Jan. 10, 1933. D. G. LILLEY 1,894,047

HYDRAULIC PROPELLER

Original Filed Jan. 13, 1930 3 Sheets-Sheet 1

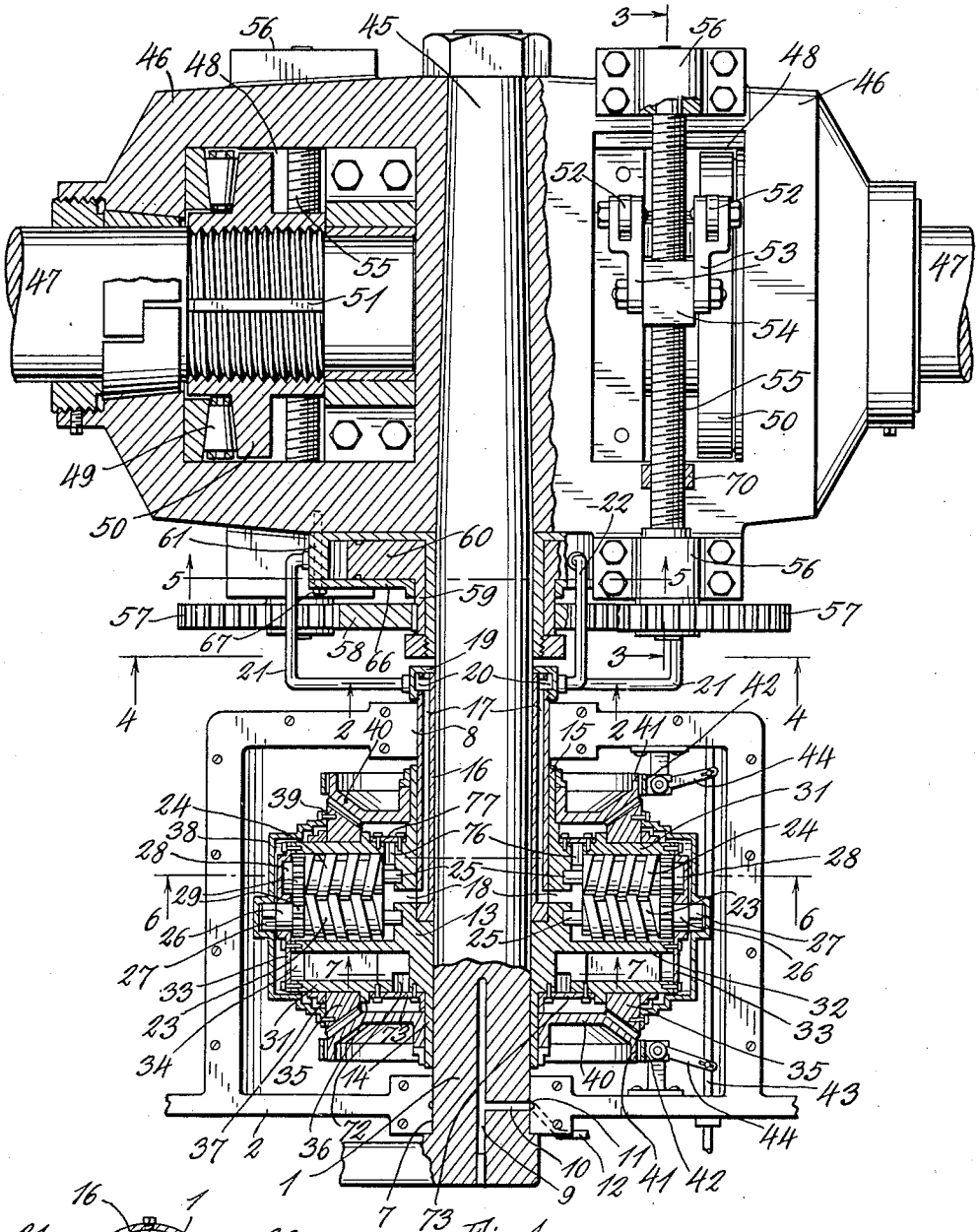


Fig. 1.

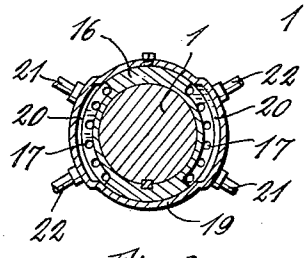


Fig. 2.

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HYDRAULIC PROPELLER

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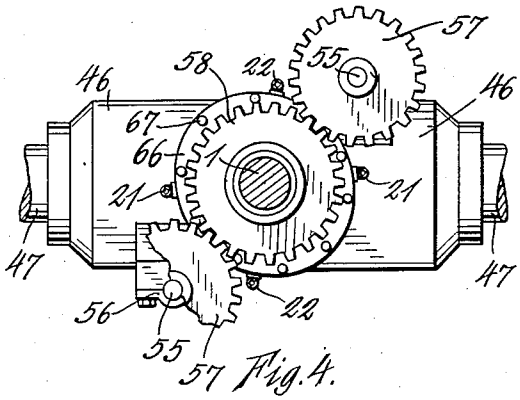


Fig. 4.

