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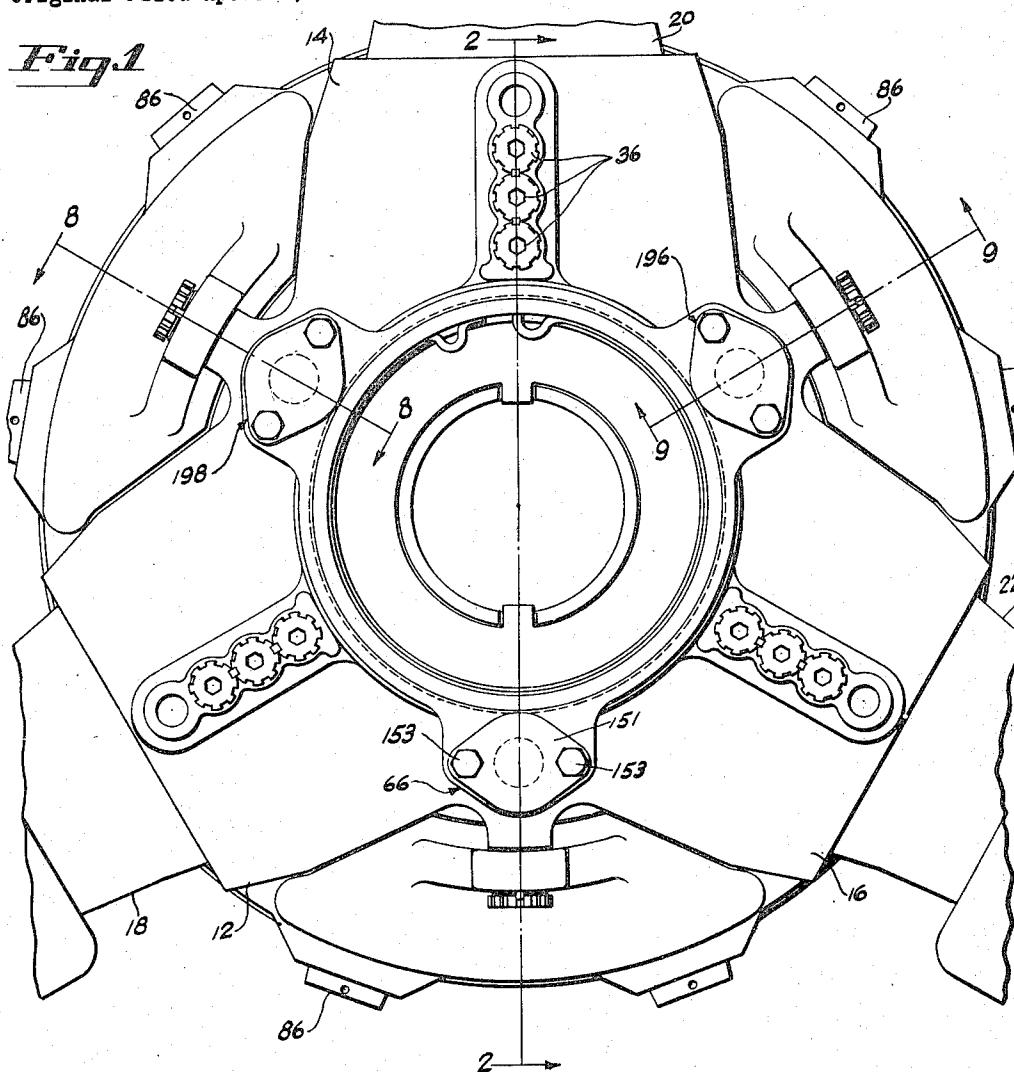
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2,462,932

