Aug. 24, 1954 R. K. TIEDEMAN 2,687,181

VARIABLE PITCH COAXIAL PROPELLER

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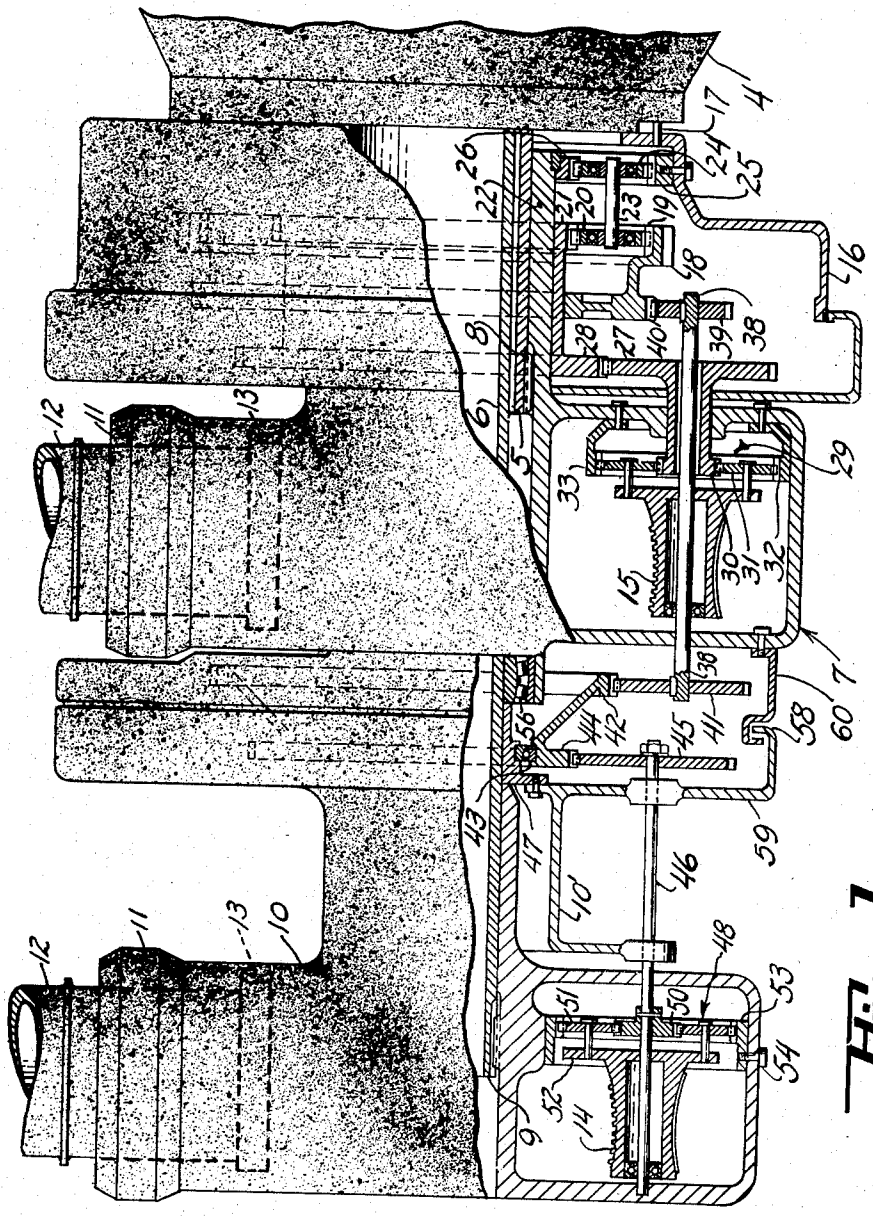


