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PROPELLER GOVERNOR

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This invention relates to improvements in hydraulic control means and has for an object the provision of an improved hydraulic control mechanism for a hydro-controllable aeronautical propeller.

An object of the invention resides in the provision of an improved control means for a hydro-controllable propeller, operable in both directions by fluid pressure, so arranged that the fluid pressure tending to operate said propeller in one direction is greater when operative than the pressure tending to operate the propeller in the opposite direction.

A further object resides in the provision of a control means for a hydro-controllable propeller utilizing hydraulic fluid at two different pressures, so arranged that one of said hydraulic pressures, will, whenever utilized, exceed the other of said hydraulic pressures by a predetermined amount.

A still further object resides in the provision of a control means for a hydro-controllable propeller utilizing hydraulic fluid in which such control means includes a pump for supplying hydraulic fluid to said propeller, and means for regulating the pressure of the fluid supplied by said pump to the varying pressure requirements of said propeller, thus obviating the necessity of maintaining the pump outlet pressure always at the maximum pressure required by said propeller and permitting the pump to operate at a greatly reduced outlet pressure at all times except when the maximum pump pressure is required to change the propeller pitch.

Other objects and advantages will be more particularly pointed out hereinafter or will become apparent as the description proceeds.

In the accompanying drawing in which like reference numerals are used to designate similar parts throughout there is illustrated a suitable mechanical arrangement for the purpose of disclosing the invention; the drawing, however, is for the purpose of illustration only and is not to be taken as limiting or restricting the invention as it will be apparent to those skilled in the art that various changes in the illustrated arrangement may be resorted to without in any way exceeding the scope of the invention.

In the drawing,

Fig. 1 is a diagrammatic illustration of a controllable-pitch propeller and a hydraulic control means constructed according to the invention various parts being shown in section to better illustrate the construction thereof, and

Fig. 2 is a vertical sectional view of an improved propeller control constructed according to the invention.

Referring to the drawing in detail, the numeral 10 generally indicates a propeller driving engine from which projects a propeller drive shaft 12 upon which is mounted a hydro-controllable propeller generally indicated at 14. The propeller has a plurality of blades, as indicated at 16, rotatably mounted in a propeller hub 18 to which is secured a hydraulic pitch changing motor 20 including a piston 22 reciprocable in a cylinder 24 and operatively connected to the propeller blades by suitable means such as the intermeshing gears 26 and 28 for converting reciprocating movements of the piston 22 in the cylinder 24 into pitch changing movements of the blades 16. For a more detailed description of such a propeller, reference may be had to United States Patent No. 2,280,714, issued April 21, 1942, to Erle Martin for Feathering propeller control.

A tube 30 extends from the engine lubricating system which is supplied with lubricating oil under pressure by the lubricating oil pump 32, through the hollow shaft 12 and motor 22 to the space between the motor 22 and closed end of the cylinder 24 remote from the engine. This lubricating oil may be withdrawn from a suitable reservoir such as the engine sump or oil tank 34 and the pressure of the oil in the system may be regulated by a suitable pressure relief valve as generally indicated at 36 of some form well known to the art. A plug 38 is disposed in the interior of the hollow shaft 12 surrounding the tube 30 to provide a second fluid channel leading to the motor 22 this channel comprising the interior of the hollow shaft surrounding the tube 30 on the propeller side of the plug 38. This construction provides two fluid channels leading to the propeller pitch changing motor, the first channel 30 leading to the pitch reducing side of the motor and connected with the engine lubricating fluid at lubricating oil pressure to continuously supply fluid at this pressure to the pitch reducing side of the motor to assist the action of centrifugal force on the blade 16 in changing the propeller from a higher to a lower pitch condition while the channel comprising the interior of the hollow drive shaft surrounding the tube 30 on the propeller side of the plug 38 connects with the pitch increasing side of the pitch changing motor 22 to supply hydraulic fluid to this side of the motor to change the propeller pitch from a lower to a higher pitch condition. Obviously the pressure of the hydraulic fluid supplied to the pitch increasing side of the motor must be higher than

the pressure of the fluid supplied to the pitch decreasing side by an amount sufficient to overcome the pressure of the hydraulic fluid on the pitch decreasing side and the effect of centrifugal force acting on the blade 16 tending to turn the blade toward a lower pitch, as well as the frictional resistance of the propeller blades and pitch changing motor.

Hydraulic fluid is supplied to the pitch increasing channel through a booster pump generally indicated at 40, which is connected with the outlet of the lubricating oil pump 32 by a suitable conduit 42, a control valve 44 actuated by the speed responsive governor, generally indicated at 46, a channel 48, conduit 50, bushing 52 surrounding the drive shaft, and ports 54 leading through the drive shaft from the exterior to the interior thereof on the propeller side of the plug 38.