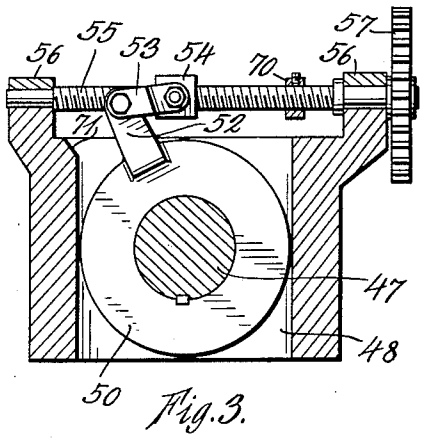


Fig. 3.

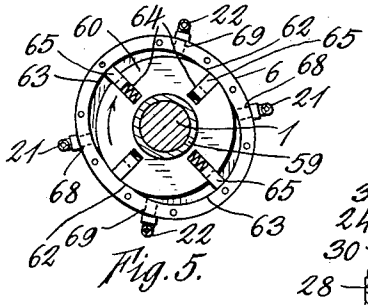


Fig. 5.

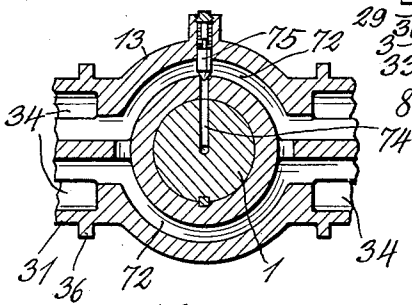


Fig. 7.

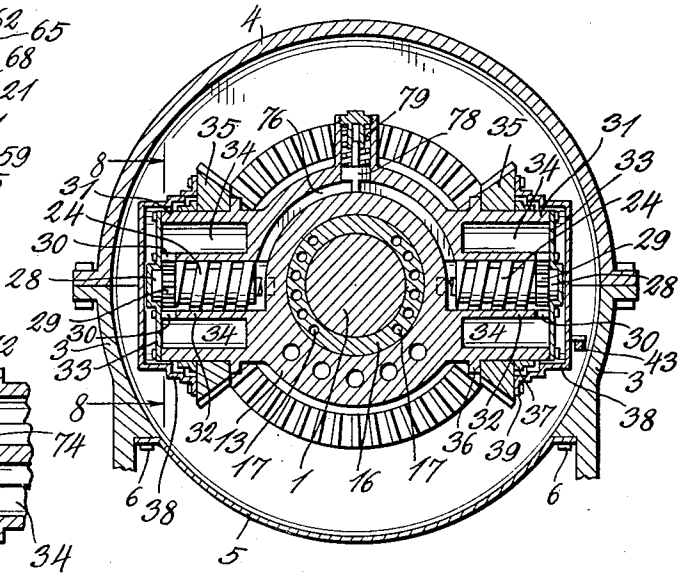


Fig. 6.

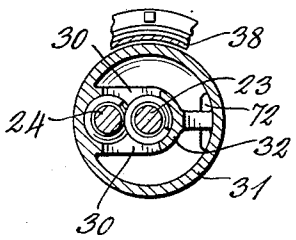


Fig. 8.

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HYDRAULIC PROPELLER

Original Filed Jan. 13, 1930 3 Sheets-Sheet 3

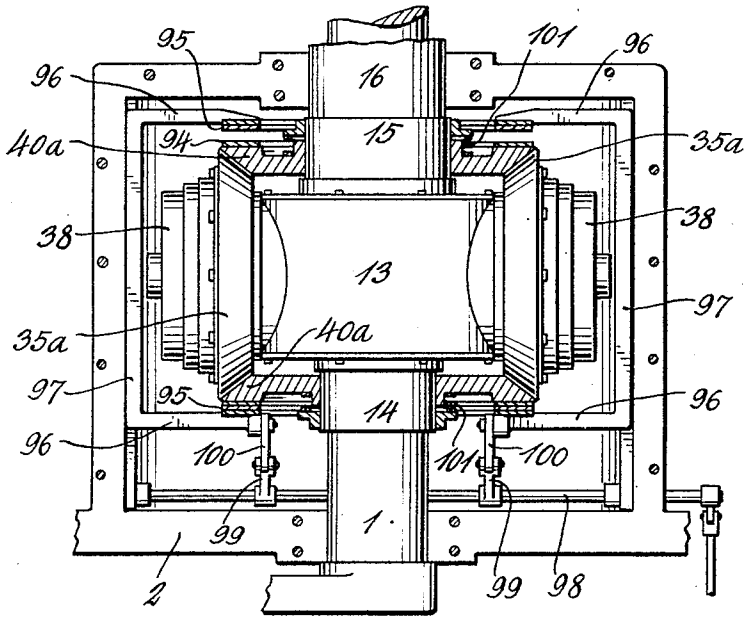


Fig. 9.

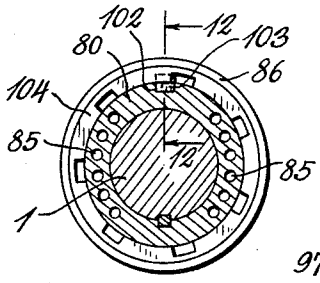


Fig. 11.

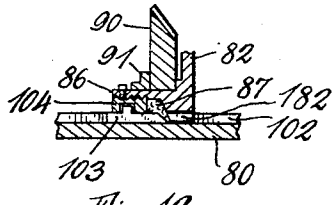


Fig. 12.