PITCH CHANGING MECHANISM

Original Filed April 8, 1943

4 Sheets-Sheet 1



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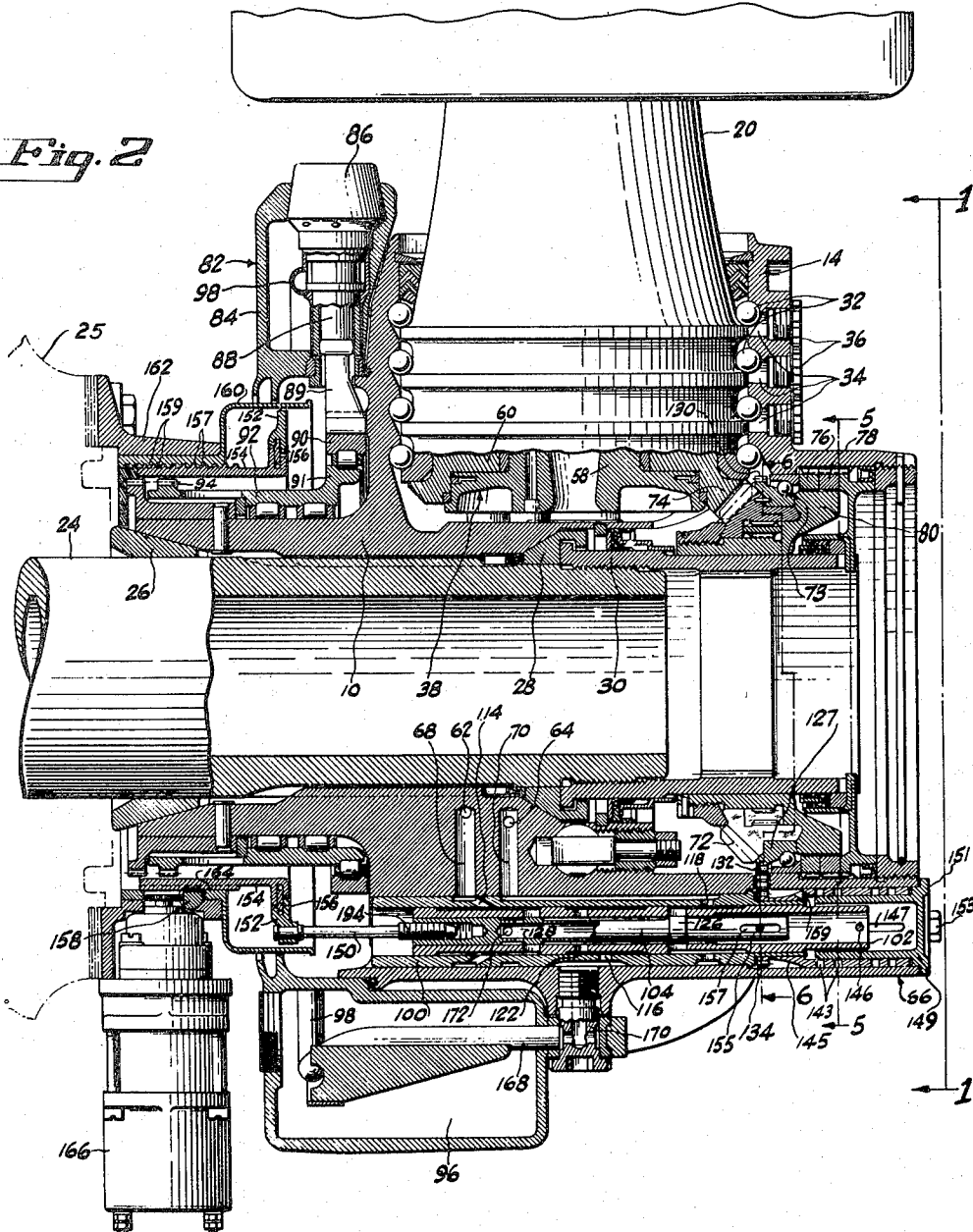
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4 Sheets-Sheet 2