Fig. 1

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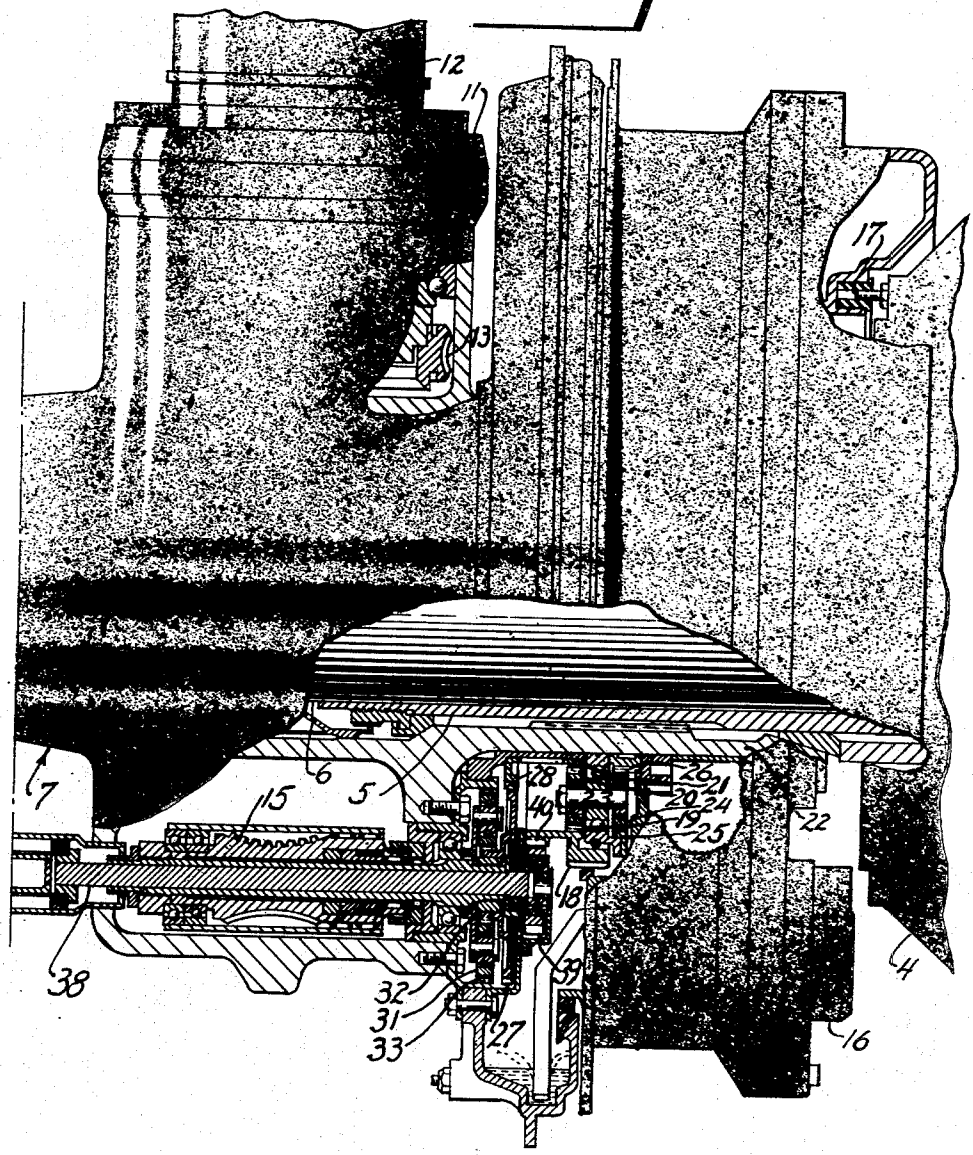
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Fig. 2a



