, this inner seal edge **115** slides along the surface of the shaft **26**. The outer edge **117** of this seal **112** remains fixed in an annular recess **118** (FIGS. 4 and 7) in the hub **22**. Thus, movement of the outer portion of the seal is accommodated by flexing its convolutions **119**.

In order to reduce the volume of the liquid-actuated cylinder **90**, so as to minimize the amount of oil in this cylinder, the hub includes an annular mass **120** (FIG. 4) extending into this chamber. This annular mass **120** serves as a fixed stop to limit the minimum possible low-pitch setting, and a passageway **121** provides communication between the inner and outer portions of the pitch-control cylinder **90**. It will be understod that the seal **112** is a body of revolution which extends completely around the propeller shaft **26**. An O-ring **125** seals the front end of chamber **90** around the propeller shaft **26**.

In this illustrative embodiment there is provision for adjusting the minimum value of the low-pitch position so as to prevent over-speeding of the engine when the boat is started at full throttle in low pitch. This low-pitch setting is adjusted by means of a plurality of adjustment screws **122** (see also FIGURE 6) which extend forward from the rear of the hub, and the ends of these screws

serve as stops for engaging the tail ends 123 of the arms 96, as shown in FIGURE 4. These adjustable low-limit stops 122 are all ganged together so that adjustment of any one of them will correspondingly adjust the others, as seen in FIGURE 6. These machine screws 122 have heads 124 with Allen wrench sockets therein and with peripheral gear teeth engaging a ring gear 126. It is possible to change this adjustment at any time by temporarily removing the cap 128 from the threaded end 130 of the propeller shaft and then reinstalling it. The cap 128 may include a pair of flats 132 for accommodating a wrench and may be locked in place by a cotter pin passed through an opening 134.

The torque from the propeller shaft 26 is suitably transmitted by conventional means from the propeller shaft 26 to the hub 22, for example, as shown in FIGURE 4 the torque is transmitted through a shear pin 136 to an inner tough metal sleeve 138. This sleeve 138 extends within the body of the hub 22 and is coupled to the interior of the hub body through a shock-absorbing resilient overload slip coupling 140 of conventional type.

Advantageously, the pitch control arms 96 serve as retainers for securing the rotatable stub shafts 102 in their respective sockets 103. The hub 22 is made in three main parts, 22A, 22B and 22C, as shown in FIGURES 9, 10 and 11. The control arms 96 (FIG. 8) include a C-shaped center portion with a slot 142 for engaging flats 144 on the stub shafts 102. The C-shaped portion of each arm 96 fits snugly into a semi-circular bearing channel 146 in the rear hub part 22C, as shown in FIGURES 4, 7 and 10. The middle and rear hub parts 22B and 22C are fastened together by machine screws 150 in the holes 152, and threaded holes 151 (FIG. 11), and the front hub part 22A is secured to the middle part 22B by radial screws 153 (FIGS. 4, 4A and 7). The front part 22A includes a forward projecting lip 155 so as to minimize the gap between hub 22 and lower unit 32 so as to reduce water resistance. An O-ring seal 154 (FIG. 5) about each stub shaft 102 is held in a groove 156 (FIG. 10).

As seen in FIGURE 10, there is a semi-cylindrical seat forming one half of each socket 103 in the front face of the rear hub part 22C and a mating semi-cylindrical seat (FIGURE 11) in the rear face of the middle hub part 22B forming the other half of each socket 103. Thus, advantageously, the stub shafts 102 are supported along their full lengths by the sockets 103 so as to provide a strong, rigid mounting for each of the blades 24, while permitting them to turn with respect to the hub 22.

In order to provide cylinder means in the hub for accommodating operation of the piston 94 and seal 112, the middle hub part 22B includes a deep well 158 (FIGURE 9) in its front end surrounded by an outer cylinder wall portion 160 including screw holes 161 for receiving the radial attachment screws 153.