Fig. 2



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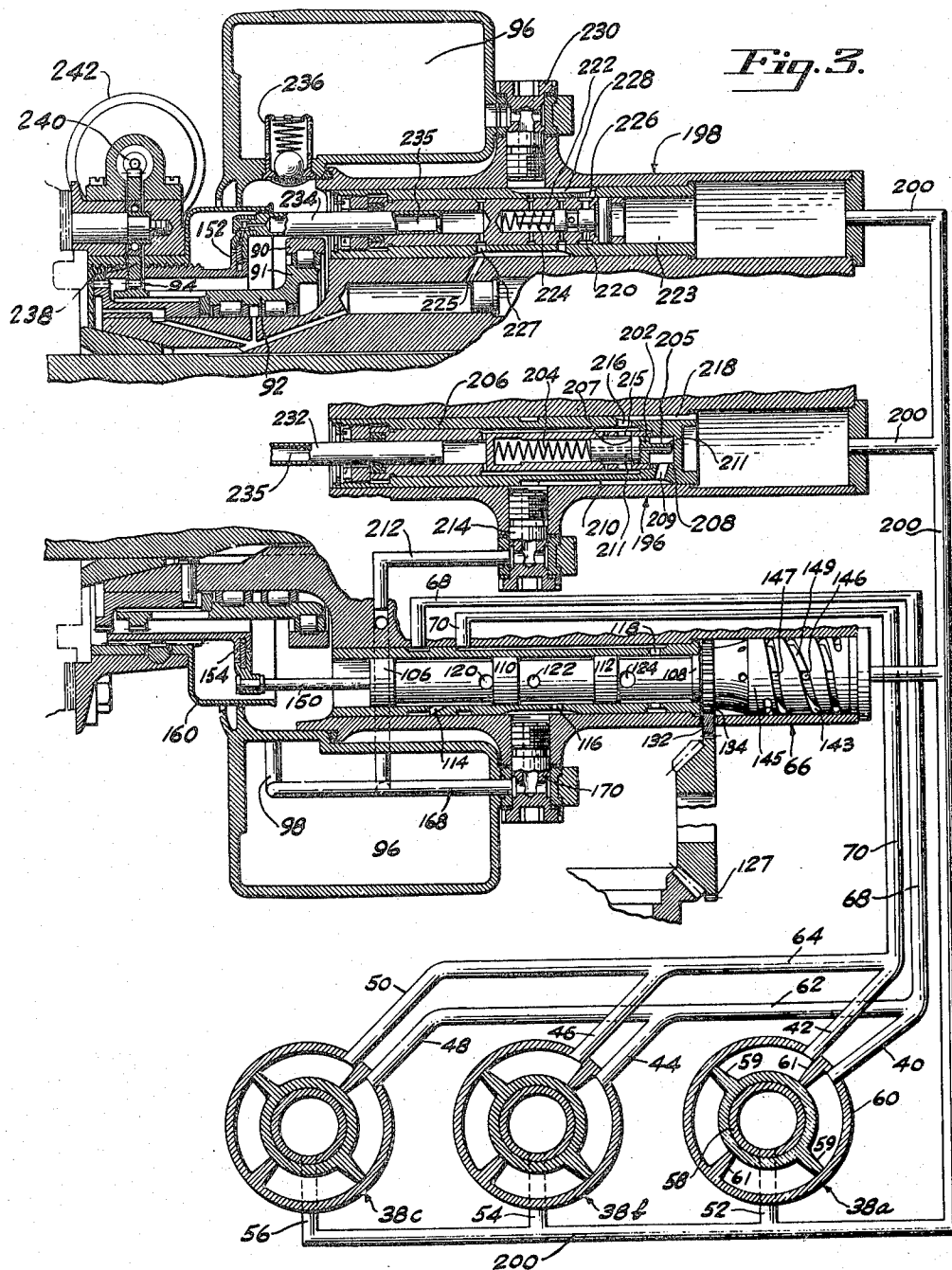
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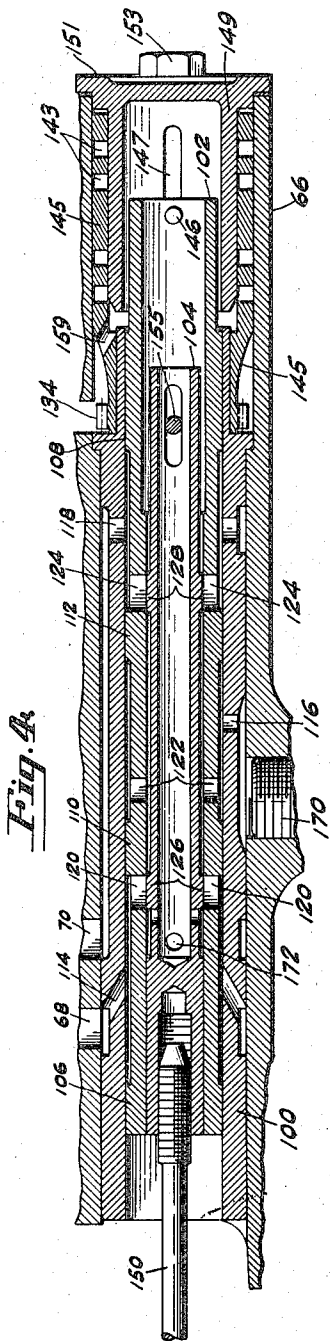
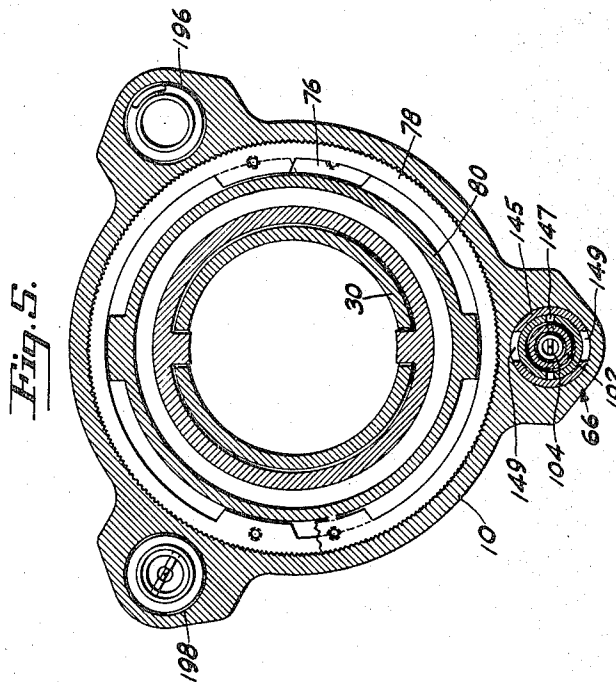
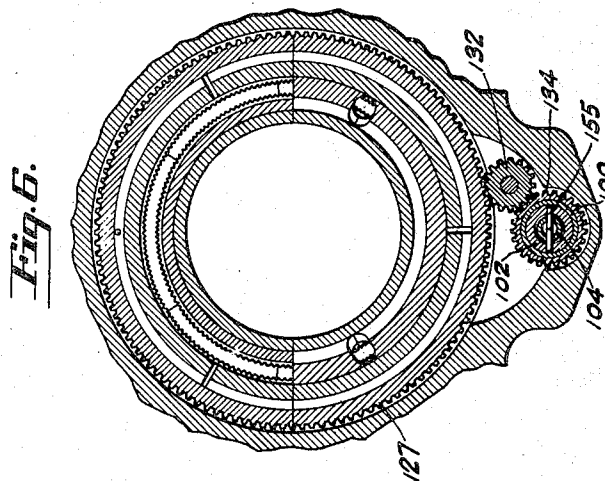
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2,462,932

PITCH CHANGING MECHANISM

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Continuation of application Serial No. 482,265,
April 8, 1943. This application filed July 26,
1946, Serial No. 686,298

12 Claims. (Cl. 170—160.33)

1

This invention pertains to aeronautical propellers, with particular reference to an improved pitch changing mechanism.

