July 23, 1946. E. FLORIAN ET AL 2,404,703

VARIABLE PITCH AIR PROPELLER

Filed July 12, 1940 2 Sheets-Sheet 1

Fig.1

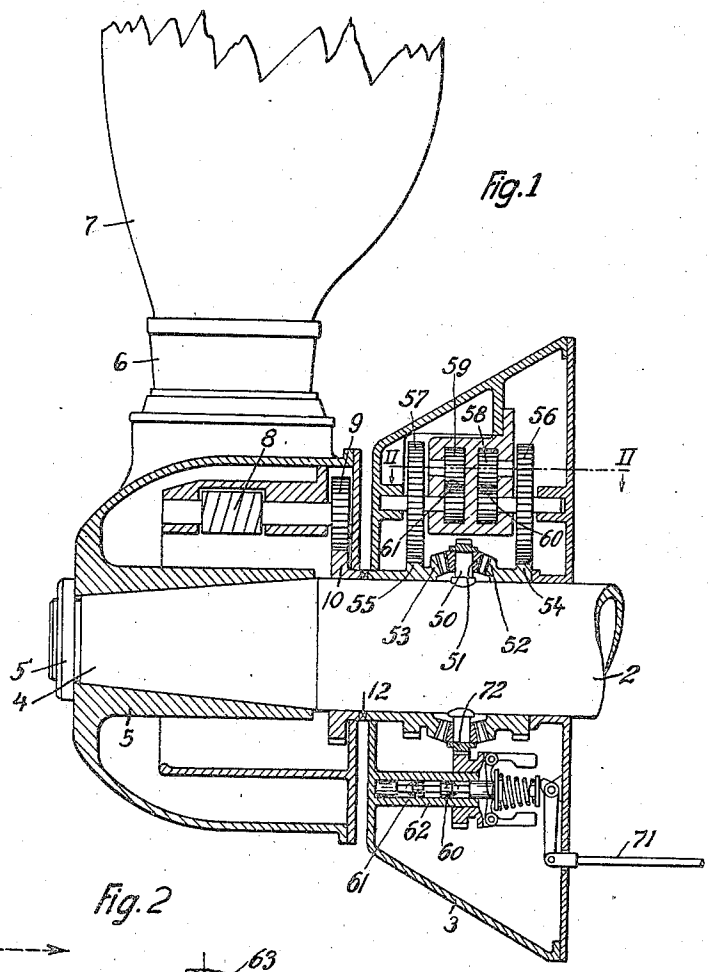
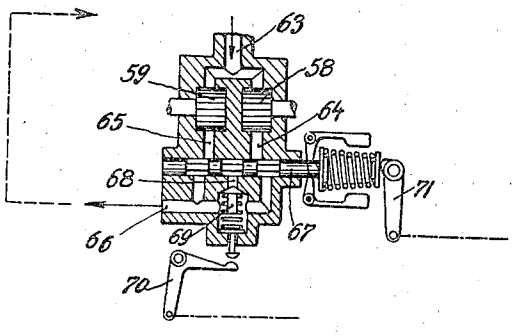