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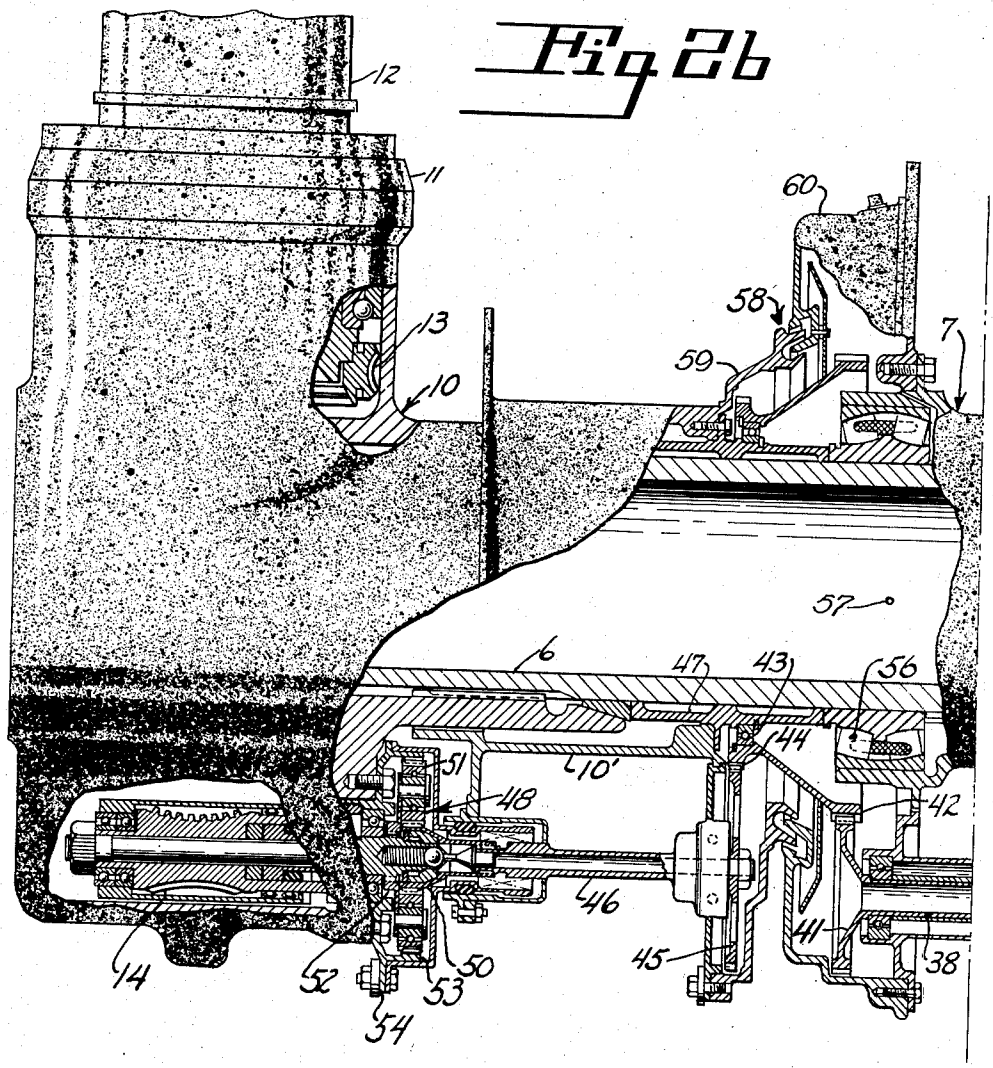
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Fig 2b



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UNITED STATES PATENT OFFICE

2,687,181

VARIABLE PITCH COAXIAL PROPELLER

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Application December 1, 1950, Serial No. 198,530

4 Claims. (Cl. 170—135.27)

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This invention relates to dual rotation controllable pitch propellers for aircraft. Its provisions are particularly applicable to propellers of a dual system which are constrained to rotate at equal or proportional and opposite speeds, and whose blades are intended to operate coincidentally as to pitch change from a single pitch change mechanism.

While not limited to any particular sort of pitch changing mechanism, the invention may be used in conjunction with mechanisms shown and described in copending patent applications Serial Nos. 143,636, filed February 11, 1950 (Mergen and Murphy), 73,586, filed January 29, 1949 (Mergen and Murphy) now U. S. Patent 2,646,131, 34,984, filed June 24, 1948 (Mergen and Tiedeman), and 675,383, filed June 8, 1946 (Chillson) now U. S. Patent 2,640,552.

The invention provides improvements in the means for transmitting pitch changing movement from a pitch changing mechanism through an inboard propeller to the blades of the outboard propeller.

The invention further includes bearing, sealing, and transmission arrangements between inboard and outboard propellers which allow relative articulation without imposing harmful stresses in the mechanism.

The invention further comprises an adjustable but normally stationary pitch control gear inboard of the inboard propeller. The inboard propeller carries a shaft, parallel to the propeller shaft, having a gear meshing with the control gear; and another gear at its outboard end meshed with a pitch control gear normally rotatable with, but adjustable relative to, the outboard propeller. This outboard pitch control gear is drivably connected to the blades of the outboard propeller. The ratios of the several gears mentioned are arranged to produce the desired rotational relationship of the gears.

