May 17, 1949. W. S. HOOVER 2,470,560

OPPOSITELY ROTATING PROPELLERS

Filed June 13, 1939 4 Sheets-Sheet 1

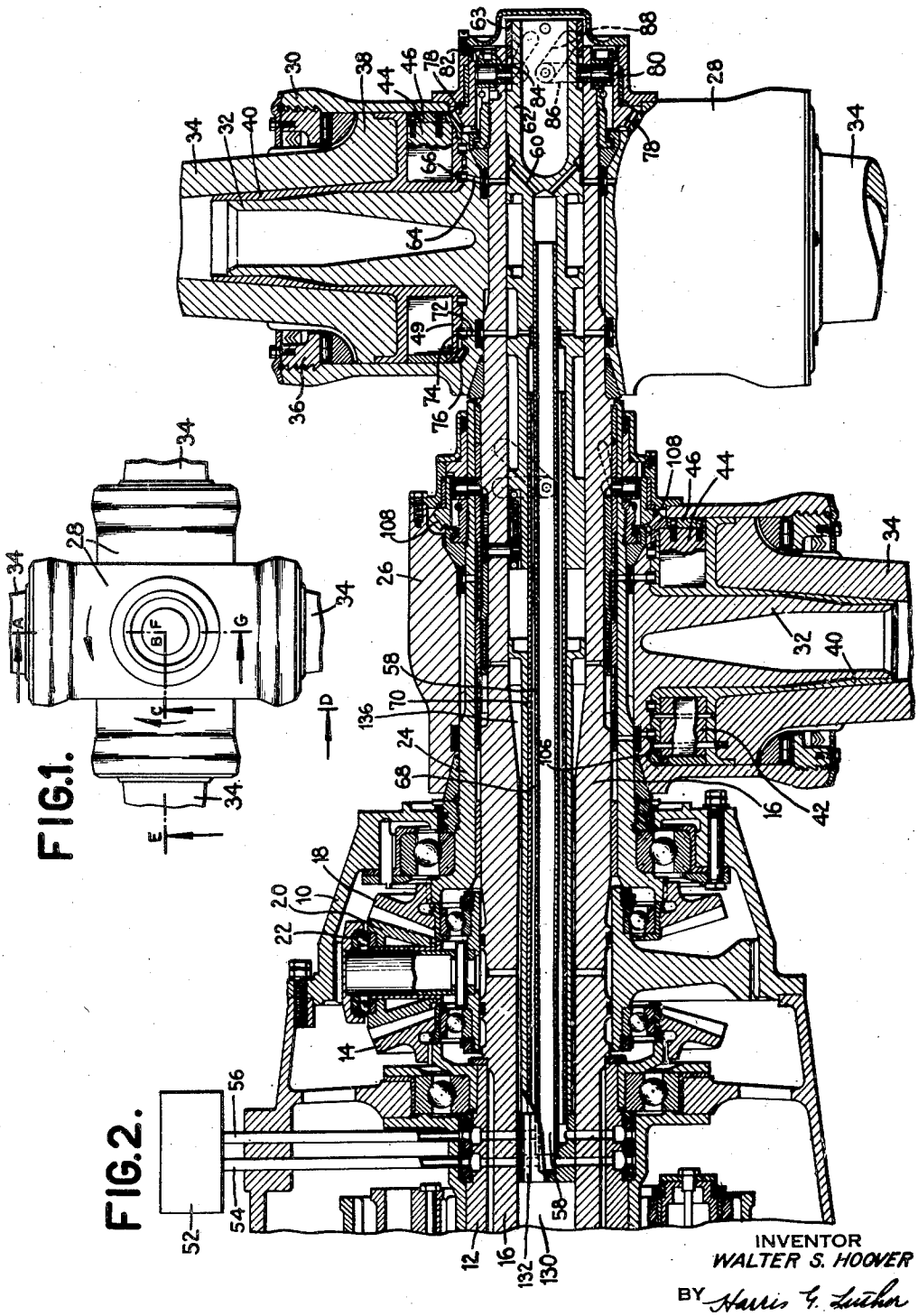


FIG.1.

FIG.2.

