Feb. 15, 1949. R. H. WARDE 2,461,791

VARIABLE PITCH AIRSCREW

Filed Aug. 2, 1943 3 Sheets-Sheet 1

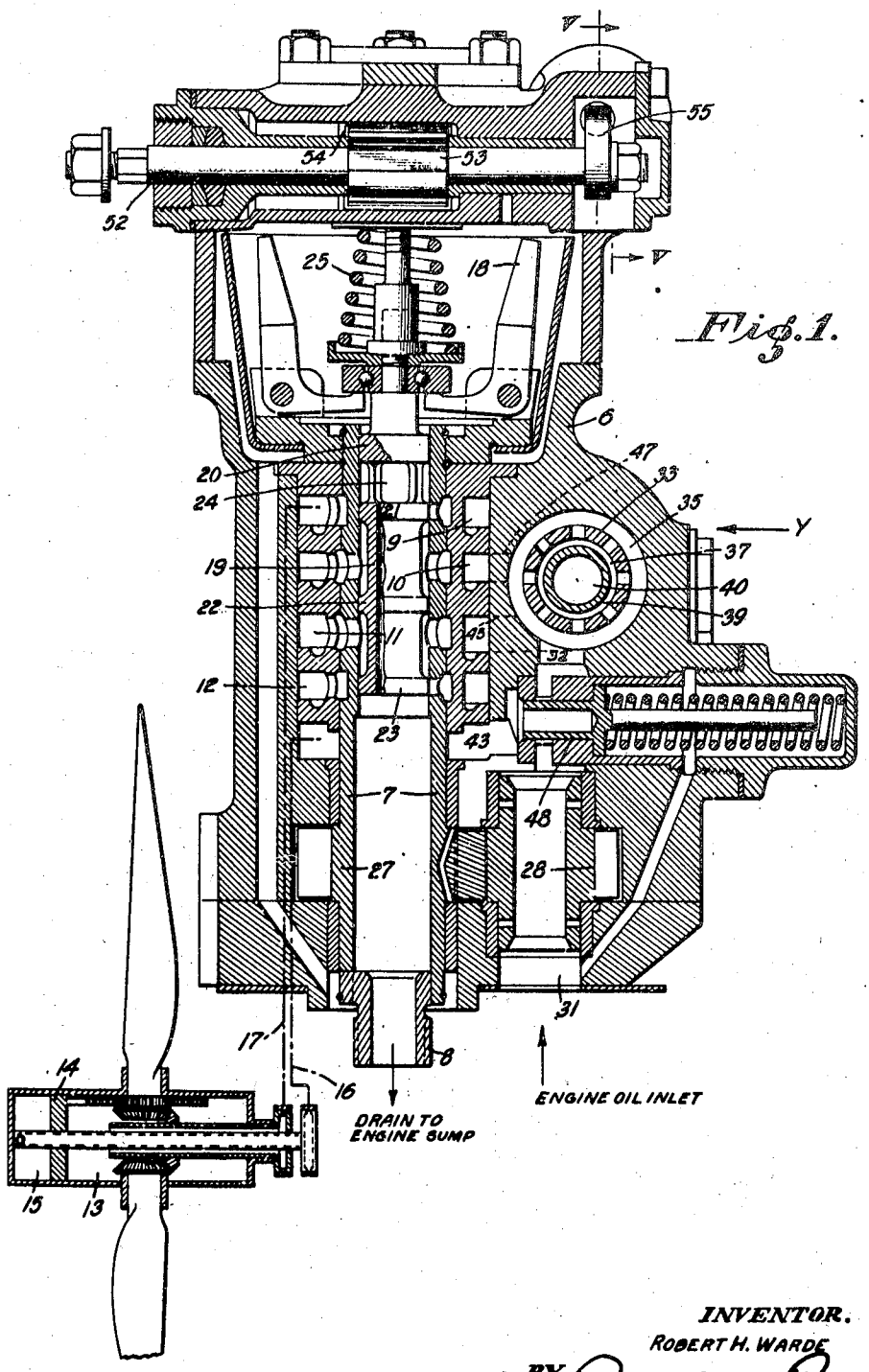



Fig. 1.