Exemplary embodiments of the invention are shown in the annexed drawings, which are not to be construed as limiting the scope of the invention, in which similar reference characters designate similar parts and in which

Fig. 1 is a schematic elevation of portions of a dual rotation propeller system showing parts in longitudinal section;

Fig. 2*a* is an elevation, partly in longitudinal section, of the inboard unit of a dual rotation propeller; and

Fig. 2*b* is an elevation, partly in longitudinal section, of the outboard unit of a dual rotation propeller.

The invention as shown in Fig. 1 is a simplified

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more or less schematic arrangement of the invention while Figs. 2*a* and 2*b* represent a version whose design details have been developed. This description is readable both on Fig. 1 and on Figs. 2*a* and 2*b*, the reference characters for parts having similar function being the same. A housing 4, such as an engine or gear box nose, forms a fixed part of the aircraft, and sleeved propeller shafts 5 and 6 extend therefrom, the shaft being embraced by the shaft 5, and extending outwardly therebeyond. By gearing, well known in the art and lying within the housing 4, the shafts 5 and 6 are constrained, when driven, to rotate in opposite directions and preferably, though not necessarily, at the same rotational speed. An inboard propeller hub 7 is mounted on the shaft 5 through splines 8 and suitable centering cones and nut, and an outboard propeller hub 10 is mounted on the shaft 6 through splines 9 also on suitable centering cones and nut. Each hub has blade sockets 11 in which blades 12 are mounted for pitch changing rotation in a suitable manner known in the art. Each blade, at or near its butt, carries a worm wheel 13, the worm wheels of the outboard propeller blades being engaged by worms 14, and those of the inboard propeller blades being engaged by worms 15, the worms being mounted in suitable bearings in respective hubs.

Between the inboard hub 7 and the housing 4 is a housing 16 containing a pitch changing mechanism, held against rotation by a dowel 17 engaging the housing 4. The parts of the mechanism which are germane to this invention include a normally stationary pitch control gear 18 coaxial with the hubs which may be rotated by a meshing pinion, not shown, in either direction, or held stationary, by any of the devices shown in the previously identified patent applications or by other means. The gear 18 is provided with internal teeth 19 engaging planet pinions 20, meshed in turn with a hub concentric sleeve gear 21 piloted on an extension 22 of the inboard hub. Pinions 20 are freely rotatable on shafts 23, carried by a spider, and freely rotatable pinions 24 are also carried on these shafts, the pinions 24 meshing with a stationary ring gear 25 secured to the housing 16, and with a sun gear 26 keyed to the hub extension 22 and consequently to the shaft 5. By this planetary gearing, the sleeve gear 21 is enforced to rotate with the inboard hub when the control gear 18 is stationary, and to advance and retard relative to the hub as the gear 18 is rotated in one or the other direction.

The inboard hub 7 carries a hub-eccentric gear

27 meshing with a hub-concentric gear 28, the latter being rotatable or integral with the sleeve gear 21. Gear 27 drives a planetary speed reducer 29 mounted in the hub which drives the blade engaging worm 15. The speed reducer includes a sun pinion 30 on the shaft of gear 27 driving pinions 31 on a spider 32 connected to the worm 15, the pinions meshing also with a ring gear 33 secured rigidly to the hub 7. The train including the gear 27, the reducer 29 and worm 15 is duplicated for each blade 12 of the inboard propeller. The mechanism thus far described provides for pitch control of the inboard propeller blades, and is not new, per se.

For pitch changing motion to be transmitted from the control gear 18 to the outboard propeller 10, it is necessary to provide gearing having members passing through the inboard propeller. To this end, a lay shaft 38 is journalled in the inboard hub 7 and for convenience and space saving, it extends through the worm 15 and gear 27 although it has no functional relation to these parts. The shaft 38 carries an inboard gear 39 meshed with an external hub-concentric gear 40 solid with the normally stationary control gear 18. The gears 40, 39 have a ratio R_1 relative to each other which as shown is of the order of 6:1, although any suitable ratio may be used. On the outboard end of the shaft 38 is a gear 41 meshed with a hub-concentric gear 42 embracing the outboard propeller shaft and carried for relative rotation with respect thereto on a bearing 43. The gears 42, 41 have a ratio R_2 relative to each other which as shown is of the order of 3:1, although any suitable ratio may be used so long as it bears the proper relationship as noted below with respect to the ratio R_1.