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OPPOSITELY ROTATING PROPELLERS

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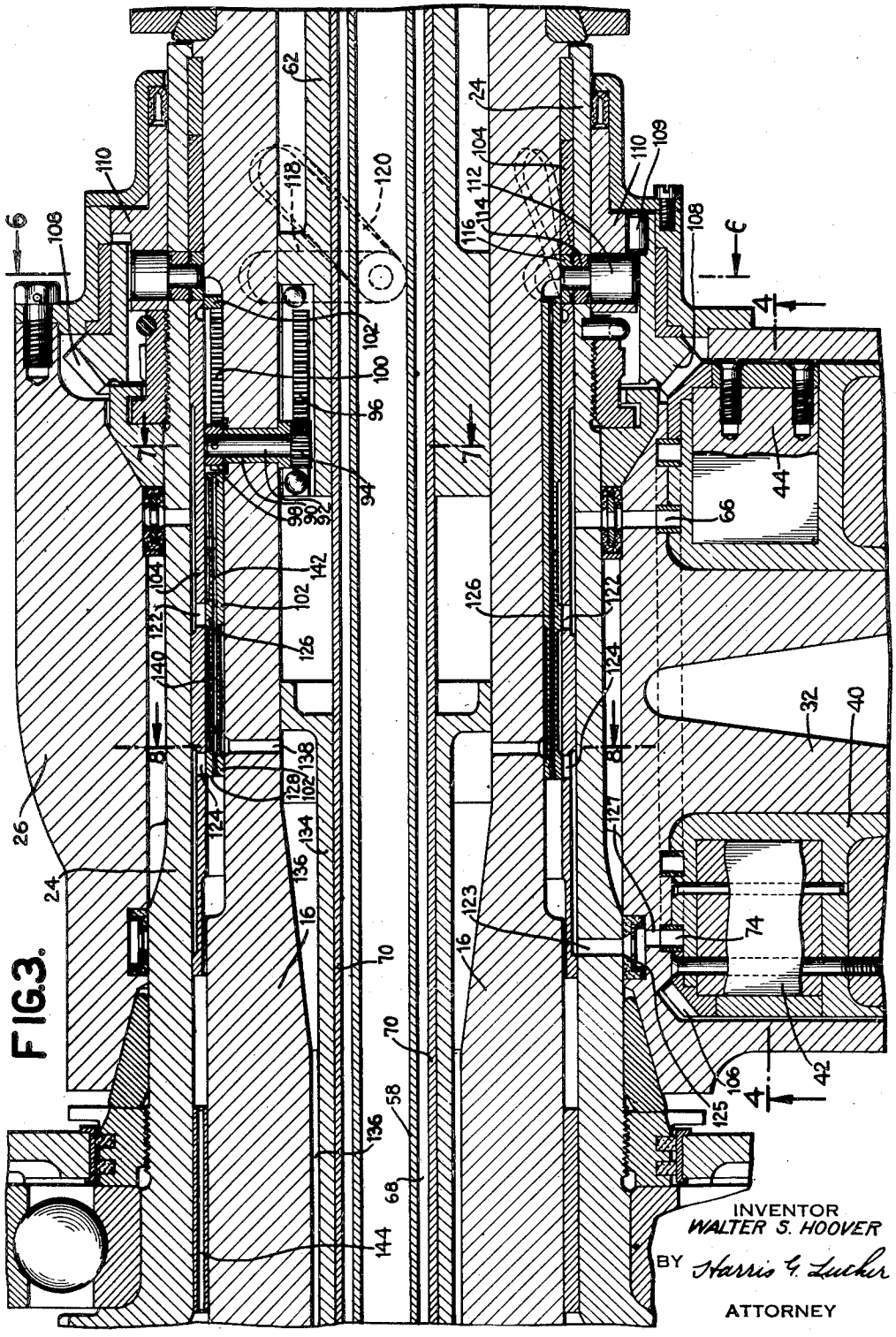


FIG. 3.

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OPPOSITELY ROTATING PROPELLERS

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FIG. 5.