Fig.2



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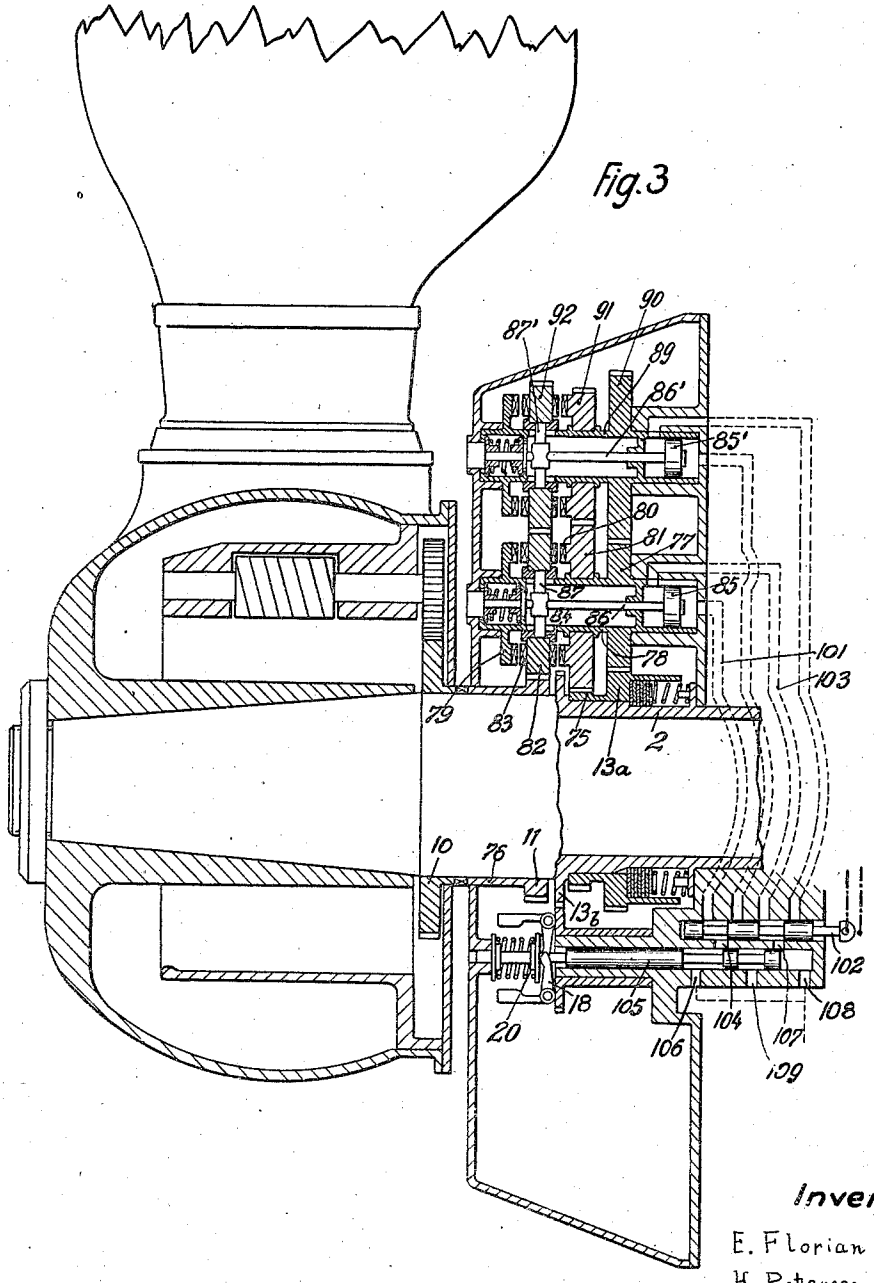
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Fig. 3



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VARIABLE PITCH AIR PROPELLER

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4 Claims. (Cl. 170—163)

1

The present invention relates to variable pitch air propellers in which the position of the blades is altered by a gear arranged in the hub, said gear being driven by a hollow shaft surrounding the shaft of the air propeller.

In some of the early automatic variable pitch air propellers this was effected by the use of centrifugal weights which were connected to the propeller blades. A definite position of the centrifugal weights corresponded to a definite position of the blades and the power for adjusting the blades was supplied by the centrifugal weights themselves. With higher motor outputs, however, the power required for adjustment is so large that an auxiliary device for supplying the power necessary for the adjustment of the blades is required while the centrifugal weights act as a centrifugal governor controlling only the auxiliary power for adjusting the propeller blades.

Hitherto such auxiliary power for instance has been obtained by arranging in front of the propeller a blade wheel driven by the relative air current or by arranging upon the hub of the propeller an electro motor which was supplied with current by means of slip rings.

All these known devices, however, have the drawback that a rather complicated construction is necessary if a stepwise adjustment is required including the feathering or idle running position. The interior of the prior propeller hub which itself is rather difficult to manufacture is provided with cross walls, bearings and other irregularities of its form and in the hub a gear drive is provided having a large number of gears as well as a corresponding large number of individual elements. This considerably increases the weight of the total propeller and makes questionable the reliability of service.

The present invention is concerned with a stepless automatically operating variable pitch propeller in which for the adjustment of the blades an auxiliary power is used, whereas a centrifugal governor controls the auxiliary power only. The object of the present invention is to considerably simplify the construction of such a device, particularly the construction of the hub.