The invention is an improvement on the invention of Caldwell et al., Patent Number 2,308,488, issued January 19, 1943. This application is a continuation of application Serial No. 482,265 of John E. Anderson filed April 8, 1943, now abandoned.

One object of the invention is to provide a follow-up valve having one element thereof positively movable in response to pitch changes of the blades, and another element which may remain fixed, may be governor controlled, or may be manually controlled, all at the will of the operator.

Furthermore, if the propeller is operating with the controllable element of the valve in fixed-pitch position, and the blades tend to creep to higher or lower pitch positions, the valve functions to prevent the creeping.

Each blade is provided with a pitch-changing hydraulic motor of the vane type. Fluid for the motors is provided by a high pressure pump having several cylinders and pistons rotating with the propeller hub. The fluid exhausts from the motors into the hub mechanism where it is used for lubricating purposes, and finally drains to sump.

Another object is to provide a control valve with cooperating ports and lands dimensioned to provide a leak through the valve when the lands on the control valve are centered with relation to the ports in the follow-up valve, in order to maintain pressure in the vane motors to keep the blades at required angles against the blade twisting moments.

Other objects and advantages will be apparent from the specification and claims, and from the accompanying drawings which illustrate what is now considered to be a preferred embodiment of the invention.

Fig. 1 is a front view of the hub portion of an aeronautical propeller constructed according to the invention.

Fig. 2 is a sectional view on line 2—2 of Fig. 1.

Fig. 3 is a diagrammatic illustration of the hydraulic system mounted on the hub for changing the propeller pitch, and particularly illustrating the follow-up valve, a high pressure safety valve and a lubricating pressure-maintaining valve.

Fig. 4 is a longitudinal sectional view on an enlarged scale of the control valve shown in Figs. 2 and 3.

2

Fig. 5 is a view on line 5—5 of Fig. 2 showing the control valve in section and the locations of the safety valves.

Fig. 6 is a transverse sectional view on line 6—6 of Fig. 2.

The propeller has a hub 10 (Fig. 2) with three blade sockets (Fig. 1) 12, 14 and 16 supporting blades 18, 20 and 22 in a manner permitting the blades to rotate about their longitudinal axes.

The hub has an internally splined bore into which the externally splined end of the propeller shaft 24 is fitted (Fig. 2). The hub is secured on shaft 24, adjacent engine 25, by conical rings 26, 28 and 30, in a well known manner. The blades are retained in their sockets by thrust bearings comprising circular grooves filled with steel balls 32, the balls being inserted through holes 34 in the wall of the sockets while the blades are in loading position with the end of vane motor 38 against hub 10, after which the holes are closed by plugs 36 and the blades are moved outwardly to their operative positions.

The pitch changing vane motor 38 (Fig. 2) is located within the shank of each blade, and is particularly illustrated and described in United States application Serial No. 474,638 filed February 4, 1943, by John E. Anderson and Arthur N. Allen, Jr., for Propellers.

Each motor has fluid conduits, as indicated at 40—42, 44—46, and 48—50 (Fig. 3). Each conduit is, in reality, also connected by passages, not shown, to the chamber diametrically opposite the chamber to which it is shown to be connected in the drawing. The vane motors diagrammatically shown in Fig. 3 are indicated by the numerals 38a, 38b and 38c. Each motor comprises a fixed inner member 58 having a pair of abutments 59, and an outer member 60 having a pair of vanes 61 and rotatable about inner member 58 to change the pitch of the blades. The fluid connections to the motors lead from manifolds 62 and 64 (Figs. 2 and 3) extending around the propeller hub, and these manifolds are connected with the control valve generally indicated at 66, by channels 68 and 70. The passages 52, 54 and 56 take care of leakage from the vane motors.

The blades are interconnected for simultaneous and coextensive movements by a three piece adjustable bevel gear 72 (Fig. 2), rotatably supported on a bearing 73 mounted in hub 10 coaxial with shaft 24 and meshing with gear sectors secured to the shank ends of the blades, the sector for blade 20 being indicated at 74 (Fig. 2). Limiting positions of the propeller blades in their

pitch changing movements are determined by stop rings 76 and 78 (Fig. 5) cooperating with a member 80 rotatable with gear 72.