The governor 46, as illustrated, is a centrifugal type governor having centrifugally actuated flyballs 56 which react against a compression spring 58 through a suitable thrust bearing 60. The speeder spring 58 may be adjusted by a suitable or conventional means, as indicated at 63, to change the speed setting of the governor. The flyballs 56 are driven from the engine through the hollow drive shaft 62, which has a driving connection with the engine, such as the gear drive generally indicated at 64 in Fig. 1, to which the shaft may be connected by a suitable spline drive 66, so that changes in engine speed change the action of centrifugal force on the flyballs 56 resulting in a movement of the thrust bearing 60 and a consequent movement of the valve plunger 68 in the hollow shaft 62. The plunger 68 is provided with spaced valve pistons 70, 72 and 74 separated by reduced portions providing annular fluid spaces between the pistons. The plunger is provided with an internal channel 76 leading from a port 78 between the pistons 70 and 72 to a port 80 below the piston 74, the reduced end portion of the plunger below the port 80 being closed.

The hollow drive shaft 62 is provided with two rings of ports or apertures, as indicated at 82 and 84, which lead into respective annular channels 86 and 88 provided in the governor housing 90 surrounding the bore provided in the housing for the drive shaft 62. The pistons 70, 72 and 74 and the ports 82 and 84 are so disposed as to provide a valve action within the movement limits of the governor 46 such that when the plunger 68 is moved upwardly, incident to an engine speed in excess of the speed for which the governor is set, the piston 72 will be above the port 82 and piston 74 below the port 84 thereby connecting these ports through the reduced portion of the valve plunger so that hydraulic fluid will flow directly from the annular channel 88 into the annular channel 86 and, when the speed of the engine is below the speed for which the governor is set, the ports 82 will be between the pistons 70 and 72 and the port 84 between the pistons 72 and 74 under which condition the channel 88 will be blocked and the channel 86 will be connected through the plunger port 78, the internal channel 76 and the port 80 with drain through the lower end of the hollow drive shaft 62. Since the channel 86 is connected with the channel 48 conduit 50 and drive shaft port 54 with the pitch increasing side of the pitch changing motor 22 and the annular channel 88 is connected with the outlet of the booster pump 40 it will be apparent that when the valve plunger is in the upper position connecting the annular channels 86 and 88 hydraulic fluid under high pressure will be supplied to the propeller pitch changing motor to increase the pitch of the propeller, and when the plunger is in its lower position the pitch increasing side of the pitch changing motor will be connected with drain and the pitch of the propeller will be reduced by the pressure of the hydraulic fluid admitted to the pitch reducing side of the motor through the tube 30 in cooperation with the pitch reducing action of centrifugal force on the propeller blades 16. It has been found desirable to close the lower end of the valve plunger 68 and have the drain fluid flow laterally from the plunger through the port, or ports 80 in order to avoid any disturbing force on the plunger by the jet action of the fluid occasioned by discharging the fluid in line with the plunger movements.

The booster pump 40 may conveniently comprise a gear element 92 formed integrally with or rigidly secured to the drive shaft 62 and a cooperating gear element 94 meshing with the gear 92 and having an integral or rigidly attached hollow axle 96 supported in a bore provided in the governor base 98 and lower portion of the housing 90. These gears are disposed in suitable recesses provided in the base 98 which constitute in effect the pump casing. The hydraulic fluid inlet from the pump 32 through the conduit 42 may include the groove 100 in the lower surface of the casing and the channel 102 schematically shown in Fig. 1. The pump outlet is connected through a channel 104, schematically shown in Fig. 1, with a pressure chamber 106 which pressure chamber communicates, under certain conditions, through the hollow axle 96 of the gear 94 with the pump inlet so that fluid may be recirculated through the pump when the fluid line to the propeller is blocked by the valve plunger 68 in the manner indicated above. For a more detailed description and illustration of the booster pump inlet and outlet channels reference may be had to United States Patent No. 2,204,640, issued June 18, 1940, to Elmer E. Woodward, for Governor mechanism.

The connection between the pressure chamber 106 and the return to the pump inlet through the axle 96 is controlled by a pressure relief valve, generally indicated at 108, which regulates the pressure of the hydraulic fluid supplied to the pitch increasing side of the pitch changing motor 22. The valve may conveniently comprise a hollow plunger 110 slidably mounted in the end of the pressure chamber remote from the drive shaft 62, a compression spring 112 for urging the plunger to valve closing position and a screw threaded nut 114 constituting a fixed rear abutment for the spring. When the plunger 106 is in the position illustrated in Fig. 2 the relief valve is closed. If the pressure in the chamber 106 exceeds a predetermined value the plunger 110 will be forced to the right, as viewed in Fig. 2, until its closed end passes beyond the left hand side of the chamber 116 which communicates with the interior of the hollow axle 96. When the plunger is in this last described position the pressure chamber 106 will be connected with the intake of the pump 40 through the hollow axle 96 and groove 100 and the pressure of the hydraulic fluid in the chamber will be reduced by the venting of a portion of the fluid to the pump intake. If desired, a suitable stop for the left hand movement of the valve plunger, as viewed in Fig. 2, may be provided in the form of an

annular collar or plunger extension 118 inserted in the right hand end of the pressure chamber 106.