The bottom of the deep well 158 is defined by a partition 162, in the rear face of which are formed the semi-cylindrical halves of the sockets 103, as mentioned above. To provide clearance for movement of the ends 110 and 123 of the control arms 96 there are long narrow clearance openings 164 passing through the partition 162. As seen in FIGURE 11, the planes of these clearance openings are perpendicular to the respective axes of the sockets 103, and the openings 164 are slightly wider than the curved bearing channels 146 so that the ends of arms 96 can move freely in the openings 164. As shown in FIGURES 4 and 7, the lever end 110 of each control arm 96 extends forward through its clearance opening 164 and into engagement with the piston 94.

By virtue of the construction of the hub parts 22A, 22B, and 22C and the internal moving elements of the pitch-control system as described above, it is convenient to remove and replace any blade if it should strike an object and become damaged. The rear cap 128 is removed, as described further above, and then the six longitudinal machine screws 150 are taken out so that the rear hub part 22C can be lifted away from the middle part 22B. This simultaneously releases all of the blades and their retainer-control arms 96 for convenient replacement of the damaged blade. Also, the control arms 96, springs 104 and O-rings 154 are released for replacement if desired. It is an advantage of this construction that any one or more blades and arms 96, springs 104 and O-rings 154 can be removed without disturbing the cylinder means 158 or its contents including the piston 94, seal 112 and coil spring 116. Conversely, by removing the radial attachment screws 153, the front and middle hub parts 22A and 22B can be separated so as to expose the liquid actuated parts within the chamber means 158 without disturbing any of the blades or associated parts.

FIGURE 2 shows a modified embodiment of this pitch-control system in an outboard motor 170. Many of the components of this modified system are identical to those in the system described above, and so only the differences will be discussed. The oil flow circuit is identical to that shown in FIGURE 3 or 14 including an oil pump 72. This oil pump 72 which is also shown in FIGURE 2 is identical to that of FIGURE 1 and may serve to lubricate the engine 172 or to lubricate the working parts of the lower unit 32A of the outboard motor 170 or both, whereas in the case of the outdrive shown in FIGURE 1, the pump 72 serves to lubricate only the working parts of the lower unit 32. In the outdrive system of FIGURE 1 the engine 46 includes its own separate lubrication pump and sump, which are conventional and are not shown. In the case of a four-cycle outboard engine 172, then the pump 72 can be the existing lubrication pump for the engine 172.

In the system of FIGURE 2 the axial oil flow passage 61 extends to the front end of the propeller shaft 26A and is supplied by oil from pump 72 feeding through a supply line 58A in the frame 30A of the lower unit 32A. The thrust bearing 174 for the shaft 26A includes a pair of annular U-shaped resilient oil seals 176 (see also FIG. 13) for containing the oil as it flows into the passage 61. These seals 176 are seated around the shaft 26A and are held within a collar 178 on a thrust washer 180. A stationary seal to the frame is provided by an O-ring 182.

If desired, either the outdrive or outboard motor system may include an oil-pressure switch 184 (FIG. 3) for controlling an electrical circuit including an audible or visible alarm 186, such as a buzzer, connected through the switch 184 to a source of electrical energy such as a battery 188 for providing an alarm signal upon an undue drop in the operating oil pressure.

From the foregoing specification it will be understood that the present invention in hydraulically actuated controllable-pitch propeller systems as described above is well suited to provide the advantages set forth. It will be appreciated from this specification that various possible embodiments of the various features of this invention can be made and the apparatus herein described can be varied in various parts, all without departing from the scope of the invention, and that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense, and that, in certain instances, some of the features of the invention can be used without a corresponding use of other features, all without departing from the scope of the invention.