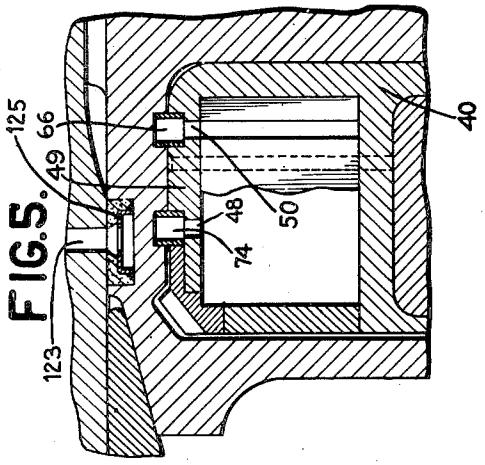
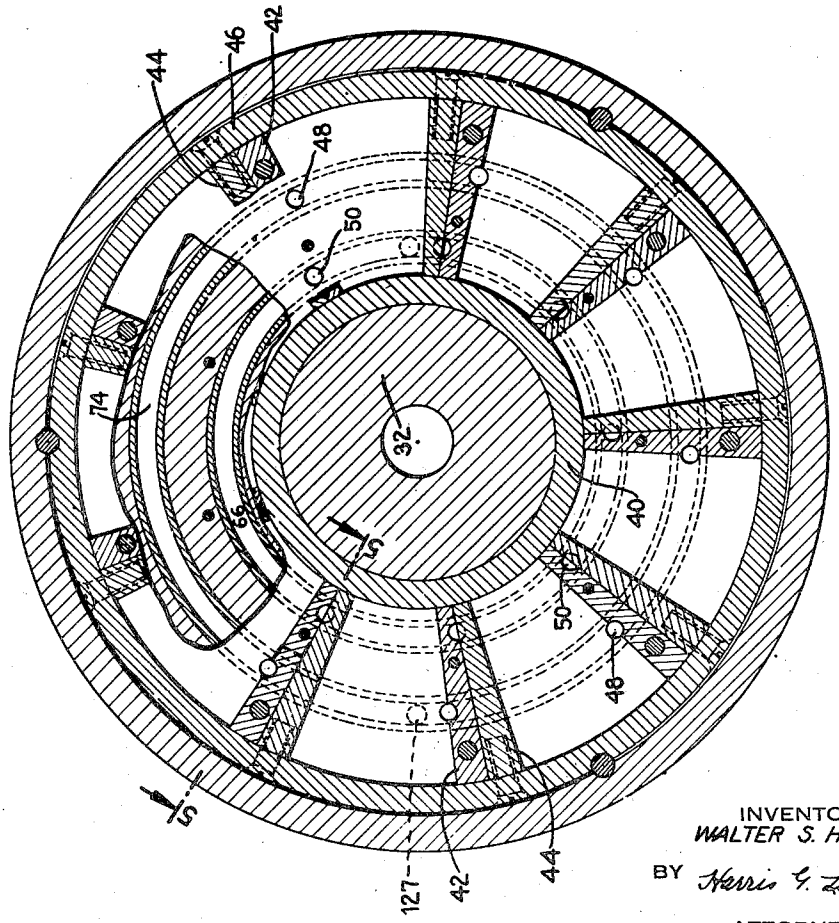


FIG. 4.



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OPPOSITELY ROTATING PROPELLERS

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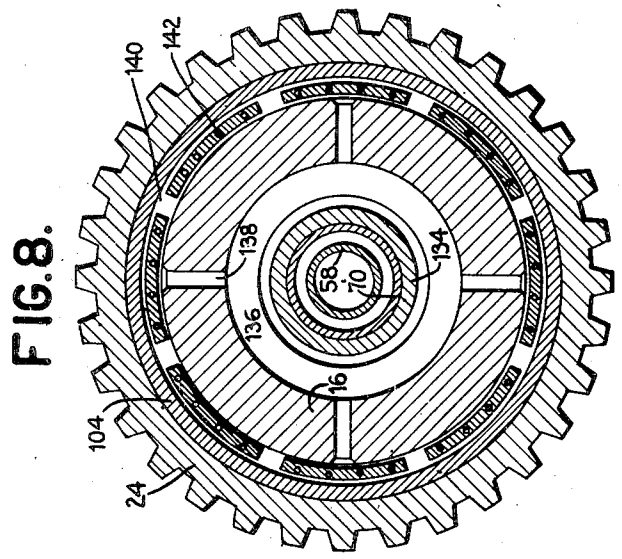


FIG.8.