In connection with variable pitch propellers used for driving vessels or boats it is already known to arrange in the hub of each of the propellers a gear acting upon the rotatably mounted base of the blades, whereby the drive of this gear is effected by a hollow shaft surrounding the propeller shaft. With this known construction, however, the adjustment could only be effected by arbitrary operation by hand, for which purpose

2

the hollow shaft had to be axially displaced. The automatic stepless adjustment of the propeller blades was, therefore, not obtained by this prior construction.

According to the present invention the problem in question is solved mainly by a stationary device driven by the shaft of the propeller for producing the movement required for adjusting the blades. This adjustment device, therefore, is an additional constructional part arranged outside of the hub, whereby the manufacture of the hub is very simplified and the weight thereof considerably reduced. A further advantage results from the fact that the device for producing the power for the adjustment is no longer subjected to the centrifugal forces and, therefore, need not be balanced absolutely exactly. The control of the device supplying the power of adjustment preferably is effected by a centrifugal governor.

Further features and advantages of the invention result from the following specification and the accompanying drawings, wherein

Fig. 1 is a cross section of a construction in accordance with the invention having a mechanically operated adjusting device, and

Fig. 2 is a section on line II—II of Fig. 1, and

Figure 3 is another modification shown partly in section on a larger scale.

In the figures the front end of an aircraft engine having an adjustable pitch propeller is shown. To simplify the understanding of the invention such details only are described and provided with reference characters which directly relate to the invention.

In Figs. 1 and 2 a variable pitch propeller is shown according to which the drive of the members effecting the adjustment of the propeller pitch is obtained directly and mechanically by way of a differential gear, each of the members engaging the differential wheels being controlled by an oil pressure brake associated therewith.

A plurality of bevel gear wheels **51** is mounted upon stationary bolts **50** securing gear wheels **51** to propeller shaft **2**. Bevel gear wheels **52, 53** rotatably mounted upon shaft **2** engage with bevel gear wheels **51**. The two bevel gear wheels **52, 53** are connected with toothed rims **54** and **55**, respectively. Toothed rim **55** is connected with the adjusting gear mounted in the air propeller hub. Casing **3** is flanged to the engine casing and surrounds propeller shaft **2**. By means of nut **5'** propeller hub **5** is fixed upon bevelled end portion **4** of propeller shaft **2**. Propeller blades **7** are mounted to turn about their longitudinal axis in a manner known per se. They are rotatable in or

about lugs or projections 6 on propeller hub 5. Worm 8 engages a toothed ring not shown in the drawings and arranged at the base of the propeller blade. Gear wheel 9 is secured to the shaft bearing worm 8 and meshes with gear wheel 10 rotatably mounted on shaft 2. The hub of gear wheel 10 is coupled to the hub of toothed rim 55 by means of claws 12. Toothed rim 55 is rotatably mounted upon propeller shaft 2. By way of spur wheels 56, 57 toothed rims 54, 55 drive spur wheels 58, 59 forming a part of two oil brakes constructed in the manner of gear wheel pumps. Thus, the two spur wheels are normally driven with the same driving force so that when the back pressure on both pumps is the same they are both driven at the same speed. However, the gearing mechanically connecting these two spur wheels, comprising the gear chain 56, 54, 52, 51, 53, 55 and 57, causes a change in the speed of one of the spur wheels 58, 59 which causes an opposite change in the speed of the other spur wheel. The control unit regulates the back pressures effective independently against the two spur wheels 58 and 59 so that the relative speed of the spur wheels is controlled. The gear mechanism and spur wheels 58 and 59 are shown at the top of Fig. 1 while the control assembly is shown at the bottom of the figure. These two units are normally positioned adjacent each other as shown in Fig. 2, and are shown separated from each other in Fig. 1 for the sake of clearness only.

Fig. 2 shows in section on line II—II of Fig. 1 a construction of the above mentioned brake device with governor and control by hand. Oil brakes 58 and 59 are, by way of pipe system 63, supplied with oil from storage tanks not shown in the drawings or from the oil sump of the engine. The oil flows through conduits 64, 65 and through the control cylinder into collecting pipe 66 and back again through an oil cooler into the storage tank. Only if control slide 67 occupies the centre position shown in Fig. 2 may the oil flow without resistance being offered. If slide 67 is shifted for instance towards the left, then the oil must flow from channel 65 into channel 68 in which an overpressure valve 69 or a nozzle is arranged. The resistance of valve 69 acts upon adjusting gear 57 and 55 in the manner of a brake so that a relative movement between shaft 2 and gear wheel 55 occurs. If slide 67 is shifted towards the right, brake 58 mounted at the right-hand side comes into operation. The resistance of valve 69 may be altered in a simple manner by lever 70 acting upon the valve spring and adapted to be affected by hand or by a special control means. Lever 70 may also be adjusted together with lever 71 operatively connected with the centrifugal governor.