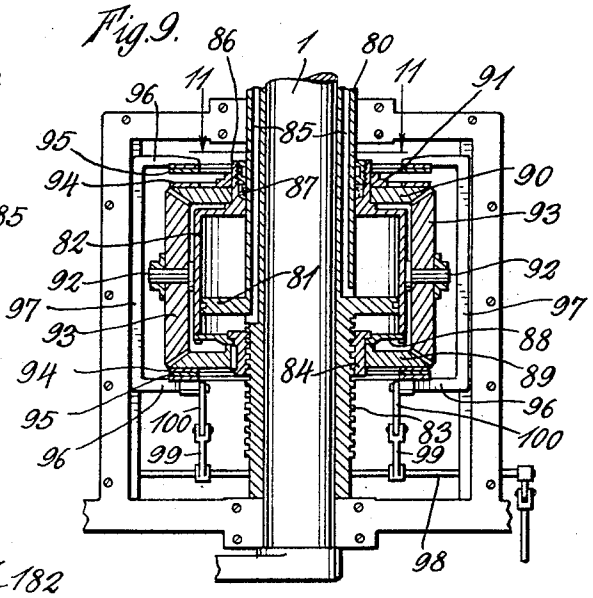


Fig. 10.

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UNITED STATES PATENT OFFICE

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HYDRAULIC PROPELLER

Application filed January 13, 1930, Serial No. 420,402. Renewed March 18, 1932.

This invention relates to improvements in mechanical movements or mechanisms and has reference more particularly to a mechanism that finds its greatest field of usefulness in connection with variable pitch propellers, but which may also be used for other purposes.

It has long been recognized that it is very desirable to be able to vary the pitch of the blades of a propeller of the type employed with aeroplanes and airships while it is in operation, and for this purpose a number of different means have been invented.

It is an object of this invention to produce a mechanism that shall be especially well adapted for use with airship and aeroplane propellers and by means of which the pilot can change the pitch of his propeller blades while they are in motion and by means of which it is also possible to reverse the pitch of the propeller so that it can be used as a brake in landing.

This invention briefly described, consists in the combination of a drive shaft to the front end of which a propeller hub is secured. A plurality of propeller blades are mounted in the hub in such a way that they can be rotated about an axis substantially radial with respect to the drive shaft. For the purpose of rotating the propeller blades, I have provided a hydraulic motor that is secured to the hub and which is provided with a rotor. Means is provided between the rotor and the propeller blades for the purpose of rotating the latter whenever the rotor is rotated. The hydraulic motor is operated in either direction by means of oil or other liquid that is supplied to it by a pump that is secured to the shaft so as to rotate therewith. This pump is provided with outlet and inlet ports and is reversible so that either one of the ports can be the outlet, while the other is the inlet port. The ports of the pump are connected with the hydraulic motor in such a way that when the pump operates or moves in one direction, the motor will rotate in a corresponding direction and when the direction of movement of the pump is reversed, the motor will be reversed. The pump is operated by power derived from the drive shaft and this power is transmitted to the pump by a differential gear comprising a bevel gear rotatably connected with the pump and two bevel gears that are rotatable about the axis of the drive shaft and which cooperate with the first named gear at diametrically opposite points. Friction brake mechanisms are provided for retarding the rotation of the gears that are connected with the drive shaft, and therefore when one of these gears are held against rotation, the pump and the motor, as well as the propeller blades will be rotated in one direction, and when the other gear is held against rotation, the pump, motor and propeller blades will be rotated in the other direction. The pump and motor have been so designed that the parts are balanced and therefore they will not cause vibrations of the drive shaft.

Having thus briefly described the invention, the same will now be described in detail, and for this purpose, reference will be had to the accompanying drawings in which the preferred embodiment of the invention has been illustrated, and in which:

Fig. 1 is a section taken along the axis of the drive shaft, some of the parts being shown in elevation while others are shown in section;

Fig. 2 is a section taken on line 2—2, Fig. 1;

Fig. 3 is a section taken on line 3—3, Fig. 1;

Fig. 4 is a view taken on line 4—4, Fig. 1;

Fig. 5 is a section taken on line 5—5, Fig. 1, and shows the relationship of the rotor and the casing of the hydraulic motor;

Fig. 6 is a section taken on line 6—6, Fig. 1;

Fig. 7 is a section taken on line 7—7, Fig. 1;

Fig. 8 is a section taken on line 8—8, Fig. 6;

Fig. 9 is a plan view, partly in section of a modified form of construction;

Fig. 10 is a section of a modified form of pump;

Fig. 11 is a section taken on line 11—11, Fig. 10; and

Fig. 12 is a section taken on line 12—12, Fig. 11.