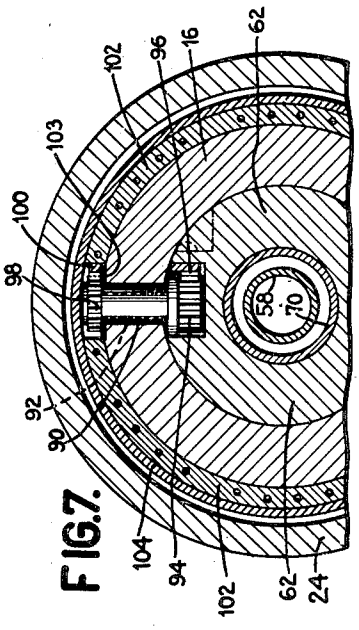


FIG.7.

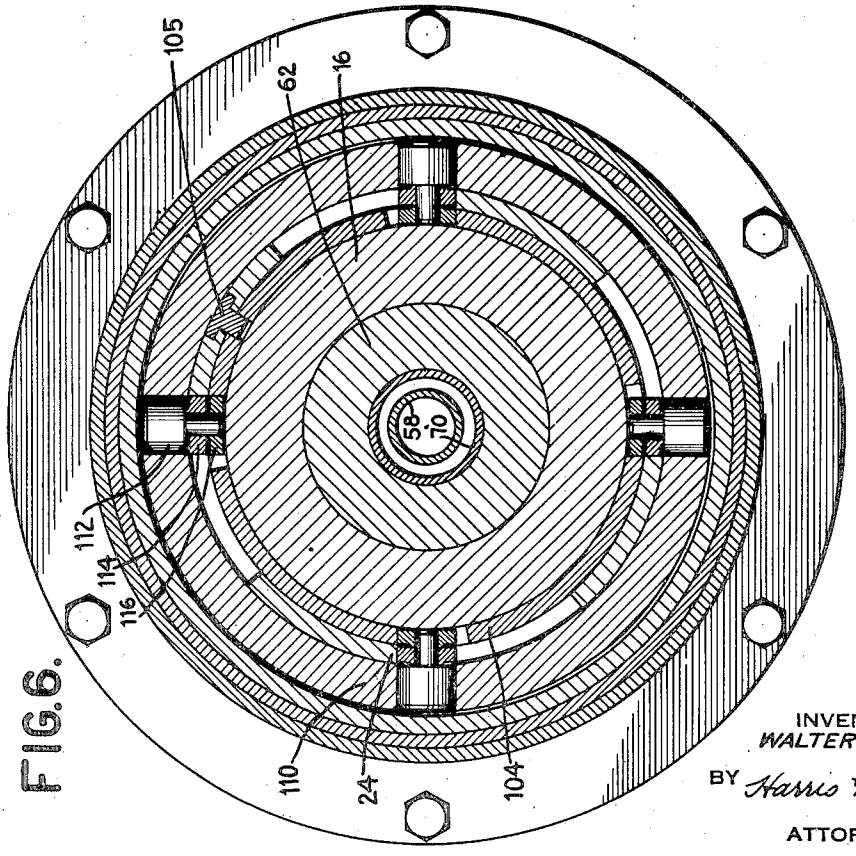


FIG.6.

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Patented May 17, 1949 2,470,560

UNITED STATES PATENT OFFICE

2,470,560

OPPOSITELY ROTATING PROPELLERS

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Application June 13, 1939, Serial No. 278,860

14 Claims. (Cl. 170—135.27)

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This invention relates to controls and more particularly to controls for airplane propellers.

An object of this invention is to provide means for controlling oppositely rotating propellers.

Another object of this invention is to provide means for controlling one of two oppositely rotating propellers by the other propeller.

Further and other objects of this invention will be apparent from the following specification and drawings and the appended claims.

In the accompanying drawings in which like reference numerals are used to designate similar parts throughout, there is illustrated what is now considered to be the preferred form of the invention. The drawings, however, are for the purpose of illustration only and are not to be taken as limiting the invention.

Figure 1 shows an end view of the two propellers.

Fig. 2 is a cross-section through the two propellers taken on the lines A, B, C, D, of Fig. 1 for the first propeller, and E, F, G, of Fig. 1 for the second propeller.

Fig. 3 is an enlarged sectional detail of the second propeller and its actuating mechanism taken on the lines E, F, G, of Fig. 1.

Fig. 4 is a cross-section on the lines 4—4 of Fig. 3, showing the vanes for actuating the blade.