For a dual propeller system in which the inboard and outboard propellers rotate in opposite directions at equal speeds, the ratio of $R_1:R_2$ must be equal to 2 in order that the gear 42 will rotate in the same direction and at the same speed as the outboard propeller 10. Considering the gear relationships in another fashion, the shaft 38 rotates on its own axis and around the propeller axis since it is carried by the inboard propeller and since the gear 39 rolls around the gear 40. To make the gear 42 rotate with the outboard propeller, the gear 41 must be of such diameter as to have twice the peripheral speed of the rim of the gear 39. Stated in another way, either the pitch diameters or the number of teeth in the gears must bear the following relationships:

$$\frac{\text{gear } 40}{\text{gear } 39}=2\times\frac{\text{gear } 42}{\text{gear } 41}$$

As pointed out above, the specific ratios of the gears 42:41 and of the gears 40:39 is not material toward obtaining rotation of the gear 42 with the outboard propeller, so long as the inboard gear ratio is double the outboard gear ratio.

Now it will be seen that if the control gear 18, which is normally stationary, is advanced or retarded rotationally, corresponding advance or retard rotation of the gear 42 will occur with respect to the outboard propeller hub 10. It should be further noted that the gear and shaft assemblies 38, 39, 41 are preferably plural in number and spaced around the inboard propeller 7, the number of these units being equal to the number of blades of the inboard propeller.

The gear 42 carries an integral gear 44 meshed with gears 45 mounted on shaft 46 journalled in the outboard hub 10 and in associated housing portions rotatable therewith, certain of these housing portions being indicated at 10' and being secured in part to a sleeve 47 mounted on and rotatable with the outboard propeller shaft 6. Each shaft 46 drives a planetary speed reducer 48 on the hub 10, the output element of which drives the outboard propeller worm 14 meshed with the worm wheel 13 of each outboard propeller blade 12. The speed reducer 48 is like the speed reducer 29 and consists of a sun pinion 50 keyed or pinned to the shaft 46 engaged by planet pinions 51 mounted on a spider 52, the pinions 51 also being meshed with a ring gear 53 anchored as at 54 within a portion of the propeller hub 10. In Fig. 1 the spider 52 is formed integral with the worm wheel 14 but it may be formed separately therefrom and splined to the worm as in Fig. 2b.

The ratios of the speed reducers 29 and 48 and of the gears 28, 27 and 44, 45 respectively on the inboard and outboard propeller hubs may be equal if desired to provide equal rates of pitch change for the blades of both propellers 7 and 10 or, alternatively, as is known in the art, the ratios of these reduction gears may be slightly different in order that the inboard and outboard propellers will have differential pitch change to produce equal thrust from the two propellers since one of the propellers is in the wake of the other.

Should the propellers 7 and 10 be geared to rotate oppositely but at different speeds, the gear 44 must still be driven to rotate at outboard propeller speed when no pitch change is called for. To accomplish this, the ratios between the gears 40, 39 and 41, 42 are altered from the arrangements above described. The system herein disclosed is not applicable if the outboard and inboard propellers operate at speeds which are independent of one another; the two propeller shafts must be arranged to operate at definite proportional speeds.

In Figs. 2a and 2b detailed provisions are included for providing bearings and seals, and elastic driving connections where there is relative yield in operation between cooperating parts.

The propellers 7 and 10 and their various parts are subject to deflections in operation due to operating stresses. The outboard propeller 10, for instance, may weave relative to the inboard propeller 7 and the outboard shaft 6 may deflect in various ways relative to the inboard shaft 5.