In the drawings numeral 1 represents the

drive shaft which may be integral with the crank shaft of the engine and 2 represents one of the end walls of the crank case. Secured to or formed integral with wall 2 is a casing comprising side members 3 and the removable top 4. This casing is preferably provided with a removable bottom 5 that is held in place by means of bolts 6, and which can be removed for the purpose of cleaning and repairing the parts. The two end walls of the last named casing are provided with bearings 7 and 8. The drive shaft is rotably mounted in bearing 7 and is provided with a central oil passage 9 from which an opening 10 extends outwardly and communicates with the groove 11 of bearing 7. Oil under pressure is supplied to groove 11 through a pipe 12. A pump casting 13 is provided with a hub portion 14 that surrounds the shaft and which is held against rotation with respect to the shaft by means of a key which has not been shown. The other side of the pump casting is provided with a hub portion 15 that has a larger diameter than the shaft and which receives the annular sleeve 16. The sleeve 16 is held against rotation with respect to the shaft and with respect to the pump casting and has a driving fit with both of these parts. Sleeve 16 is provided with two groups of openings 17 that are symmetrically arranged on opposite sides of the diameter in the manner shown in Fig. 6. These openings form passages through which the oil or other liquid flows, and the openings of each group is connected with the port 18 of one of the two pumps that are provided in the embodiment shown in Fig. 1. Secured to the outer end of sleeve 16 is an annular ring 19 that is provided with two diametrically placed recesses 20, each of which communicates with the openings of one of the groups of openings 17. From each of the openings 20 two pipes 21 and 22 extend to the hydraulic motor which will be hereinafter described. The pump shown in Fig. 1 is of the type known as a screw pump and since the constructon of this pump follows old and well known lines, it will not be described in any greater detail than made necessary for the purpose of describing the invention. Each pump consists of two square threaded screws 23 and 24. These screws are located in intersecting circular openings and have the threads intermeshed as shown in Fig. 1. The inner end of each screw is provided with a trunnion 25 and the outer end of screws 23 are provided with extended trunnions 26 of larger diameter whose outer ends are square as indicated by reference numeral 27. The outer end of screws 24 are provided with journals 28 and each of the screws carries a gear wheel 29. These gears intermesh so as to maintain an equal rotation of the screws in opposite directions. When the screws rotate in one direction, ports 18 are the outlet ports and ports 30 the inlet ports, but when the screws rotate in the opposite direction, ports 18 become the inlet ports. The pumps are so arranged that when two pumps are employed, one forces liquid into the openings 17, while the other one receives liquid that is returned through openings 17 of the other group of openings. The pump casting is provided with two radially extending cylindrical portions 31 within which the cylinders 32 that contain the screws 23 and 24 are located (Fig. 8). The ends of the cylinders are closed by means of caps 33 that are provided with bearings for the reception of the journals 26 and 28. The cylinders are smaller than the openings in the cylindrical parts 31 and therefore a chamber 34 is formed in each cylindrical member and this chamber partially surrounds the cylinders 32. Mounted for rotation on each cylindrical member is a bevelled gear 35. This bevelled gear is held from longitudinal movement by means of shoulders 36 and 37. A cap 38 is provided with a flange 39 that is secured to the gear wheel 35 by means of bolts or screws. From Fig. 1 it will be seen that the caps 38 are provided with outwardly extending recesses for the reception of the square ends 27 of screws 23 and therefore when the gears 35 are rotated, they will rotate screws 23 and 24. Since these screws are rotated in such a way that the corresponding oppositely located screws turn in the same direction, it is evident that the two pumps operate in such a way that one tends to force liquid from the cylinders into the openings 17 on one side of sleeve 16, while the oppositely located pump receives liquid from opening 17 and discharges it through the ports 30 into chamber 34. For the purpose of operating the pumps in either direction at will, two bevel gears 40 have been provided. One of these gears is journalled on hub 14, and the other on hub 15. Gears 40 mesh with gears 35 and form with these gears a differential. When the shaft rotates, the pumps and the gear assembly will rotate with the shaft and the pumps will remain inoperative. If either of gears 40 are held against rotation while the shaft and pumps are rotating, it is evident that gears 35 will rotate and the direction of rotation will depend on which of the two gears 40 are held against rotation. Each of the gears 40 are provided with a cylindrical drum surface 41 with which a brake band 42 is associated. These brake bands are constructed in a manner old and well known and are operated by means including a rod 43 and levers 44 in such a way that when rod 43 is moved in one direction, it will tighten one of the brake bands, and when it is moved in the opposite direction, it will tighten the other brake band, and therefore by means of rod 43, the direction in which the pumps move can

be controlled. When the parts are in the position shown in Fig. 1, gears 40 will be free to rotate with the shaft and the pumps will therefore not function.

The hub which is shown attached to the tapering end 45 of the drive shaft is constructed in the manner described and claimed in my copending application, Serial No. 365,703, filed May 24, 1929, and which will therefore not be described herein except to the extent necessary to explain the operation of the mechanism that forms the subject of this invention. The hub has been shown as being provided with two radial arms 46 that have bearings for the reception of the root portions 47 of the propeller blades. Each radial arm has a recess or opening 48 within which the thrust bearing comprising the tapering rollers 49 is located. A portion of this bearing is formed by the inclined surface of flange 50 of the nut that is threaded onto the root portion of each propeller blade. These nuts are held against rotation by means of keys 51 and are each provided with two outwardly extending arms 52.