By adjusting lever 70 controlling the loading of valve cone 69 a change from slow gear to fast gear may be effected. Preferably, besides the adjustment to ordinary adjusting speed an adjustment for higher adjusting speed is provided. If instead of valve 69 a nozzle is provided, then the opening of the nozzle and thereby the resistance thereof may be altered by adjustment.

The device operates as follows:

If the engine runs with a constant number of revolutions, and if there is no reason for altering the position of the propeller blades, both oil brakes run idle, i. e. the oil sucked in and fed by both oil brakes flows in a circuit without appreciable resistance being offered thereto. If by means of control slide 67 the stream of oil is throttled at the left- or right-hand side, then a brake action occurs by which for instance toothed rim 55 rotating hitherto with the number of revolutions of shaft 2 is caused to run slower and to act upon the position of the blades by way of the adjusting gear described herein above. If, however, a braking action is applied to gear wheel 54, the relative movement is, by way of planet pinions 51, transferred upon the adjusting gear in a reverse sense of rotation. In this manner the blades may selectively be rotated in the one or the other sense by hand or automatically by the centrifugal governor. The number of revolutions of the governor depends on the number of revolutions of the engine. In the construction of Fig. 1 driving wheel 72 of the centrifugal governor is fixed upon bolt 50 of the planet pinions.

In the modification shown in Fig. 3 the power derived from the motor shaft 12 is directly used for adjusting the air propeller without employing the power transformers described in connection with some of the above modifications which transform the power occurring first as rotary movement into pressure or electric power which in turn is transformed into rotary movement. Nevertheless, in the modification according to Fig. 3 also the main inventive idea is reduced to practice, i. e. a stationary device driven by the air propeller shaft itself is provided for automatically producing the adjusting movement.

As in the modifications already described in this case also the means for driving the centrifugal governor 18 is a toothed rim 13*a* mounted upon the air propeller shaft 2 which, however, in the present case has a second toothed rim 75. The drive of the governor is effected in the same manner as described in connection with the other construction but a special toothed rim 13*b* directly mounted upon the air propeller shaft 2 is provided adjacent the toothed rim 75. These two drive gears act upon two groups of back gears which are independent on each other and may selectively come to action. The purpose of arranging two back gears is to allow the adjustment of the air propeller blades with various speeds. For special cases a quick adjustment of the blades seems to be necessary. For the normal operation of the adjusting gear in dependence on the automatically operating governor such a quick adjustment, however, has the drawback that an "over-control" of the blades may occur, i. e., that an adjustment once initiated is continued if the automatically operating governor is again in its state of equilibrium. By a slower adjustment of the blades which is possible in this modification by the special second back gear such an over-control is prevented.

Below the back gear for the fast gear of the adjusting device will first be described:

A gear wheel 77 the opposite end of the shaft 78 of which is rigidly connected to the clutch disc 79 engages the gear wheel 13 mounted on the main shaft 2. Rotatably mounted upon the shaft 78 is a gear wheel 81 provided with claws 80. Between the latter and the disc 79, also provided with claws, a gear wheel 82 is axially displaceably mounted upon a sleeve 84. The gear wheel 82 carries claws 83 at both sides and engages with the gear wheel 11 to which the wheel 10 is coupled in the manner already described.

The gear wheel 82 is connected to a pressure piston 85 arranged in the interior of the hollow shaft 78. For this purpose the piston rod 86 is provided with a cross rod 87 movably arranged in slots of the shaft 78. The cross rod 87 extends through the sleeve 84 and carries the same