What is claimed is:

1. A hydraulically actuatable controllable-pitch propeller adapted to be mounted upon the propeller shaft of outboard motors, outdrives and the like comprising a rotatable hub having an axial opening therein extending longitudinally in the hub for receiving the propeller shaft in said axial opening for mounting the hub thereon, said hub having an annular cylinder therein surrounding said axial opening, an annular piston in said cylinder and surrounding said axial opening, said piston being movable

longitudinally in said cylinder, said annular cylinder and said annular piston rotating with said hub, said cylinder having a space communicating with said axial opening for receiving hydraulic fluid into said space from a propeller shaft which has been received therein, a plurality of propeller blades mounted at spaced points around the periphery of said hub, said blades extending outwardly from the hub, each of said blades having a stub shaft extending into said hub from the periphery of the hub toward said axial opening, each of said stub shafts being turnably mounted in said hub for changing the pitch of its blade, a plurality of control arms, one of said control arms being secured to each of said stub shafts for turning its blades to different pitch positions, each of said control arms having a projecting end resting in contact with said annular piston, a plurality of compression springs in said hub extending parallel to said axial opening, one of said springs engaging the projecting end of each control arm for pressing said end into contact with said piston, whereby said propeller can be installed on the propeller shaft and changes in the amount of hydraulic fluid in said annular cylinder changes the pitch of all of said blades simultaneously.

2. A hydraulically actuated controllable-pitch propeller for outboard motors and outdrives comprising a rotatable hub including a first body part and second body part forward of said first body part, each of said body parts being rotatable and having an axial opening therein mountable on a rotatable propeller shaft inserted into both of said body parts for rotation with said shaft, fastening means for detachably fastening said body parts together along a radial joint perpendicular to the axis of the propeller, said hub including an axially extending annular cylinder therein surrounding said axial opening and an axially movable annular piston in said cylinder, said annular piston also surrounding said axial opening and rotating with said hub, said first and second body parts defining a plurality of radially extending cylindrical sockets positioned at uniformly spaced points along and aligned with said radial joint, a plurality of blades each having a base with a stub shaft projecting from the base and each stub shaft fitting into and being supported by a respective one of said sockets, said rotatable hub having a plurality of clearance openings therein, each of said clearance openings extending between a respective one of said sockets and said annular cylinder, a pitch control arm secured to each of said stub shafts and held by said body parts at the joint aligned with the respective clearance openings for removably holding the stub shafts in said sockets, said pitch control arms extending through the respective clearance openings, said pitch control arms being movable within said clearance openings and all being engaged by and moved by said annular piston for turning all of said stub shafts within their respective sockets for controlling the pitch of all of said blades, and said hub having a passage therein communicating with said cylinder and with said axial opening for admitting hydraulic control liquid into said cylinder for moving said piston to simultaneously change the pitch of all of said blades.

3. A hydraulically actuated controllable-pitch propeller for outboard motors and outdrives comprising a rotatable hub having an axis of rotation and including a first body part and a second body part forward of said first body part, fastening means for detachably fastening said body parts together along a joint extending outwardly around said axis, said hub including an axially extending cylinder therein and an axially movable piston in said cylinder, said cylinder and piston rotating with said hub, said first and second body parts having aligned semi-cylindrical recesses therein extending outwardly along said joint defining a plurality of outwardly extending round sockets positioned at said joint, each of said sockets having a curved channel in a plane perpendicular to the length of the socket, said curved channels being located intermediate the ends of said sockets, said hub having a plurality of clearance openings therein, each of said clearance openings being aligned with a respective one of said channels, a plurality of blades each having a base with a round stub shaft projecting from the base and each stub shaft fitting into a respective one of said sockets, the inner and outer ends of said stub shafts being closely held in said sockets, a plurality of pitch control arms each having a C-shaped portion secured to a respective one of said stub shafts intermediate the ends of said stub shaft and engaged in and held by the curved channel of the socket for removably holding the stub shafts in said sockets, said pitch control arms extending through the respective clearance openings and all being engaged by said piston for turning all of said stub shafts within their respective sockets for controlling the pitch of all of said blades, and said hub having a passage therein communicating with said cylinder for admitting hydraulic control liquid into said cylinder for moving said piston.