Fluid for operating the motors is supplied by a pump generally indicated at 82 (Fig. 2) and illustrated and described in detail in United States application Serial Number 482,264, filed April 8, 1943, by John E. Anderson for Pumps for hydraulic pitch changing mechanisms. The pump comprises an annular header 84 surrounding the rearward portion of the propeller hub and carrying circumferentially spaced cylinders 86 (Figs. 1 and 2) within each of which is a piston 88 operable by a connecting rod 89 the ends of which are engaged by sockets in the piston and in the outer race of a ring 90 supported by rollers on an eccentric rim 91 carried by a sleeve 92, and having gear teeth 94 engaged by the teeth of gear 238 of an auxiliary feathering motor 242 (Fig. 3), which is fixedly mounted so as not to rotate with the propeller shaft 24. Thus rotation of sleeve 92 is prevented except as controlled by motor 242. The pump casing includes an annular reservoir or sump 96 to which are connected the suction ports of all the pump cylinders, and also includes a pressure manifold 98 connected with the discharge ports of the cylinders.

Valve 66 (Figs. 2, 3 and 4), comprises three concentric members, the fixed outer bushing 100, the slidable intermediate follow-up sleeve valve 102 and the slidable inner control valve 104. Bushing 100 is fixed in the propeller hub parallel to the axis of shaft 24. Follow-up valve 102 is in the form of a sleeve provided with end lands 106 and 108 and intermediate lands 110 and 112, the adjacent lands being separated by annular spaces in the sleeve, which overlie ports 114, 116 and 118 in bushing 100. Connecting with the above annular spaces, follow-up valve 102 is provided with ports 120, 122 and 124 leading from the interior to the exterior thereof, and control valve 104 is provided with spaced lands 126 and 128 which serve to control ports 120 and 124 in a manner to be presently described.

Sleeve valve 102 is moved in accordance with the pitch changing movements of the propeller blade through connection with blade synchronizing gear 72 (Fig. 2). To gear 72 is secured a spur gear 127 which, through an idler pinion 132, drives pinion 134 formed at one end of sleeve 145 (Figs. 3, 4 and 6) in which are two helical cam grooves 143, 180 degrees apart. Sleeve 145 rotates around an inner sleeve 149 which is provided with diametrically opposed longitudinal slots 147 (Figs. 2 and 4). A pin 146 through the end of valve 102 passes through slots 147 with each end of the pin in one of the cam grooves 143. Sleeve 149 and its slots 147 are non-rotatable with respect to the hub, being integral with cap 151 which is secured to the hub by screws 153 (Figs. 1, 2 and 4). With the above structure in mind, it will be realized that rotation of gear 134 will rotate cam 145. Cam grooves 143 engage the ends of pin 146 and therefore move the pin longitudinally along slots 147, and the pin will move valve 102 with it. Thus is established the control of follow-up valve 102 from gear 72, through gear 134 and pin 146.

Control valve 104 is connected through a screw threaded rod 150 (Figs. 2 and 4) with a ring 152 which is connected to an axially-movable but non-rotatable member 154 by a flat slip ring 156 engaging aligned grooves in ring 152 and member 154. A pin 155 (Fig. 2) extending through a longitudinal slot 157 in control valve 104, and se-

cured at its ends in follow-up sleeve 102 limits the extent of longitudinal movement of valve 104 relative to the sleeve. Pin 155 is also used for adjusting the position of the control valve through threaded rod 150. The pin is kept from rotating by engaging holes in follow-up sleeve 102, which in turn is prevented from rotating by pin 146 in slots 147. To adjust the position of the control valve screws 153 are removed, sleeve 149 is rotated a proper amount, and screws 153 are replaced.

Member 154 is movable by a pitch control mechanism, not illustrated, but which may be of the character illustrated and described in United States application Serial No. 664,640, filed April 24, 1946, by Perin and Richmond for Propeller control means, and assigned to the assignee of this application. In such an arrangement a servo-motor-operated rack 158 (Fig. 2) imparts a slight rotational movement to member 154 to cause a relative movement between external spiral splines 157 provided on member 154 and corresponding internal spiral splines 159 in an annular member 160 rigidly secured, by annular bracket 162, to the front end of the casing of engine 25.

Because of the spiral arrangement of splines 157 and 159 the slight rotational movement of member 154 will cause a longitudinal movement of this member proportional to the movement of a straight-toothed rack 158 which engages teeth 164 provided on a portion of member 154. For the number of straight teeth in 154 plus the necessary rotational travel, the spiral teeth in fixed member 160 are removed. Movement of rack 158 may also be utilized to turn the rotor of a generator 166 of a Selsyn pitch indicating apparatus particularly illustrated and described in United States Patent No. 2,393,189, filed June 13, 1942, patented Jan. 15, 1946, by Richmond for Remote indicating means.

The pump pressure manifold 98 is connected (Figs. 2, 3 and 4) through pipe 168 and plug 170 (Fig. 2) with port 116 in tube 100, while channel 68 leading to manifold 62 is connected with port 114, and channel 70 leading to manifold 64 is connected with port 118. With this arrangement, fluid under pressure from the pump is supplied through port 116 in tube 100 and port 122 in follow-up valve 102 to the annular space within the valve between lands 126 and 128 of control valve 104. Flow of fluid from this space to either manifold 62 or 64 is controlled by movement of control valve 104. When that valve is moved to the left as viewed in Figs. 2 and 4, fluid will flow from the space within valve 102 between lands 126 and 128 of valve 104 through port 120 in valve 102, and port 114 in tube 100, and thence through channel 68 to manifold 62 to supply hydraulic fluid to one side of each pitch changing motor. At the same time, exhaust fluid from the opposite sides of the motors will flow from manifold 64 through channel 70, port 118 and port 124 to the interior of valve 102 and thence through channels 159 in sleeve 145 to the interior of the propeller hub.