Pivotally connected to each arm 52 is a connecting rod 53. The other ends of these connecting rods are attached to a nut 54 that is associated with a screw 55. The two ends of this screw are journalled in bearings 56. A gear 57 is attached to the rear end of each screw 55, and these two gears are interconnected by means of a third gear 58, and this gear is keyed to the hub 59 of the rotor 60. Rotor 60 is located within a casing 61. This casing has its inner surface formed by four arcuate portions. The two diametrically located portions 62 are of the same diameter as the rotor and concentric with shaft 1, while the other two arcuate portions that have been designated by reference numeral 63 are eccentric to shaft 1. The rotor is provided with four radial slots 64 in each of which is located a blade 65 and a spring. The springs tend to hold the blades against the inner surface of the casing. The casing is secured to the shaft in such a way that it rotates with the shaft and it may also be secured to the hub. A cover 66 is removably secured to the casing by means of screws 67. The pump is provided with four ports or openings two of which have been designated by numeral 68 and the other two by numeral 69. Pipes 21 are connected with openings 68 and pipes 22 with openings 69. If oil under pressure is forced into the motor through pipes 21 and openings 68, the rotor will rotate clockwise in the direction of the arrow in Fig. 5, and if the oil is introduced through the openings 69, the rotor will turn in a counterclockwise direction. It is therefore evident that by operating the pumps in a certain direction, the rotor can be turned in a corresponding direction and the motion of the rotor will be communicated by means of gears 58 and 57 to the screws 55 and as the latter rotate the nuts 54 will move longitudinally on the screws thereby rotating the blades 47 in a manner quite clear from an inspection of Figs. 1 and 3. The extent to which the blades 47 can be rotated depends upon the width of the opening 48 and to some extent on the distance to which the nut 54 can move along the screw 55, and this is limited by means of an adjustable collar 70 secured to each screw for the purpose of limiting the movement of the nut in one direction. The movement in the other direction is limited by the arms 52 striking the surface 71. The angle through which the blades may be rotated can be varied from the maximum angle suitable for high speed travel, and to reverse angle suitable for procuring a braking action while landing. The chambers 34 are connected one with the other by means of grooves or channels 72, one side of which is formed by a removable cover 73, (Fig. 1). One of these channels 72 is connected with the opening 9 of shaft 1 by means of a radial opening 74, which is held closed by means of a spring pressed valve member 75 (Fig. 7). The purpose of this construction is that any leakage of oil from chambers 34 will be replenished from the lubricating system and the check valve 75 will prevent the oil from returning when the pressure lubricating system is not functioning. The ports 18 are connected by means of a groove or channel 76, one side of which is closed by a cover 77, (Figs. 1 and 6). A valve member 78 forms a partition between the two parts of groove 76 and normally prevents oil from flowing through this channel. Valve member 78 is held in closed position by means of a spring 79 and is so adjusted that when the pressure in either section of channel 76 exceeds a predetermined amount, the valve will open against the closing action of the spring and permit oil to flow through the channel from one pump to the other. Since one pump functions to force oil into one end of channel 76, while the other one receives oil through the port in communication with the other end of this channel, then the pumps can continue to function without danger of breakage after the nuts 54 have reached one or the other of the limiting positions. The safety valve 78 makes it possible to operate the mechanism without danger of breakage and this simplifies the construction and guards against accidents that otherwise might happen.

At this point I want to call particular attention to the fact that by means of the construction shown and described, the oil is transferred from the pumps to the motor without using any slidable connections that need to be kept tight by means of packing and therefore there is no chance for leakage. Any leakage or slippage that takes place in the pumps merely slows up the operation without losing

the oil as this simply returns to the storage chambers 34. The only place where oil can be lost is between the motor and the sides of the motor casing and this leakage can be made negligible by the use of proper rings and other approved construction.

In Figs. 9, 10, 11 and 12, I have illustrated another form of pump which can be substituted for the one shown in Fig. 1. In this pump a sleeve 80 is substituted for the sleeve 16 and this sleeve is provided on its outer surface with an outwardly extending flange 81 that forms a piston, and cooperates with the inner surface of the cylinder 82. On one side of flange 81, the outer surface of the sleeve is provided with square threads 83 with which a nut 84 is operatively connected. The sleeve 80 is provided on the other side of the flange 81 with a cylindrical outer surface and is also provided with two groups of openings 85 that are located on opposite sides of a diameter in the manner shown in Fig. 11, one group of these openings communicate with the interior of the cylinder on one side of the piston, and the other group with the other side. The cylinder is provided at one end with a hub 86 that forms part of a packing box 87, and the other end has secured to it an annular cover 88 that has a rotatable connection with the nut 84. Secured to the nut 84 is a bevel gear 89 and a similar bevel gear 90 is rotatably secured to the hub 86 and is held against movement by a collar 91. Secured to diametrically opposite points of the cylinder 82 are pivot pins 92. A bevel gear 93 is mounted for rotation on each of pins 92 and these gears are in mesh with gears 89 and 90. Gear 89 is keyed to the nut 84 so that whenever this gear rotates, the nut will also be rotated. Each of the gears 89 and 90 are provided with a friction surface 94 which is adapted to be engaged by an annular surface 95 that is carried by the arms 96 of a slidable yoke member 97. These yoke members are controlled by a mechanism comprising a rod 98 that is rotated by the pilot and which is provided with cranks 99 whose outer ends are connected to the yoke members by means of connecting rods 100. By moving the yoke members either one of the gears 89 or 90 can be clamped against rotation and by moving the yoke members 97 to neutral position, the parts are all free to rotate with the shaft. Since gear 89 is nonrotatably connected with the nut 84, and since the sleeve 80 rotates with shaft 1, it is evident that when gear 89 is held against rotation, as shown in Fig. 10, the nut will move relative to member 80 and this will move the pump cylinder 82 longitudinally of the shaft. If gear wheel 90 is clamped so that it cannot rotate, the differential action produced by gears 93 will rotate the nut 84 in the opposite direction relative to the sleeve 80 and this will move the pump cylinder in the opposite direction with respect to the piston. It is evident that if the cylinder moves upwardly with respect to the piston when viewed as in Fig. 10, the oil contained in that part of the cylinder below the piston will be forced outwardly through that group of openings that communicate with this part of the cylinder chamber, and oil will flow inwardly through the other group of openings into the space above the piston. The parts are so arranged that as the pump cylinder moves, it tends to move away from the friction members 95 and the pilot must continue to exert pressure until the desired adjustments are effected because if the yoke members 97 are left stationary the parts will immediately become inoperative as soon as the friction has been decreased.