4. A hydraulically actuated controllable-pitch propeller system for outboard motors and outdrives comprising a lower drive unit having a propeller shaft extending therefrom and means for rotating the propeller shaft, said lower drive unit being swingable from side to side for steering a vessel, said propeller shaft having a passage extending longitudinally therein, a source of hydraulic liquid under pressure connected to said shaft passage for feeding hydraulic liquid under pressure into said shaft passage, a rotatable propeller hub mounted on said shaft and having annular cylinder means therein surrounding said shaft and communicating with said shaft passage for receiving hydraulic liquid from said passage, annular piston means in said annular cylinder means, said annular piston means surrounding said shaft and being axially movable in said annular cylinder means for movement by the hydraulic liquid in said cylinder means, said annular cylinder means and said annular piston means being rotatable with said hub, a plurality of propeller blades having stub shafts extending from the base of said blades, said hub having sockets therein having said stub shafts mounted in said sockets, said stub shafts being turnable within their respective sockets for changing the pitch of said blades, said hub having a plurality of clearance openings therein extending between respective ones of said sockets and said annular cylinder means, and control arms secured to said stub shafts and extending through the respective clearance openings and all coupled to said annular piston means for actuation by said piston means for changing the pitch of all of said blades simultaneously.

5. A hydraulically actuated controllable-pitch propeller system for outboard motors and outdrives comprising a lower drive unit having a propeller shaft extending therefrom and means for rotating the propeller shaft, said lower drive unit being movable for changing the direction of the propeller shaft to steer a vessel, said propeller shaft having a passage extending longitudinally therein, a source of hydraulic liquid under pressure, a control valve, hydraulic liquid conducting means connected between said source and said valve and between said valve and said shaft passage, said valve having a first position for connecting said source to said shaft passage for feeding hydraulic liquid under pressure into said shaft passage, a rotatable propeller hub mounted on said shaft and having cylinder means therein communicating with said shaft passage for receiving hydraulic liquid from said passage, a piston movably mounted in said cylinder means for movement by the hydraulic liquid in said cylinder means, said cylinder means and said piston rotating with said hub, a plurality of propeller blades having stub shafts extending from the base of said blades, said rotatable hub having sockets therein for receiving said stub

shafts, control arms secured to said stub shafts and a plurality of compression springs mounted in said hub and engaging said control arms for pressing said control arms against said piston for actuation by said piston for turning said blades into their high-pitch position when hydraulic fluid is introduced into said cylinder means, and said valve having a second position for removing hydraulic liquid from said cylinder means for said compression springs to turn said blades back to their low-pitch position, and said hydraulic liquid conducting means including flow control means controlling the rate of pitch change.

6. A hydraulically actuated controllable-pitch propeller system for outboard motors and outdrives comprising a lower drive unit having a propeller shaft extending therefrom and means for rotating the propeller shaft, said propeller shaft having a passage extending therein, a source of hydraulic liquid under pressure, a control valve, hydraulic liquid conducting means connected between said source and said valve and between said valve and said shaft passage, said valve having a first position for connecting said source to said shaft passage for feeding hydraulic liquid under pressure into said shaft passage, a rotatable propeller hub mounted on said shaft and having cylinder means therein communicating with said shaft passage for receiving hydraulic liquid from said passage, a piston movably mounted in said cylinder means for movement by the entry of hydraulic liquid into said cylinder means, said cylinder means and said piston rotating with said hub, a plurality of propeller blades having stub shafts extending from the base of said blades, said rotatable hub having sockets therein for receiving said stub shafts, control arms secured to said stub shafts and a plurality of compression springs mounted in said hub and holding said control arms against said piston for actuation by said piston for turning said blades into their high-pitch position against the force of said springs in response to entry of hydraulic liquid into said cylinder means, said valve having a second position for removing hydraulic liquid from said cylinder means for turning said blades back to their low-pitch position in response to the force of said springs, and said valve having a third locking position for blocking the flow of hydraulic liquid for locking the blades in an intermediate pitch position.