When valve 104 is moved to the right as viewed in Figs. 2 and 4, fluid will be supplied from 170 through ports 116, 122, 124, 118 and channel 70 to manifold 64, while the exhaust fluid from the opposite side of the motors will flow from manifold 62 through channels 68 and 114, through ports 120 and holes 172, into valve 104, and thus through the front end of sleeve 102 into the propeller hub, as described above.

When valve 104 has been moved a certain dis-

tance corresponding to a speed change demand of the governor control apparatus, one side of each motor will be connected with the fluid from the pump pressure manifold 98 in the manner described above and the opposite sides of the motors will be vented to the sump 96. The rotatable portions of the motors will thereupon start to rotate turning the propeller blades to change the propeller pitch. As the blades are rotated gear 72 is also rotated, and it rotates member 145 causing pin 146 to track through cam slot 143 and thereby moving follow-up valve 102 in the same direction in which the control valve 104 was moved. When the blades have changed their pitch an amount corresponding to the movement of valve 104, sleeve 102 will have reached a position in which ports 120 and 124 are again centered relative to lands 126 and 128 of control valve 104 and movement of the motors will thereupon cease. When valve 102 is in above position relative to plunger 104, lands 126 and 128 have negative lap i. e., they fail to entirely cover ports 120 and 124 but provide bleeder openings through the ports and surplus output of the pump can flow through control valve 102 to drain. Thus the valves act to unload the pump when the pitch changing motors are not operating and also maintains an equal pressure on both sides of the pitch changing motors. As soon, however, as control valve 104 moves with respect to follow-up valve 102 negative lap will be eliminated and the output of the motor will be directed to one side or the other of the pitch changing motors, depending upon the direction of movement of valve 104, and the opposite sides of the motors will be connected with drain in the manner described above. The position of valve 104 may be adjusted relative to ring 152 by the adjustable screw thread connection 194 (Fig. 2) to obtain the proper position of this valve relative to follow-up valve 102.

High pressure and low pressure relief valves, generally indicated at 196 and 198, respectively, and particularly illustrated in Fig. 3 are included in the pitch changing hydraulic system to supplement the operation of control valve 66. The high pressure relief or blow-off valve 196 is provided to vent the pump outlet at a predetermined safe maximum pressure in the event the control valve 66 should, for some reason, fail to entirely dispose of the pump output. The low pressure control or exhaust pressure valve, interposed between the space within the propeller hub and the sump 96 is provided mainly to insure that the hub remains full of fluid for lubricating purposes. The space within the hub which hydraulically connects valves 66, 196, and 198 is diagrammatically indicated by the channel 200 in Fig. 3. The three valves are symmetrically arranged in the hub as indicated in Fig. 1.

The high pressure relief valve 196 comprises a plunger 202 urged toward valve closing position by a compression spring 204. This plunger has at one end a reduced extension 205 which projects into a cylindrical chamber 208 in the end of the hollow valve bushing 206 to provide a stop. Chamber 208 is connected through port 209 and channels 210, hollow plug 214 and channel 212 with pressure manifold 98. The area of the end of plunger 202 in the space 208 is slightly greater than the area of the end in contact with the spring 204, as indicated by the slight shoulder 207, and a bore 211 extends longitudinally through plunger 202 so that the high fluid pressure is applied to both ends thereof. The

space immediately to the left of the shoulder 207, however, is connected with drain channel 216 so the shoulder provides a small differential area permitting fluid pressure in chamber 208 to move plunger 202 against spring 204. When the plunger is moved, fluid from the pump may flow from manifold 98 through the channel 212, plug 214, channel 210 and port 209 past the end of plunger 202 through ports 215 and 219 and channel 218 to the space within the propeller hub diagrammatically indicated as pipe 200 which space is connected with sump 96 through the low pressure relief valve 198 (Fig. 3).

The low pressure relief valve 198 (Fig. 3) comprises a plunger 220 slidably mounted in a bushing 222 and urged to valve closing position by a relatively light compression spring 224. Bushing 222 is secured in a sleeve 223 which is in turn secured in the propeller hub. Fluid from hub space 200, entering the end of the sleeve 223 acts on the end of the plunger 220 urging it to move against spring 224. When this fluid pressure is sufficient to overcome the force of the spring the plunger uncovers port 226, which is connected with sump 96 through channel 228 and plug 230.

Guide members 232 and 234 connected to ring 152 and slidably supported in the hollow valve bushings 206 and 222, respectively, (Fig. 3) assist in maintaining ring 152 (Figs. 2 and 3) in operative position, and prevent the ring from warping out of alignment with the periphery of annular member 154.