Means are included to provide concentricity and self-alinement in the pitch changing transmission from the inboard propeller to the outboard, and to localize operating deflection to specific locations. A rugged self-alining pilot bearing 56 is provided between the outboard end of the inboard hub 7 and the inboard end of the outboard shaft 6. By this bearing, the shaft 6 and the hub 7 are held concentric at the plane of the bearing 56 even though, outboard of the bearing, the shaft 6 and hub 10, with its own components, may deflect and weave. The bearing 56 establishes a center of articulation 57 for the outboard elements. A labyrinth seal 58, whose elements are concentric with 57, is arranged between housing elements 59 and 60 respectively secure with the hubs 10 and 7, to allow relative movement (other than rotationally) of the housing elements. Also, the engagements between the gears 41 and the gear 42 are located substantially in the plane of the bearing 56. As has been noted, the gears 41 are carried by the inboard hub

7, while the gear 42 is carried by the outboard shaft 6. With the gear engagements substantially in the plane of the bearing 56, articulation and relative movement is enabled between the inboard and outboard gear trains, the articulation occurring by axial sliding of the engaged teeth of the gears 41 and 42, the teeth of the gears 41 and 42 being slightly barrel-shaped.

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

What is claimed is:

1. In a dual rotation propeller system, an inboard propeller shaft having a propeller mounted thereon, an outboard propeller shaft passing through the inboard shaft and having a propeller mounted thereon outboard of the inboard propeller, a self-alining bearing between the inboard propeller and the outboard shaft, disposed between said propellers and enabling weaving of said propellers relative to each other about the center of said self-alining bearing, pitch change mechanism for and carried by the inboard propeller, pitch change mechanism for the outboard propeller carried in part by the inboard propeller and in part by the outboard propeller; said latter mechanism including a gear between the propellers and carried by the outboard propeller, a layshaft journalled in the inboard propeller and spaced from and substantially parallel to the inboard propeller shaft, and a gear on the layshaft engaging said outboard propeller gear substantially in a plane normal to the propeller axes and passing through said bearing.

2. In a dual rotation propeller system, an inboard propeller shaft having a propeller mounted thereon, an outboard propeller shaft passing through the inboard shaft and having a propeller mounted thereon outboard of the inboard propeller, a self-alining bearing between the inboard propeller and the outboard shaft, disposed between said propellers and enabling weaving of said propellers relative to each other about the center of said self-alining bearing, pitch change mechanism for and carried by the inboard propeller, pitch change mechanism for the outboard propeller carried in part by the inboard propeller and in part by the outboard propeller; said latter mechanism including a gear between the propellers and carried by the outboard propeller, a layshaft journalled in the inboard propeller and spaced from and substantially parallel to the inboard propeller shaft, and a gear on the layshaft engaging said outboard propeller gear, the teeth of said gears extending forwardly and rearwardly and substantially tangent to a circle whose center coincides with the center of said self-alining bearing.

3. In a dual rotation propeller system, an outboard propeller having a pitch change mechanism including a gear coaxial with the propeller and normally rotatable therewith, an inboard propeller including a gear coaxial therewith and normally rotatable therewith, said propellers being constrained to opposite rotation at equal speeds and being mounted on concentric shafts, a normally stationary pitch control gear, gearing connecting the control gear to the coaxial gear of the inboard propeller; gearing including a layshaft carried by the inboard propeller, a gear on the layshaft engaging the control gear, and a gear on the outboard end of the layshaft engaging the gear of the outboard propeller; and a self-alining bearing between and having its races secured to said inboard propeller and to the shaft of said outboard propeller, said bearing being concentric with and lying in a plane normal to the propeller shafts, the engagement of the outboard layshaft gear and the outboard coaxial gear lying substantially in said normal plane.

4. In a dual rotation propeller system, an outboard propeller having a pitch change mechanism including a gear coaxial with the propeller and normally rotatable therewith, an inboard propeller including a gear coaxial therewith and normally rotatable therewith, said propellers being constrained to opposite rotation at equal speeds and being mounted on concentric shafts, a normally stationary pitch control gear, gearing connecting the control gear to the coaxial gear of the inboard propeller; gearing including a layshaft carried by the inboard propeller, a gear on the layshaft engaging the control gear, and a gear on the outboard end of the layshaft engaging the gear of the outboard propeller; and a self-alining bearing between and having its races secured to said inboard propeller and to the shaft of said outboard propeller, said bearing being concentric with and lying in a plane normal to the propeller shafts, the engagement of the layshaft gear and the outboard coaxial gear meshing on lines substantially tangent to a construction sphere concentric with said self-alining bearing.

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