7. A detachable propeller blade assembly for use in a hydraulically actuated controllable-pitch propeller comprising a blade having a base and a blade area extending outward from the base, a round stub shaft extending inward from the base, said round stub shaft having a round inner end and a round outer end adjacent to the base of the blade for being firmly held along the full length of the stub shaft and having a flat surface thereon at an intermediate point forming an indentation in said stub shaft intermediate the inner end of said shaft and said base, a control arm having a recess fitting partially around said shaft with a part of said control arm engaging in said indentation locking said control arm and stub shaft together with respect to turning movement about the axis of said shaft and locking said shaft against axial movement relative to said control arm, and said control arm having a lever portion extending laterally from said shaft for turning said shaft to control the pitch of said blade.

8. A detachable propeller blade assembly for use in a hydraulically actuated controllable-pitch propeller for outboard motors and outdrives comprising a blade having a base and a blade area extending outward from the base, a round stub shaft extending inward from the base, said round stub shaft having a round inner end and a round outer end adjacent to the base of said blade for being firmly held along the full length of said stub shaft and having a pair of flat surfaces on directly opposite sides of said shaft at an intermediate location on the length of said shaft forming a pair of indentations in said stub shaft intermediate the inner end of said shaft and said base, a control arm having a C-shaped portion for fitting partially around said shaft at the location of said flat surfaces with said control arm engaging in said pair of indentations securing said control arm and stub shaft together with respect to rotation about the axis of said shaft and with respect to axial movement of said shaft relative to said control arm, and said control arm having a lever portion extending outwardly from said C-shaped portion.

9. A detachable propeller blade assembly for use in a hydraulically actuated controllable-pitch propeller for outboard motors and outdrives comprising a blade having a base and a blade area extending outward from the base, a round stub shaft extending inward from the base, said round stub shaft having a round cylindrical surface extending along its inner end and also extending along its outer end with a pair of notch surfaces on directly opposite sides of said shaft at an intermediate location on the length of said shaft forming indentations in said stub shaft between the end of said shaft and said base, a control arm having a C-shaped portion fitting partially around said shaft at the location of said notch surfaces with said control arm engaging in said indentations holding said shaft against turning and against axial movement, said control arm having a lever end portion extending outwardly from said C-shaped portion on one side of said shaft, and said control arm having a second end portion extending outwardly from said C-shaped portion on the other side of said shaft.

10. A hydraulically actuated controllable-pitch propeller for outboard motors and outdrives comprising a rotatable hub having an axial shaft opening therein for mounting on a propeller shaft by inserting the shaft into said shaft opening, said hub including an outer wall encircling said axial shaft opening and spaced radially therefrom for defining an annular cylinder therein surrounding said axial shaft opening, an annular piston in said cylinder, an annular resilient flexible seal in said cylinder adjacent to said piston, said annular cylinder and said annular piston and said annular seal rotating with said hub, an inner edge of said seal surrounding said shaft opening for slidingly embracing a propeller shaft inserted therein, and outer edge of said seal engaging the outer wall of said cylinder, and said seal having an annular face area extending between its inner and outer edges, said face area of said seal engaging said piston, said hub including a plurality of outwardly extending sockets at spaced points around said shaft opening, a plurality of blades mounted on said hub each having a base with a stub shaft projecting from the base and each stub shaft turnably fitting into a respective one of said sockets, a plurality of pitch control arms each secured to a respective one of said stub shafts and all engaged by said piston for controlling the pitch of said blades, and said hub having a passage therein communicating with said shaft opening and said annular cylinder for admitting hydraulic control liquid into said cylinder for moving said piston.

11. A hydraulically actuated controllable-pitch propeller for outboard motors and outdrives as claimed in claim 10 and including an annular coil spring embracing said inner edge of the resilient flexible seal for holding said inner edge against centrifugal force in fluid-tight engagement with the propeller shaft.

12. A hydraulically actuated controllable-pitch propeller for outboard motors and outdrives as claimed in claim 10 and including an inturned lip on said outer edge of the resilient flexible seal for sealingly engaging in a recess in the hub, and a convolution in the outer edge of said seal adjacent to the cylinder wall accommodating movement in an axial direction of the annular face area of said seal.