In Fig. 9 the gears have been shown as friction gears but either toothed or friction gears may be employed, as may be desired. Where friction gears are used, springs 101 are employed for holding the gear surfaces in contact. The pump illustrated in Fig. 9 is of the same construction as that shown in Figs. 1 and 6, but instead of using toothed gears 35 and 40, friction gears 35*a* and 40*a* are employed.

For the purpose of holding the cylinder 82 against rotation on the sleeve 80 while permitting it to move longitudinally thereon the hub 86 has been provided with a key 182 that engages in the key slot 102 in the manner shown in Fig. 12. In order to prevent leakage through the slot 102, a key 103 has been provided. This key is of such size that it makes a close fit with the sides and bottom of slot 102 and is held in place by the packing nut 104 that is provided with a groove that receives a projection on the key. The packing 87 is pressed against key 103 so as to make a tight joint at this point.

I also desire to call attention to the fact that the ports 30 are located at the outer ends of the pumps near the covers 33 of the oil chambers 34 and therefore the oil or other liquid will be held in place adjacent ports 30 by the centrifugal force that is produced when the shaft rotates; this assures that the oil will always be in position to enter the pumps during operation.

The pump shown in Figs. 9 and 10 is concentric with the shaft and rotates therewith and the oil can be forced from this pump to the motor and be returned without the use of sliding connections so that very little, if any leakage takes place.

In the drawing and in the foregoing description the differential gear mechanism comprising gears 40 and 35 have been shown as transmitting motion to the propeller blades through the intermediary of a pump and a hydraulic motor. In its broadest aspect, however, my invention is independent

of the specific means employed for transmitting motion from the differential gear to the propeller as this can be effected by many specifically different means of which the one shown is merely an example.

Having described the invention what is claimed as new is:

1. In a device of the class specified, in combination, a shaft, a pump secured to the shaft and rotatable therewith, a hydraulic motor also secured to the shaft and rotatable therewith, conduits connecting the pump with the motor and means for operating the pump and the motor in either of two directions while the shaft is rotating in the same direction.

2. In a device of the class described, in combination, a shaft mounted for rotation about its own axis, a hydraulic motor carried by the shaft and rotatable therewith, a pump carried by the shaft and rotatable therewith, means comprising conduits for interconnecting the pump and the motor, and means for operating the pump in either direction while the shaft rotates in the same direction.

3. In a device of the class described, in combination, a shaft mounted for rotation about its own axis, a hub secured to one end of the shaft, a plurality of propeller blades mounted in the hub and rotatable about their own axes, a hydraulic motor connected with the hub, means for rotating the propeller blades in one direction when the motor turns in one direction and in the opposite direction when the rotation of the motor is reversed, a pump secured to the shaft and rotatable therewith, said pump and motor being connected by means of conduits whereby the motor will be operated in a direction corresponding to the direction in which the pump rotates, and means for operating the pump in either direction while the shaft rotates in the same direction.

4. In a device of the class described, in combination, a shaft mounted for rotation about its own axis, a hub secured to one end of the shaft, a plurality of propeller blades mounted in the hub and rotatable about their own axes, a hydraulic motor having a rotor and a casing secured to the hub and the shaft, the rotor and the shaft having a common axis of rotation, means for transmitting motion from the motor to the propeller blades whereby the motor will rotate the blades about their axes, a pump secured to the shaft and rotatable therewith, conduits extending from the pump to the motor for conducting liquid from one to the other whereby the operation of the pump will operate the motor in a corresponding direction, and means for operating the pump in either direction while the shaft is rotating in the same direction.

5. In a device of the class described, in combination, a shaft mounted for rotation about its own axis, a hub secured to one end of the shaft, a plurality of propeller blades mounted in the hub and rotatable about their own axes, a hydraulic motor having a rotor and a casing secured to the hub and the shaft, the rotor and the shaft having a common axis of rotation, means for transmitting motion from the motor to the propeller blades whereby the motor will rotate the blades about their axes, a pump secured to the shaft and rotatable therewith, conduits extending from the pump to the motor for conducting liquid from one to the other whereby the operation of the pump will operate the motor in a corresponding direction, and means for operating the pump in either direction while the shaft is rotating in the same direction, said last named means comprising a differential gear, and means for controlling the operation of the gear.

6. In a device of the type specified, in combination, a drive shaft mounted for rotation about its own axis, a hub secured to one end thereof, a body rotatably secured to the hub, a motor casing secured to the hub, a rotor within the casing, said rotor being rotatable about the axis of the shaft, a pump secured to the shaft so as to rotate therewith, said motor being reversible and provided with two ports that serve as intake and outlet ports, conduits extending from the ports to the pump for conducting liquid between the two, means for operating the motor in either direction while the shaft rotates in the same direction, and means for transmitting motion from the motor to the body carried by the hub.

7. In a device of the class described, in combination, a shaft mounted for rotation about its own axis, a hydraulic motor secured to the shaft, said motor having a casing that is nonrotatably secured to the shaft and a rotor that is rotatable with respect to the shaft and the casing, a pump being movable in two directions and provided with ports that serve as intake and delivery ports, conduits extending from the ports to the motor, and means for operating the pump in either direction, while the shaft rotates in one direction.