Fig. 5 is an enlarged detail of one of the vanes showing the oil inlet and outlet.

Fig. 6 is a cross-section on the lines 6—6 of Fig. 3.

Fig. 7 is a cross-section on the lines 7—7 of Fig. 3.

Fig. 8 is a cross-section on lines 8—8 of Fig. 3.

In the drawings the propellers which may have any desired number of blades are shown as mounted at the forward part of an engine 10 and having a driving connection with the engine through the member 12 which is splined to the bevel gear 14 and to the propeller shaft 16. Bevel gear 14 drives the bevel gear 18 through a pinion 20 mounted on a cage 22 fixed to a stationary part of the engine 10. Gear 18 is splined to propeller shaft 24 which drives propeller hub 26 and the blades carried thereby.

Propeller shaft 16 passes through propeller shaft 24 and drives a propeller hub 28 and its associated blades located at the forward end thereof.

The mechanism so far described, when driven through the member 12, will cause the shaft 16 and its attached propeller to rotate in one direction, and the shaft 24 and its attached propeller to rotate in the opposite direction.

The two propeller hubs and the blades carried

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thereby are generally similar and a description of one will serve to describe both. The hub 28 comprises an outer shell 30 and an integral spider 32. The propeller blades 34 are mounted on the spider and held in position by the nut 36 acting, through thrust bearings, on the flange 38 of the blade. A sleeve 40 is located between the spider and the blade and carries vanes 42 (shown on the rear propeller). Stationary vanes 44 are secured to a ring 46 which, in turn, is fixed to the hub barrel.

By leading oil to the spaces between the vanes carried by the hub and one side of the vanes carried by the propeller blade, the blade may be turned in one direction. By leading oil to the space on the other side of the vanes, the blades may be turned in the other direction. Referring to Figs. 4 and 5 the blades 44 carried by the hub are shown substantially in contact with the vanes 42 carried by the propeller blades. Conduit 48 leads through a flange 49 at the base of sleeve 40 to one side of vane 42, and a conduit 50 leads through that flange to the other side of the vane 42. These conduits may be connected, by means presently to be described, respectively with sources of oil pressure and a drain to cause rotation of the propeller blade in its hub and thereby cause a change in the pitch of the propeller.

In the operation of this propeller, oil from a governor 52 is led to the vanes in the blade of the forward propeller to control its pitch. The pitch of the rear propeller is controlled by the position of the forward one. This control takes the form of a follow-up valve, which will be presently described, which controls the flow of oil to and from the vanes in the base of the blades 34 of the rear propeller. Oil from any suitable source of pressure is led in the usual manner to a governor 52. This governor, which may be driven by the engine or any other suitable source of power, directs the oil under pressure through either conduit 54 or conduit 56 to change the propeller pitch in accordance with the speed variations of the governor drive to thereby maintain a particular speed relation. It is now preferred to drive the governor from the engine and use the propeller to maintain constant engine speed. Whenever conduit 54 is connected with a source of pressure conduit 56 is connected with a drain and vice versa.

Assuming that engine speed change has taken place which causes the governor to introduce fluid under pressure to the conduit 54, this oil is led through appropriate passages to the interior of the tube 58 located in the interior of propeller shaft 16. This oil passes through the tube 58 to the conduit 60 in member 62 and through appro-

priate passages to conduit 64 and into the annular groove 66. This groove is connected by means of the previously described conduit 50 (see Figs. 4 and 5) with the space on one side of the vane 42.

At the same time that the conduit 54 is leading oil under pressure to one side of the vane 42, the conduit 56 is connected with a drain. This conduit 56 is connected by appropriate passages to the space 68 between the tubes 58 and 70. This space is connected by appropriate passages at the forward end of shaft 16 with a conduit 72 leading to the annular groove 74 in the hub 28 adjacent the blade end. This annular groove 74 is connected by the previously described conduit 48 (see Figs. 4 and 5) with the side of the vane 42 opposite to that fed by the conduit 50.

It will thus be seen that the governor under the condition just described acts to connect the area at one side of the vane 42 with a source of pressure and to connect the area at the other side with a drain. This action will cause the blade 34 to rotate in one direction in its socket. When the operation of the governor acts to connect the conduit 56 with pressure and the conduit 54 with a drain, the pressure and drain connections to the vane 42 will be thereby reversed and the blade 34 will be rotated in the opposite direction.