The spring 112 is made very light, theoretically having only sufficient strength to overcome the frictional resistance of the plunger, and to resiliently urge the plunger toward its valve closing position. In order to insure the performance of the theoretical requirements, in actual practice the spring 112 is made strong enough to close the valve against a small hydraulic head. In certain commercial installations a spring requiring 50 pounds per square inch pressure to open the valve has been found satisfactory. With this arrangement, when no additional force is exerted to maintain the plunger in its valve closing position the load on the pump 40 will be reduced since it will be pumping only against the hydraulic head necessary to overcome spring 112. When the port 82 is blocked by piston 72 and the blades are thereby held against pitch changing movements, the pump will be working against the hydraulic head necessary to overcome spring 112 and the hydraulic head created by the effect of the blade centrifugal twisting moment on the oil trapped in the propeller and acting on the rear of the plunger 110. These conditions can exist at all times at which the booster pump 40 is not supplying hydraulic fluid under pressure to the pitch increasing side of the pitch changing motor 22 for changing the propeller pitch. When such fluid is supplied the pressure must be increased by an amount sufficient to overcome the inertia and frictional forces opposing a change of propeller pitch. A channel 120 is provided through the governor housing 90 leading from the annular channel 86 to the space in the valve bore at the rear of the piston 110 so that when the channel 86 is connected with the booster pump outlet through the channel 88 and pressure chamber 106, hydraulic fluid under the booster pump pressure will be carried to the rear of the relief valve plunger to add its force to the force exerted by the spring 112. Since the pressure in the annular channel 86 is controlled by the rate of flow of hydraulic fluid to the pitch changing motor and this rate of flow is determined largely by the resistance encountered by the motor in changing the propeller pitch, the pressure developed by the pump 40 will be limited substantially to that necessary to change the propeller pitch. Under these conditions a hydraulic pressure could be built up in the pressure chamber 106 limited only by the capacity of the pump 40. However, a channel 122 is provided leading from the space at the rear of the relief valve plunger 110 through a second pressure relief or "blowoff" valve, generally indicated at 124, and a channel 126 connects this valve with the pump inlet or drain to limit the maximum pressure which can be developed by the booster pump and pressure relief valve combination. This pressure limiting valve 124 may be of any conventional or desired form but may conveniently be provided as a ball check valve having a ball 128 urged to seating position against the end of the channel 122 by a compression spring 130 held in a bore 132 provided in the governor base 98 by a screw threaded plug 134. With this construction the strength of the spring 130 will determine the maximum pressure which the booster pump can build up in the pressure chamber 106 and in the pitch changing motor of the propeller. A spring will be selected having a strength which will permit the fluid to escape from the space behind the relief valve piston 110 before fluid pressures are reached which would endanger the structure of the pitch changing motor or the control therefor or the connecting conduit. Whenever the piston 72 of the plunger 68 is below the port 82, the space at the rear of the relief valve plunger 110 will be vented to drain through the channel 86 and the internal passage 76 of the pilot valve plunger 68 so that the only force acting on the plunger 110 will be that of the spring 112.

From the above description it will be observed that there has been provided an arrangement in which the pitch changing motor of a controllable-pitch propeller is actuated in one direction by hydraulic fluid at one pressure to assist centrifugal action acting on the blades in reducing the pitch of the propeller and in which the pitch changing motor is actuated to increase the propeller pitch by hydraulic fluid at a pressure higher than said one pressure by an amount sufficient to overcome the force exerted by the hydraulic fluid at said one pressure and the effect of centrifugal action on the blades plus the frictional resistance of the propeller blades and pitch changing motor, and in which the higher pressure of the hydraulic fluid is developed by a booster pump which operates under load only during those intervals in which the propeller pitch is being increased and in which the pressure developed by the pump is only sufficient to accomplish the indicated pitch change, thereby saving wear and tear on the booster pump and preventing this pump from absorbing engine power unnecessarily when its function is not being utilized.

While a particular mechanical arrangement has been hereinabove described and illustrated in the accompanying drawing for the purpose of disclosing the invention, it is to be understood that the invention is not limited to the arrangement so illustrated and described but that such changes in the size, shape and arrangement of the various parts may be resorted to as come within the scope of the sub-joined claims.