13. A hydraulically actuated controllable-pitch propeller system as claimed in claim 5 and including adjustable flow control means for adjusting the rate of flow of

the hydraulic liquid into said cylinder means for controlling the rate of pitch change.

14. A hydraulically actuated controllable-pitch propeller for outboard motors and outdrives comprising a hub having cylinder means therein, movable piston means in said cylinder means, a plurality of blades mounted on said hub having stub shafts rotatably received in said hub, pitch control arms secured to said stub shafts and each having first and second ends on generally opposite sides of said stub shaft, a plurality of springs in said hub pressing said first ends of the control arms against said piston means for engaging said piston means for changing the pitch setting of the blades in response to movement of said piston means, said hub having means for admitting hydraulic liquid into said cylinder means for moving said piston means, and a plurality of stop screws in the hub for engaging the second ends of said control arms for limiting the range of movement of said piston means for limiting the range of pitch adjustment, and gear means ganging all of said stop screws together for simultaneous adjustment thereof.

15. A hydraulically actuable controllable-pitch propeller adapted to be mounted upon the propeller shaft of outboard motors, outdrives and the like comprising a rotatable hub having an axial opening therein extending longitudinally in the hub for receiving the propeller shaft in said axial opening for mounting the hub on the propeller shaft, said hub having an annular cylinder therein surrounding said axial opening, an anuular piston in said cylinder and surrounding said axial opening, said piston being movable longitudinally in said cylinder, said annular cylinder and said annular piston being rotatable with said hub, said cylinder having a space communicating with said axial opening for receiving hydraulic fluid into said cylinder space from a propeller shaft which has been inserted into said axial opening, said hub having a plurality of cylindrical sockets positioned at spaced points around the periphery of the hub, said sockets extending into the hub from its periphery toward said axial opening, a plurality of propeller blades extending outwardly from the periphery of the hub, each of said blades having a round stub shaft extending into one of said sockets in the hub, each stub shaft being turnably mounted in its socket for changing the pitch of its blade, a plurality of control arms each secured to one of said stub shafts for turning the blades to different pitch positions, each of said control arms having a first projecting end resting in contact with said annular piston, a plurality of compression springs in said hub extending parallel to said axial opening, one of said springs engaging the first projecting end of each control arm for pressing said end into contact with said piston, and each of said control arms having a second projecting end located generally on the opposite side of the stub shaft from said first end, and an adjustable stop screw extending into the hub for engaging the second end of one of said control arms for adjustably limiting the range of pitch change, whereby said propeller can be installed on the propeller shaft and changes in the amount of hydraulic fluid in said annular cylinder changes the pitch of all of said blades simultaneously.

16. A pitch control system for controlling the blade pitch of propellers on outboard motors and outdrives comprising a lower drive unit having a propeller shaft extending from said unit adapted to have a propeller mounted thereon and drive means for rotating said shaft, said shaft having an internal passage therein extending from a point within said lower unit to a point outside of said unit, said passage extending to the outside of said shaft at said outside point, a rotating seal communicating with said passage within said lower unit, a source of liquid under pressure within said lower drive unit, a reservoir for holding said liquid, liquid-conducting means extending from said pressure source to said rotating seal, a control valve in said liquid conducting means having a plurality of operating positions, in a first of said positions said control valve feeding liquid under pressure into said shaft passage and in a second of said positions said control valve returning the liquid from said shaft passage to said reservoir, and a manual control handle connected by flexible connecting means to said control valve.

17. A pitch control system as claimed in claim **16** and wherein said liquid reservoir is a lubrication oil sump in the lower unit and said source of liquid under pressure is an oil pump within said lower drive unit having its intake connected to said sump and having its delivery connected to a lubrication network in said lower unit for lubricating the working parts of the lower unit, and said control valve controls the flow of oil from said pump into said shaft passage and controls the return of oil from said shaft passage back into said sump, whereby oil under pressure is controllably fed into said shaft passage adapted for controlling the pitch of the blades of a propeller mounted on said shaft.

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