The bevel gear 76 (see Fig. 2) is secured to the sleeve 40 of the blades of the forward propeller to rotate with the sleeve and its associated propeller blade. A gear 78 meshes with the gears 76 and carries a plurality of studs 80 on which are mounted rolls 82 and 84. Roll 82 reciprocates in elongated slot 86 cut in propeller shaft 16. This slot lies in a plane at right angles to the axis of the propeller shaft and serves to prevent longitudinal movement of the stud 80 and its associated rolls. The roll 84 reciprocates in elongated slot 88 cut at an angle to the axis of member 62, in cam member 63 fixed to member 62. As stud 80 is reciprocated in slot 86 by the turning of propeller blades 34, roll 84 in attempting to reciprocate in slot 88 causes member 62 to slide axially within the propeller shaft 16.

Member 62 (see Figs. 3 and 7) is prevented from rotation relative to the shaft 16 by the head of the bushing 90 passing radially through shaft 16. This bushing supports a shaft 92 in the shaft 16. A gear 94 is formed at one end of shaft 92 and meshes with a rack 96 secured in a recess in the axially slidable member 62. A gear 98 is pinned to the end of the shaft 90 opposite the gear 94 and meshes with a rack 100 carried by an axially slidable valve member 102.

This valve member is adapted to slide axially on the outside of shaft 16 and inside of a cooperating valve member 104 carried by, rotating with, and located inside of propeller shaft 24. This shaft, as previously described, rotates in the opposite direction from shaft 16. The valve member 102 is prevented from rotating relative to shaft 16 by collar 103 supported on the outer end of bushing 90 in contact with the sides of the slot in which rack 100 is located. The valve member 104 is prevented from rotating relative to the shaft 24 by means of a key 105.

In a manner similar to that described for the forward propeller, each rear propeller blade carries a gear 106 (see Fig. 3) which meshes with a gear 108. The gear 108 is pinned by a pin 109 to a member 110 which carries a stud 112. This stud has rolls 114 and 116 mounted to rotate thereon. The roll 114 reciprocates in an elongated slot 118 located in the propeller shaft 24 and in a plane transverse to the axis thereof. The roll 116 reciprocates in a slot 120 located in the cooperating valve member 104 which in the form disclosed in a sleeve mounted to reciprocate inside of the shaft 24.

The valve member 104 has valve ports 122 and 124 which cooperate with lands 126 and 128, respectively, in the axially slidable valve member 102.

As will be presently described, movement of the valve member 102 in one direction with respect to its cooperating valve member 104 will cause oil under pressure to be admitted to one side of the vanes 42 of the rear propeller and operation of the valve 102 in the other direction with respect to the cooperating valve member 104 will cause oil under pressure to be admitted to the other side of the vane 42. Whenever one side of the vane 42 is connected with oil under pressure, the opposite side is connected with a drain.

Oil under any suitable pressure, preferably engine oil pressure, is led into the area 130 in the interior of the propeller shaft 16 shown at the extreme left of Fig. 2. This oil finds its way through suitable passages 132 to the area 136 between the crank shaft 16 and the member 134 which supports tube 70. This oil passes through conduit 138 (see Fig. 8) to the space 140 located between the lands 126 and 128 of the axially slidable valve member 102. The opposite sides of the land members 126 and 128 are connected to drain through the passages 142 and 144 which lead to the engine gear box or crankcase.

Whenever the governor causes a pitch change of the forward propeller, that propeller in changing its pitch will cause axial movement of the valve member 102. This axial movement will connect one of the ports 122, 124 with oil under pressure and the other port with drain. Port 124 leads by means of conduit 123, a packed joint 125 and conduit 127 to annular ring 74 connected by port 48 with one side of the blade 42 and port 122 leads through similar passages to annular groove 66 connected by port 50 with the other side of blade 42 in the manner explained in connection with the description of the forward propeller. When oil under pressure is led through one of the ports 122, 124 it is led to one side of the vane 42 and the propeller blade is turned. This turning action of the blade changes its pitch and also moves the valve member 104 in the same direction that valve member 102 was moved to open the port. This action continues until member 104 has moved to a position where the lands of valve member 102 close the ports of the valve member 104 to shut off any further flow of oil. The rear propeller will then have assumed a pitch change commensurate with the pitch change in the forward propeller, which may be the same as, or any desired proportion of, the change in the forward propeller.