with it when being axially displaced. The piston 85 is operated by oil under pressure in a manner to be later described and is influenced by a control slide. Preferably, the piston 85 is, by means of springs, maintained in its middle position as long as the oil pressure acting upon one side of the piston does not cause displacement of the piston into another position. If now the control causes shifting of the gear wheel 82 towards the left, then the claws 83 engage with the corresponding claws provided at the clutch disc 79, i. e. the wheel 82 is rotated with the same speed as the gear wheel 77. The ratio of gearing between the gear wheel 13 mounted upon the shaft 2 of the air propeller and the gear wheel 77 arranged upon the shaft 78 of the back gear and, moreover, the ratio of gearing between the gear wheel 82 and the gear wheel 11 are so chosen that the latter as well as the adjusting gear wheel 10 rotate somewhat faster than the main shaft 2. This adjustment of the clutch results in an adjustment of the blades of the air propeller in a definite sense. The opposite adjustment of the blades of the air propeller is obtained by displacing the piston 85 by means of its hydraulic control towards the right until said piston reaches the end of its stroke. Hereby the claws 83 of the gear wheel 82 come into engagement with the claws 80 of the gear wheel 81. The ratio of gearing between the gear wheel 75 arranged upon the main shaft 2 and the gear wheel 81 of the back gear is so chosen that the wheel 11 rotates slower than the main shaft 2. Hereby an adjustment of the propeller blades in an opposite sense is effected by way of the adjusting gear wheel 10.

The second back gear serving for the slow adjustment is constructed in the same manner as the first back gear already described except that the diameters of the corresponding gear wheels are chosen differently. The gear wheel 90 arranged upon the shaft 89 of the second back gear is connected to the gear wheel 77, mounted on the shaft 78 of the back gear, and thereby to the gear wheel 13. Moreover, the gear wheel 91 is connected to the gear wheel 81 and thereby to the gear wheel 75. Finally, the gear wheel 92 is connected to the gear wheel 82 and thereby to the gear wheel 11. The axial displacement of the gear wheel 92 provided with lateral coupling claws is effected by corresponding parts, as for the gear wheel 82, that is to say, by the piston 85' with the piston rod 86' and the cross rod 87'.

As mentioned already, the axial displacement of the wheels 82 and 92 effecting the coupling either for a high pitch or for a low pitch is obtained by hydraulic actuation of the pistons 85 and 85'. Hydraulic means have already been used in connection with variable pitch propellers. Hereby in most cases the difficulty is to overcome that the hydraulic means is to be supplied under pressure from a stationary portion of the aircraft into a revolving portion, for instance the hub. This difficulty does not exist with the construction according to the present invention, because the entire adjusting device is stationary so that the hydraulic means need be conducted through stationary pipes only which easily may be sealed.

As the two pistons 85 and 85' for shifting the two back gears are identical, the description of the hydraulic control of the piston 85 only will be sufficient. Leading into the cylinder space provided in the drawings at the right-hand side of the piston 85 is a conduit 101 which discharges into a cylinder in which the control slide 102 is provided. From the cylinder space at the left of

the piston 85 a conduit 103 leads to the same cylinder of the control slide 102. In the position of the control slide 102 shown in the drawings the conduit 101 is by way of a passage 104 connected to a cylinder space in which the control slide 105 is provided. From this cylinder a further connection to a passage 106 is provided which allows the discharge of the hydraulic medium, for instance oil under pressure.

The conduit 103 is connected by way of the cylinder containing the control slide 102 to a passage 107 which leads into the cylinder of the control slide 105. In the position of the control slide 105 shown in the drawings, a connection between the passage 107 and the passage 108 representing the discharge of the oil under pressure is possible.

Into the cylinder of the control slide 105 discharges a passage 109 by which oil under pressure is supplied.

The control slide 102 is arbitrarily adjusted by hand, whereas the control slide 105 is actuated by the centrifugal governor 18. By means of the slide 102, therefore, either the back gear provided with the piston 85 and serving for the fast adjustment of the back gear provided with the piston 85' and serving for the slow adjustment may be rendered operative. The axial displacement of the clutch-gear wheels 82 and 92 respectively and thereby the adjustment of the blades of the air propeller to higher or lower pitch is effected in a manner known per se by the fact that the centrifugal governor controls the slide 105 and thereby allows the supply of oil under pressure either into the space provided adjacent the right-hand side or at the left-hand side of the piston 85 and 85' respectively.

The oil under pressure used for effecting the switching or shifting movements may be derived from any desired source, for instance also from the motor oil pump.

In the construction shown the shifting or switching of the gear is effected by a servo-motor, because thereby the centrifugal governor 18 is released from the forces necessary for effecting the shifting or switching movements and has to cause only the movement of the control slide 105. Of course, the shifting or switching could be effected without the use of the servo-motor also, that is to say, directly by the centrifugal governor.