8. In a device of the class described, in combination, a shaft mounted for rotation about its own axis, a hydraulic motor secured to the shaft, said motor having a casing that is nonrotatably secured to the shaft and a rotor that is rotatable with respect to the shaft and the casing, a pump secured to the shaft so as to rotate therewith, said pump being movable in two directions, and provided with ports that serve as intake and delivery ports, conduits extending from the ports to the motor, and means for operating the pump in either direction, while the shaft rotates in one direction, said means including a bevel gear secured to the pump and two other bevel gears concentric with the

shaft and contacting with the first gear at diametrically opposed points, and friction means associated with the gears that are concentric with the axis whereby either of them can be retarded, thereby producing rotation of the first gear.

9. In a device of the class described, in combination, a drive shaft mounted for rotation about its own axis, a pump secured to the shaft so as to rotate therewith, said pump having two ports, means for operating the pump so that either one of the ports may become the outlet port and the other the inlet port, said means comprising a bevel gear secured to the pump and rotatable about an axis that is perpendicular to the axis of the shaft, two bevel gears mounted for rotation about the axis of the shaft, said gears cooperating with the first named gear at diametrically opposite points.

10. A variable pitch propeller comprising, in combination, a drive shaft, a propeller hub secured thereto, a plurality of blades secured to the hub and mounted for rotation about axes that are substantially radial with respect to the shaft, a motor carried by the shaft so as to be rotatable therewith, means for transmitting power from the motor to the propeller blades whereby the latter will be turned about their axes when the motor operates, and means for driving the motor by power derived from the rotation of the shaft.

11. In a device of the class specified, in combination, a shaft, a pump secured to the shaft and rotatable therewith, a hydraulic motor also secured to the same shaft as the pump and rotatable therewith, conduits connecting the pump with the motor, means for operating the pump, and means for operating the motor in either of two directions relative to the shaft while the shaft is rotating in the same direction.

12. In a device of the class described, in combination, a shaft mounted for rotation about its own axis, a propeller blade carried by the shaft and rotatable about an axis substantially perpendicular to the axis of the shaft, a hydraulic motor carried by the shaft and rotatable therewith, a pump also carried by the same shaft and rotatable therewith, means comprising conduits for interconnecting the pump and motor, means for operating the pump, means comprising the pump for operating the motor in either direction relative to the shaft while the shaft rotates in the same direction, and means interposed between the motor and the propeller blade for turning the latter about its axis when the motor operates.

13. In combination, a shaft rotatable about its own axis, a hydraulic motor and a pump mounted on the shaft and rotatable therewith, means for operating the pump while the shaft rotates, means comprising the pump for operating the motor in either direction relative to the shaft while the shaft rotates in the same direction, a propeller blade carried by the shaft and rotatable about an axis substantially perpendicular to the shaft, and means interposed between the motor and the blade for turning the latter about its axis when the motor is operated.

14. In a device of the class described, in combination, a drive shaft mounted for rotation about its own axis, a hub secured to one end thereof, propeller blades journalled in the hub and rotatable about axes that are substantially perpendicular to the axis of the drive shaft, a hydraulic motor having a casing and a pump also having a casing, both secured to the same shaft, the pump and motor casings being secured to the shaft and held against relative rotation therewith, conduits for the conduction of a liquid, connecting the pump and motor casings in a manner preventing relative movement between said conduits and casings as the shaft is rotated, selective means for operating the pump, so the motor can be operated in either direction as the shaft rotates in the same direction, means interposed between the motor and the propeller blades for moving the latter about their axes when the motor operates.

15. In a device of the class described, in combination, a drive shaft mounted for rotation about its own axis, a body carried by the shaft and movable with respect thereto as it is rotating therewith, a hydraulic motor and a pump secured to the same shaft and rotatable therewith, the pump and motor having casings which are secured to the shaft in a manner preventing relative rotation with respect thereto, conduits for the conduction of a liquid, connecting the pump and motor casings in a manner preventing relative movement between said conduits and casings as the shaft rotates, selective means for operating the pump, so the motor can be operated in either direction as the shaft rotates in the same direction, and means interposed between the motor and the body carried by the shaft for moving the latter with respect to the shaft when the motor operates.

16. In a device of the class described, in combination, a shaft mounted for rotation about its own axis, a pump and a motor casing secured to the shaft, the pump and motor casings being held against rotation with respect to the shaft, conduits connecting the pump and motor casings for conducting liquid from one to the other and secured to the shaft and to the casings in a manner preventing relative movement between said conduits and casings and between the conduits and the shaft as they are rotated in unison with the shaft and casings, and means for operating the pump and motor from power derived from the rotation of the shaft.

17. In a device of the class specified, in com-

bination, a drive shaft mounted for rotation about its own axis, a power transmission member carried thereby, so as to rotate therewith, but capable of being moved with respect thereto, the axis of the power transmission member being concentric with the axis of the drive shaft, a body also carried by the drive shaft, capable of being moved with respect thereto as it is rotating therewith, means drivably interposed between the body and the power transmission member, so the body will be moved relative to the drive shaft whenever the power transmission member is moved with respect to the drive shaft, power driven means carried by the drive shaft for moving the power transmission member with respect to the drive shaft, and means also carried by the drive shaft and rotatable therewith for limiting the extent of movement of the body and the power transmission member relative to the drive shaft as the latter is rotating about its axis.