Although I have described a specific embodiment of the invention, it is to be understood that the invention is not limited to that specific embodiment but any changes and modifications may be made as come within the scope of the subjoined 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 combination with a pair of concentric oppositely rotating propellers in which the pitch of one propeller is hydraulically controlled by the

other, hydraulic means for changing the pitch of said one propeller, valve means for controlling the flow of oil to and from said hydraulic means, means for operating said valve comprising a member operatively connected by a pin and cam connection with, and operable by the pitch changing movements of said other propeller.

2. Means for operatively connecting one propeller with another to cause a pitch change of one to change the pitch of the other comprising means rotatable by pitch changing movement of the blades of said one propeller, a pin and cam connection for converting the rotary motion of said rotatable means into linear movement of a member, means operatively connecting said member with a valve for imparting linear movement to said valve, fluid operated means for changing the pitch of said other propeller, said valve controlling the admission of fluid to the pitch changing mechanism of said other propeller and having a neutral position in which the flow of fluid is blocked, means rotatable by said other propeller, a pin and cam connection for converting the rotary motion of said rotatable means into linear movement of a valve member cooperating with said valve to determine the location of the neutral point of said valve and the pitch of said other propeller.

3. In a two propeller combination in which the pitch changing movements of the blades of one propeller operate a valve which by controlling the operation of the pitch changing mechanism of the other propeller determines the pitch changing movements of the blades of the other propeller, means rotatable by the pitch changing movements of the blades of said one propeller, a pin and cam connection for converting the rotary motion of said means into linear movement of one portion of said valve and means for converting the rotary motion of the blades of said other propeller to linear movement of a cooperating portion of said valve.

4. In a two propeller combination in which the pitch changing movements of the blades of one propeller operates a valve which by controlling the energization of the pitch changing mechanism determines the pitch changing movements of the blades of the other propeller, means operable by the pitch changing movements of the blades of said one propeller for positioning one portion of said valve and means operable by the pitch changing movements of said other propeller and cooperating with said one portion of said valve for controlling the pitch changing movements of said other propeller and determining its pitch setting.

5. In combination, a pair of concentric oppositely rotating propellers, means for changing the pitch of said propellers comprising hydraulically actuated means for controlling the pitch of one propeller, hydraulically actuated means for controlling the pitch of the other propeller, means reciprocated by pitch changing movements of said one propeller for actuating a valve for controlling the flow of fluid to and from the pitch actuating means of the second propeller and means actuated by pitch changing movements of said second propeller cooperating with said valve to maintain the pitch of said second propeller in a predetermined relation with respect to said first propeller.

6. In combination, a pair of concentric oppositely rotating propellers, means for changing the pitch of said propellers comprising hydraulically actuated means for changing the pitch of one

of said propellers, means reciprocated by pitch changing movements of the other propeller for actuating a valve for controlling the flow of fluid to and from said one propeller and a follow up mechanism actuated by pitch changing movements of said one propeller and cooperating with said valve to give the blades of said one propeller a pitch determined by the position of said valve and thereby a predetermined relation with respect to the pitch of said other propeller.

7. In combination, a pair of associated propellers, means for changing the pitch of each of said propellers, the pitch changing means of one propeller comprising a governor controlled mechanism, the pitch changing mechanism of the other propeller comprising fluid actuated means, and a valve for controlling the flow of fluid to and from said fluid actuated means, said valve comprising two cooperating parts, means for actuating one of said parts by pitch changing movements of the blades of said one propeller, means for actuating the other part by pitch changing movements of the blades of the other propeller, said parts having one relative position at which flow of fluid to and from said fluid actuated means is prevented and constructed and arranged so that relative movement of either part causes the blade pitch of said other propeller to change to bring said valve parts into said one relative position.