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

1. In a control for a hydro-controllable propeller, a pitch changing motor operated by hydraulic fluid under pressure, a speed responsive governor, a pump for creating said pressure, a pilot valve operated by said governor and connecting one side of said pitch changing motor with the outlet of said pump or with a drain vent, a pressure relief valve permanently connected to said pump outlet and urged to open position by the pump created fluid pressure for limiting the pressure which may be developed by said pump, and a channel, controlled by said pilot valve, and connected with the outlet of said pump when said pilot valve is in position to apply pressure fluid to said motor, for conducting pressure fluid to the rear of said pressure relief valve to urge said pressure relief valve to closed position and vented to drain when said pilot valve is in position to vent said one side of said motor, to relieve the pressure urging the valve to closed position.

2. In a control for a hydro-controllable propeller, a pitch changing motor operated in one direction by hydraulic fluid under one pressure and operated in the opposite direction by hydraulic fluid under a higher pressure, a pump for supplying hydraulic fluid at said lower pressure, a

booster pump having its inlet connected with the outlet of said lower pressure pump for creating said higher pressure, a first pressure relief valve controlling the pressure developed by said lower pressure pump, a second pressure relief valve controlling the pressure developed by said booster pump and venting against the pressure maintained by said first pressure relief valve, a light spring for biasing said pressure relief valve to closed position, a speed responsive governor driven with said propeller, a valve operated by said governor controlling the application of hydraulic fluid at said higher pressure to one side of said pitch changing motor and alternatively venting said one side of said pitch changing motor, and a channel connected with said one side of said motor and said second pressure relief valve leading hydraulic fluid to the back of said second pressure relief valve to apply a valve closing force in addition to the force of said spring proportional to the fluid pressure in said one side of said pitch changing motor.

3. In a control for a hydro-controllable propeller, a pitch changing motor operable in one direction by hydraulic fluid under pressure and operable in the opposite direction, a booster pump for creating said pressure, a pressure chamber connected with the outlet of said pump, means connecting said chamber with said pitch changing motor, a speed responsive governor, a governor actuated valve in said connecting means for controlling the application of hydraulic fluid to said motor, and a pressure relief valve connected with said chamber for controlling the pressure in said pressure chamber comprising, a cylindrical bore, a plunger reciprocable in said bore operative to block the flow of fluid from said chamber when in valve closing position and to vent fluid from said chamber to a drain when in valve opening position, a passage between said governor actuated valve and said motor connectible by said governor actuated valve with the outlet of a pump or with said drain and a channel leading from said passage to the space within said bore at the side of said plunger remote from said chamber for applying the hydraulic pressure in said passage to said plunger to urge said plunger to valve closing position.

4. In a propeller pitch control comprising a fluid actuated motor for changing the propeller pitch, a pump driven with said propeller for supplying fluid under pressure, a governor driven with said propeller, a governor actuated valve connecting said motor with said pump or with an outlet and controlling the flow of said fluid under pressure from said pump through a pressure line to said motor or connecting said motor with said outlet, a pressure relief valve having one side operatively connected with said pump, and means for normally urging said valve to closed position to maintain a predetermined pressure on said fluid under pressure; means for varying the relief valve setting in accordance with the requirements of the fluid actuated motor comprising a permanently open connection connecting the other side of said relief valve with said pressure line for supplying fluid to said relief valve in a direction to urge said valve to a closed position.

5. In a control for a hydro-controllable propeller, a hydraulic pitch changing motor having different fluid pressure requirements for different speeds and pitch angles of said propeller, a fluid pump driven with said propeller for supplying hydraulic fluid under pressure to said motor, a fluid connection between the outlet of said pump and said motor, a speed governor driven with said propeller, a valve operated by said governor and interposed in said fluid line and having a drain connection for connecting said motor with either fluid under pressure or with a drain to change the pitch of said propeller in response to speed change demands of said governor, and a relief valve for said pump intercepting a drain channel leading from said pump outlet and urged to channel closing position by the fluid pressure in the portion of said fluid connection between said governor operated valve and said pitch changing motor to maintain the pump outlet pressure proportional to the fluid pressure requirements of said pitch changing motor.

6. In a control for a hydro-controllable propeller, a speed governor and a hydraulic pump driven with said propeller, a hydraulic pitch changing motor, a fluid connection between said pump and said motor, a governor operated valve intercepting said connection and operative to connect said motor with the outlet of said pump or with a drain, a fluid passage between the outlet and inlet of said pump, a pressure relief valve intercepting said passage including a piston movable to a position blocking said passage and urged by the pump outlet pressure to a position opening said passage, a fluid channel connecting said relief valve with the portion of said fluid connection between said governor operated valve and said pitch changing motor to apply the pressure of the fluid entering or leaving said motor to said relief valve plunger to urge said plunger to a passage blocking position, and a light spring resiliently urging said plunger to a passage blocking position.

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