18. In a device of the class described, in combination, a drive shaft mounted for rotation about its own axis, a power transmission member carried thereby, so as to rotate therewith, but capable of being moved with respect thereto, the axis of the power transmission member being concentric with the axis of the drive shaft, a body also carried by the drive shaft, capable of being moved with respect thereto as it is rotating therewith, means drivably interposed between the body and the power transmission member, so the body will be moved relative to the drive shaft whenever the transmission member is moved with respect to the drive shaft, means carried by the drive shaft and rotatable therewith for moving the power transmission member with respect to the drive shaft by power derived from the rotation of the drive shaft, and means carried by the drive shaft and rotatable therewith for limiting the extent of movement of the body and the power transmission member relative to the drive shaft as the latter is rotating about its axis.

19. In a device of the class specified, in combination, a drive shaft mounted for rotation about its own axis, a body carried by the drive shaft, designed to be moved with respect thereto as it is rotating therewith, means for moving the body with respect to the drive shaft comprising a hydraulic pump and a hydraulic motor, conduits for the conduction of a liquid connecting the pump and motor, all carried by the drive shaft and rotatable therewith, means for operating the pump and motor by power derived from the rotation of the drive shaft, the motor having a driving connection with the body that is carried by the drive shaft, so the body will be moved with respect to the drive shaft, whenever the motor is caused to move relative to the drive shaft, and limiting means comprising a stop and a bypass valve located in the hydraulic circuit that connects the pump and motor, the valve being designed to function under a given pressure and to cooperate with the stop carried by the drive shaft and rotatable therewith, for limiting the movement of the body relative to the drive shaft as the latter is rotating about its axis.

20. In a device of the class described, in combination, a drive shaft mounted for rotation about its own axis, a body carried by the drive shaft designed to be moved within definite limits with respect to the drive shaft as it is rotating therewith, means for moving the body with respect to the drive shaft, comprising a hydraulic pump and a hydraulic motor, conduits for the conduction of a liquid connecting the pump and motor, a bypass valve, designed to operate under a desired pressure, same being located in the hydraulic circuit that connects the pump and motor, all carried by the drive shaft and rotatable therewith, means for operating the pump and motor by power derived from the rotation of the drive shaft, means for drivably connecting the body to be moved to the hydraulic motor, so the body will be moved relative to the drive shaft whenever the motor is caused to move relative to the drive shaft, and a stop for limiting the movement of the body relative to the drive shaft, the bypass valve that is located in the hydraulic circuit cooperating with the stop for limiting the movement of the motor and the body relative to the drive shaft as the latter is rotating about its axis.

21. In a device of the class specified, in combination, a drive shaft mounted for rotation about its own axis, a power transmission member carried thereby and rotatable therewith, but capable of being moved with respect thereto, the power transmission member having an axis that is concentric with the axis of the drive shaft, a body also carried by the drive shaft, capable of being moved with respect thereto as it is rotating therewith, means drivably connecting the body with the power transmission member, so the body will be moved relative to the drive shaft, whenever the power transmission member is moved with respect to the drive shaft, power driven means for moving the power transmission member relative to the drive shaft, and means carried by the drive shaft and rotatable therewith, for limiting the extent of movement of the power transmission member and the body relative to the drive shaft as the latter is rotating about its axis.

22. In a device of the class described, in combination, a drive shaft mounted for rotation about its own axis, a power transmission member carried thereby and rotatable therewith, but capable of movement with re-

spect thereto, the power transmission member having an axis that is concentric with the axis of the drive shaft, a body also carried by the drive shaft capable of being moved with respect thereto as it is rotating therewith, means drivably interposed between the body and the power transmission member, so the body will be moved relative to the drive shaft whenever the power transmission member is moved with respect to the drive shaft, means for moving the power transmission member with respect to the drive shaft by power derived from the rotation of the drive shaft, and means carried by the drive shaft and rotatable therewith for limiting the extent of movement of the power transmission member and the body relative to the drive shaft as the latter is rotating about its axis.

23. In combination with a variable pitch propeller, a drive shaft mounted for rotation in a plurality of spaced bearings, propeller blades mounted for rotation with the drive shaft and for rotation about axes substantially perpendicular to the axis of the drive shaft as they are rotated therewith, a power transmission member carried by the drive shaft and operatively connected to the propeller blades, so the blades will be moved about their axes whenever the transmission member is moved relative to the drive shaft, the propeller blades and the power transmission member both located on the same side of a drive shaft bearing, power operated means located between two adjacent drive shaft bearings and mounted on the drive shaft, said means being operatively associated with the power transmission member for moving the latter relative to the drive shaft, whenever the power means is operated, and means operated by the movement of the power transmission member relative to the drive shaft for limiting the movement of the power transmission and the propeller blades relative to the drive shaft as the latter is rotating about its axis.

24. In combination, a drive shaft mounted for rotation in a plurality of spaced bearings, a body and a power transmission member carried by the drive shaft, both mounted for movement with respect to the drive shaft as they are rotated therewith, both located on the same side of said drive shaft bearings, and operatively interconnected so the body will be moved relative to the drive shaft whenever the transmission member is moved with respect thereto, power operated means located between two adjacent drive shaft bearings and mounted on the drive shaft same being operatively associated with the power transmission member for moving the latter relative to the drive shaft, whenever the power means is operated, and means operated by the movement of the power transmission member relative to the drive shaft for limiting the movement of the power transmission member and the body relative to the drive shaft as the latter is rotating about its axis.

In testimony whereof I affix my signature.

DANIEL G. LILLEY.