The above described embodiment of the invention is characterized by a very simple construction of the hub of the air propeller and by a perfectly reliable construction of the elements which produce the power necessary for the adjustment, control, transformation and transfer of this power from the stationary adjusting device upon the hub and the base of the propeller blades. The assembling and the exchange of the individual members may easily be effected and even most drastic alterations of the operating conditions, as for instance of the temperature, humidity of the air or the like have no effect whatever.

What we claim is:

1. In a variable pitch propeller mechanism comprising a plurality of blades, a driving shaft for rotating said blades, a centrifugal governor driven by said shaft, a gear train for simultaneously varying the pitch of said blades including planetary pinions rotating with said shaft, two toothed rims encircling said shaft and operatively connected with said planetary pinions for normally causing rotation thereof in unison with said shaft,

two stationary hydraulic gear pumps, two gears for connecting each of said rims with a corresponding one of said pumps, feeding pipes for feeding a hydraulic liquid to said pumps and discharge pipes for discharging the hydraulic liquid from each of said pumps, a control piston in said discharge pipes actuated by said centrifugal governor for selectively controlling the flow of the hydraulic liquid to one of said gear pumps.

2. In a variable pitch propeller mechanism including at least one blade, a hub carrying said blade, a pitch varying gear train adapted to turn said blade for varying the pitch thereof, a shaft for rotating said hub, a centrifugal governor driven by said shaft, a plurality of planetary bevel gears on said shaft, two toothed rims encircling said shaft and meshing with said bevel gears for normally causing rotation thereof in unison with said shaft, said pitch varying gear train being operatviely connected with one of said toothed rims, each of said toothed rims driving a stationary hydraulic gear pump feeding pipes for feeding a hydraulic liquid to each of said pumps and at least two discharge pipes for discharging the hydraulic liquid, a control piston in said discharge pipes actuated by said centrifugal governor for controlling the flow of the hydraulic liquid to effect a relative movement of said toothed rims with respect to said shaft, a throttle valve arranged in one of said discharge pipes behind said control piston, a spring biasing said throttle valve for offering a predetermined resistance to the flow of the hydraulic liquid therethrough, and means for varying the pressure of said spring for effecting a change in the pitch varying speed.

3. In a variable pitch propeller mechanism which includes a plurality of blades independently pivoted upon a hub so that the pitch of the blades can be changed and with a gear assembly connecting the blades, and wherein a pitch control assembly is provided to control the pitch of the blades, a pair of rotary fluid pumps adapted to independently build up fluid pressures at their respective outlets, a pair of toothed rims surrounding the shaft upon which the propeller mechanism is mounted and spaced from each other with their axes coincident with the axis of

the shaft, a gear assembly mounted to rotate with said shaft and meshing with said toothed rims at its two sides whereby said toothed rims are normally driven by the shaft with the same driving force, gear means connecting said fluid pumps with the respective toothed rims whereby the fluid pumps are driven independently, control means to regulate the back pressure on said fluid pumps whereby the relative speed of the fluid pumps can be changed with the result that said toothed rims are rotated relative to each other, and means connecting one of said toothed rims to exert a pitch control effect to the blades.

4. In a variable pitch propeller mechanism, a propeller shaft, a propeller assembly having its hub fixedly mounted upon the propeller shaft and having a plurality of axially rotatable individually mounted propeller blades, the pitch of which may be varied, a relatively stationary housing concentrically surrounding said shaft immediately behind the hub, a first ring gear fixedly mounted on said propeller shaft within said housing, a centrifugal governor supportably mounted within said housing alongside of the propeller shaft and geared to said first ring gear to be driven thereby, said governor having a piston shaft extending parallel to the propeller shaft with its axial adjustment dependent upon the speed of the governor, a fluid controlled piston operatively connected to said piston shaft and arranged to change the normal flow of fluid between a plurality of pipes in accordance with the position of the piston shaft of the governor, blade gear means for rotating the propeller blades to change their pitch, a gear operated control assembly mounted entirely within said housing comprising a pair of ring gears mounted on said propeller shaft on opposite sides of said first ring gear, said control assembly being geared to said blade gear means and geared to said pair of ring gears in a manner to rotate said propeller blades on their axes in response to flow of fluid effected by control action of said piston shaft of the governor.

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