8. In combination, a pair of telescopically arranged shafts rotatable in opposite directions, a first propeller supported by the inner shaft and rotatable thereby, an hydraulic motor for changing the pitch of said propeller, means for conducting liquid through the interior of said shaft to said motor for actuating the same, a governor for controlling the flow of liquid through said shaft, a second propeller supported by the outer shaft and rotatable thereby, an hydraulic motor for changing the pitch of said second propeller, means for continuously supplying fluid through said inner shaft, a valve having axially movable parts for controlling the flow of liquid from said continuous supply in said inner shaft to said last mentioned motor, a member operatively connected with one part of said valve and actuated in a direction axial of said shafts by pitch changing movements of said first propeller, means connecting a cooperating part of said valve to the blades of said second propeller for axially moving said cooperating part, said valve constructed and arranged so that when said valve is open the motor of said second propeller is actuated to change the blade pitch and move said cooperating valve part to close said valve and means for discharging liquid from the motor of said second mentioned propeller.

9. In combination, a pair of related propellers, hydraulically actuated means for changing the pitch of one of said propellers, a governor for controlling the supply of liquid to said propeller, independent hydraulically actuated means for changing the pitch of the other of said propellers, means for continuously conducting liquid under pressure to said independent means, a valve for controlling the supply of said liquid to said independent means, said valve having one fluid controlling part actuated by pitch changing movements of said one propeller and having a cooperating part actuated by pitch changing movements of said other propeller to maintain the pitch of said other propeller in a predetermined relation to the pitch of said one propeller.

10. In combination with a pair of concentric oppositely rotating propellers in which the pitch

of one propeller is changed hydraulically and is determined solely by the pitch of the other, hydraulic means for effecting pitch changes of said one propeller only, means for changing the pitch of said other propeller, valve means whose position determines the pitch of said one propeller for controlling the flow of oil to and from said hydraulic means to control the pitch of said one propeller and means operatively connected with said valve for operating valve comprising a member whose position is determined by the pitch of said other propeller carried by and operatively connected with said other propeller.

11. In combination with a pair of concentric oppositely rotating propellers having blades and in which the pitch of one propeller is changed hydraulically and is determined by the pitch of the other, hydraulic means for effecting pitch changes of said one propeller only, valve means for controlling the flow of oil to and from said hydraulic means to control the pitch of said one propeller and means for operating said valve comprising a member operatively connected with the blades of said other propeller and operated by pitch changing movement of said blades.

12. In combination, a plurality of propellers, hydraulically actuated means comprising a separate hydraulically actuated unit for each blade of one propeller for changing the pitch of said one propeller, a governor for controlling the supply of liquid to said hydraulically actuated means, independent hydraulically actuated means for changing the pitch of another of said propellers comprising a separate hydraulically actuated unit for each blade of said other propeller, means for continuously conducting liquid under pressure to said independent means, a valve for controlling the supply of said liquid to said independent means, said valve having one fluid controlling part actuated by pitch changing movements of said one propeller and having a cooperating part actuated by pitch changing movements of said other propeller to maintain the pitch of said other propeller in a predetermined relation to the pitch of said one propeller.

13. A dual rotation propeller of the character described which comprises a pair of hubs adapted to be received in tandem relation upon oppositely rotating drive shafts, adjustable pitch blades mounted upon said respective hubs, fluid pressure responsive means for effecting pitch adjustment of said blades, fluid pressure means for supplying fluid under pressure to effect actuation of said pressure responsive means, independent control means for one of said hubs for controlling the supply of pressure fluid to adjust the pitch of the blades of that hub to a predetermined position, and control means for the other said hub dependent upon the position of the blades of said first hub for controlling the supply

of pressure fluid to adjust the pitch of the blades of said other hub in substantially synchronized relation with the pitch of the blades of said first mentioned hub.

14. A dual rotation propeller of the character described which comprises a pair of hubs adapted to be received in tandem relation upon oppositely rotating drive shafts, adjustable pitch blades mounted upon said respective hubs, fluid pressure responsive means associated with each blade for effecting pitch adjustment thereof, means for synchronizing the adjusting operation of the blades of one hub with the blades of the other hub, fluid pressure means for supplying fluid under pressure to effect actuation of said pressure rseponsive means, independent control means for one of said hubs for controlling the supply of pressure fluid to adjust the pitch of the blades of that hub to a predetermined position, means for initiating the supply of pressure fluid to the pressure responsive means of said other hub in accordance with a change in the setting of the blades of said first mentioned hub, and means for terminating said supply of pressure fluid to the pressure responsive means of said other hub when the blades of said other hub have been adjusted to a position corresponding with that of said first mentioned hub.

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