Guide 234 is drilled, as indicated at 235, to provide a channel for lubricant from the interior of the propeller hub to the interior of the annular groove in ring 152. This fluid flows from the hub interior through channel 225, port 227 and the hollow interior of bushing 222 through a bore extending longitudinally through rod 234 and communicating with the groove containing ring 152. The pressure in 200 exerts equal thrusts on ring 152 through rods 232, 234 and valve 104 because the diameters of rods and valve are the same.

The pump cam supporting sleeve 92 (Fig. 2) is normally held against rotation by a gear train including spur gear 238 and worm gear 240 connected to an electric motor 242, (Fig. 3), the pitch of the worm gear 240 being so arranged that the gear train is not reversible. In case, however, it is desired to operate the pump to provide fluid for the pitch changing mechanism when the propeller is not rotating, motor 242 may be energized to drive member 92 through the above gear train to provide fluid under pressure to unfeather the propeller in flight or to change the pitch of the propeller when the power plant is not operating, as when the airplane is on the ground.

While one embodiment of the invention has been described and illustrated, it is to be understood that the invention is not limited to the particular embodiment 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 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 a controllable pitch propeller having a hub enclosing a central space and provided with blade retaining sockets, blades mounted one in

each socket, and at least one hydraulic motor for turning said blades in pitch changing directions, a motor controlling valve forming a portion of a fluid connection connecting said motor and a source of motor fluid under pressure and a portion of a fluid connection connecting said motor and the space within said hub for controlling the flow of motor fluid to and from said motor and venting the exhaust fluid from said motor into said hub space, said valve comprising, a sleeve having a central port connected with said source of motor fluid under pressure and end ports connected with the opposite sides of said motor and with said hub space, means operatively connecting said sleeve with said motor to impart to said sleeve lengthwise movements proportional to the movements of said motor, a plunger slidable in said sleeve movable by a propeller pitch changing mechanism and provided with spaced lands controlling the connections of said end ports with said center port and said hub space, said valve being disposed in a bore in said hub, and a detachable cover plate forming a portion of the means operatively connecting said sleeve with said motor covering the open end of said bore.

2. In a controllable pitch propeller having a hub enclosing a central space and provided with blade retaining sockets, blades mounted one in each socket, and at least one hydraulic motor for turning said blades in pitch changing directions, a motor controlling valve forming a portion of a fluid connection connecting said motor and a source of motor fluid under pressure and a portion of a fluid connection connecting said motor and the space within said hub for controlling the flow of motor fluid to and from said motor and venting the exhaust fluid from said motor into said hub space said valve comprising, a sleeve having a central port connected with said source of motor fluid under pressure and end ports connected with the opposite sides of said motor and connectable with said central port or with said hub space, means operatively connecting said sleeve with said motor to impart to said sleeve lengthwise movements proportional to the movements of said motor, a plunger slidable in said sleeve movable by a propeller pitch changing mechanism and provided with spaced lands controlling the connections of said end ports with said center port and said hub space, the means operatively connecting said sleeve with said motor comprising a fixed hollow member having a slot therein, a hollow rotatable member surrounding at least a portion of said fixed member and having a spiral cam track therein of a shape different from said slot, a pin extending transversely through said cam track said slot and said sleeve, a gear train operated by said motor for rotating said rotatable member.

3. In a controllable pitch propeller having a hub enclosing a central space and provided with blade retaining sockets, blades mounted one in each socket, and at least one hydraulic motor for turning said blades in pitch changing directions, a motor controlling valve forming a portion of a fluid connection connecting said motor and a source of motor fluid under pressure and a portion of a fluid connection connecting said motor and the space within said hub for controlling the flow of motor fluid to and from said motor and venting the exhaust fluid from said motor into said hub space, said valve comprising, a sleeve having a central port connected with said source of motor fluid under pressure and end ports con-

nected with the opposite sides of said motor and connectable with said central port or with said hub space, means operatively connecting said sleeve with said motor to impart to said sleeve lengthwise movements proportional to the movements of said motor, and a plunger slidable in said sleeve movable by a propeller pitch changing mechanism and provided with spaced lands controlling the connections of said end ports with said center ports and said hub space, the means connecting said sleeve with said motor comprising, a fixed hollow member having a slot therein, a hollow rotatable member surrounding at least a portion of said fixed member and having a spiral cam track therein of a shape different from said slot, a pin extending transversely through said cam track and said slot and said sleeve, a gear train operated by said motor for rotating said rotatable member, a blade synchronizing gear in said hub, and gear teeth on said blade synchronizing gear driving said rotatable member.

4. In a propeller having pitch changing means, blades mounted for pitch adjusting movement and a pitch-controlling follow-up valve in the propeller hub, means connecting said blades with one portion of said follow-up valve comprising, a sleeve driven at a fixed ratio of the amount of movement of said blades, and a sleeve fixed with respect to said hub, one of said sleeves having a spiral cam slot therein, a pin connecting said valve portion and said sleeves and passing through said cam slot, means for adjusting the position of said fixed sleeve with respect to said hub to adjust the relation between said valve portion and said blades.

5. In a propeller having pitch changing means, blades mounted for pitch adjusting movement and a two-part, pitch-controlling follow-up valve in the propeller hub, means connecting said blades with one part of said follow-up valve comprising, a sleeve rotatable at a fixed ratio of the amount of rotation of said blades and a sleeve fixed with respect to said hub, said rotatable sleeve having a spiral cam slot therein, said fixed sleeve having an axially extending slot therein, a pin fixed with respect to said one valve part and passing through the slots in said sleeves, means including a screw-threaded joint connecting the other part of said follow-up valve with a control device, means preventing relative rotation of the two parts of said follow-up valve, means for adjusting the position of said fixed sleeve with respect to said hub to move said pin in said spiral cam slot and move said other valve part on said threaded connection to adjust the relation between said other valve part and said blades.

6. In a propeller having pitch changing means, blades mounted for pitch adjusting movement and a pitch-controlling follow-up valve in the propeller hub and placed eccentrically with respect to the propeller shaft, means connecting said blades with one portion of said follow-up valve comprising, a sleeve mechanically connected with said blades to be driven at a multiple of the pitch changing speed of said blades, and a sleeve fixed with respect to said hub, one of said sleeves having a spiral cam slot therein, a pin connecting said valve portion and said sleeve and passing through said cam slot.

7. In a propeller having pitch changing means, blades mounted for pitch changing movement and a pitch-controlling follow-up valve in the propeller hub and placed eccentrically with respect to the propeller shaft, means connecting said blades with one portion of said follow-up

9

valve comprising, a sleeve mechanically connected with said blades to be driven at a multiple of the pitch changing speed of said blades, and a sleeve fixed with respect to said hub, one of said sleeves having a spiral cam slot therein, a pin connecting said valve portion and said sleeve and passing through said cam slot, means for adjusting the position of said fixed sleeve with respect to said hub to adjust the relation between said valve and said blades.

8. In a controllable pitch propeller having a hub enclosing a central space and provided with blade retaining sockets, blades mounted one in each socket, and at least one hydraulic motor for turning said blades in pitch changing movements, a source of fluid pressure, a sump, a first fluid connection connecting said motor and said source, a second fluid connection connecting said motor and said space and a third fluid connection connecting said space and said sump, a motor controlling valve forming a portion of said first and second fluid connections for controlling the flow of fluid from said source to said motor and from said motor to said sump through said space, means forming a portion of said third connection for maintaining fluid in said space at a relatively low pressure.

9. In a controllable pitch propeller having a hub enclosing a central space containing movable blade mechanism, and provided with blade retaining sockets, blades mounted one in each socket, and at least one hydraulic motor for turning said blades in pitch changing movements, a source of fluid pressure, a sump, a first fluid connection connecting said motor and said source, a second fluid connection connecting said motor and said space and a third fluid connection, separate from said second connection, connecting said space and said sump, a motor controlling valve forming a portion of said first and second fluid connections for controlling the flow of fluid from said source to said motor and from said motor to said sump through said space.

10. In a controllable pitch propeller having a hub enclosing a central space containing movable blade mechanism and provided with blade retaining sockets, blades mounted one in each socket, and at least one hydraulic motor for turning said blades in pitch changing movements, a source of fluid pressure, a sump, a first fluid connection connecting said motor and said source, a second fluid connection connecting said motor with one portion of said space and a third fluid connection, separate from said second connection, connecting another portion of said space with said sump, a motor controlling valve forming a portion of said first and second fluid connections for controlling the flow of fluid from said source to said motor and from said motor to said sump through said space.

11. In a controllable pitch propeller having a hub enclosing a central space containing movable blade mechanism and provided with blade retaining sockets, blades mounted one in each socket, and at least one hydraulic motor for turning

10

said blades in pitch changing movements, a source of fluid pressure, a sump, a first fluid connection connecting said motor and said source, a second fluid connection connecting said motor and said space and a third fluid connection, separate from said second connection, connecting said space and said sump, a pump continually operated by rotation of said propeller and connected with said sump and said source for pumping fluid from said sump into said source, a motor controlling valve forming a portion of said first and second fluid connection for controlling the flow of fluid from said source to said motor and from said motor to said sump through said space.

12. In a controllable pitch propeller having a hub enclosing a central space containing movable blade mechanism and provided with blade retaining sockets, blades mounted one in each socket, and at least one hydraulic motor for turning said blades in pitch changing movements, a source of fluid pressure, a sump, a first fluid connection connecting said motor and said source, a second fluid connection connecting said motor and said space and a third fluid connection, separate from said second connection, connecting said space and said sump, a pump continually operated by rotation of said propeller and connected with said sump and said source for pumping fluid from said pump into said source, a motor controlling valve forming a portion of said first and second fluid connection for controlling the flow of fluid from said source to said motor and from said motor to said sump through said space, said valve having lands and ports in which the lands are of less extent than the ports so that in central position the source is continuously connected with said sump through said space to continuously circulate said fluid through said space when the propeller is operating and the valve is in central position.

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