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VARIABLE PITCH AIRSCREW

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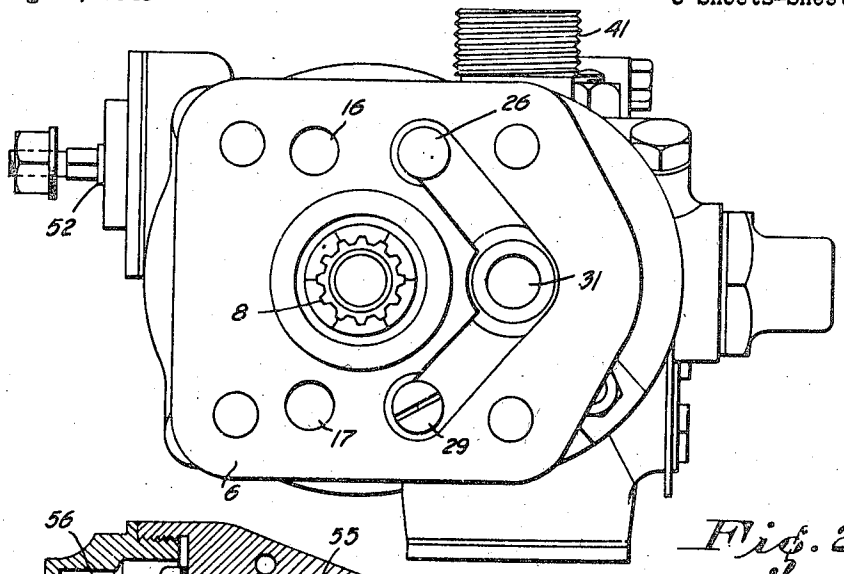



Fig. 2.

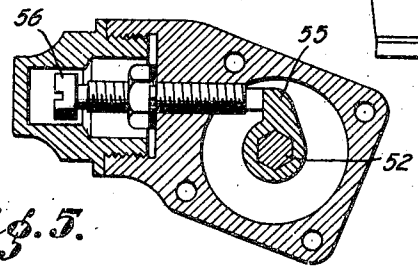



Fig. 5.

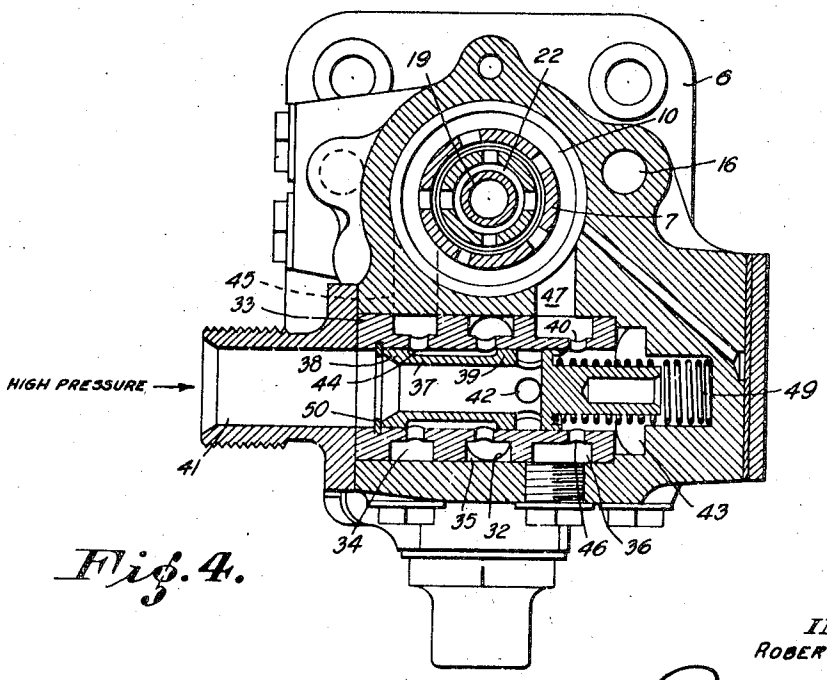



Fig. 4.

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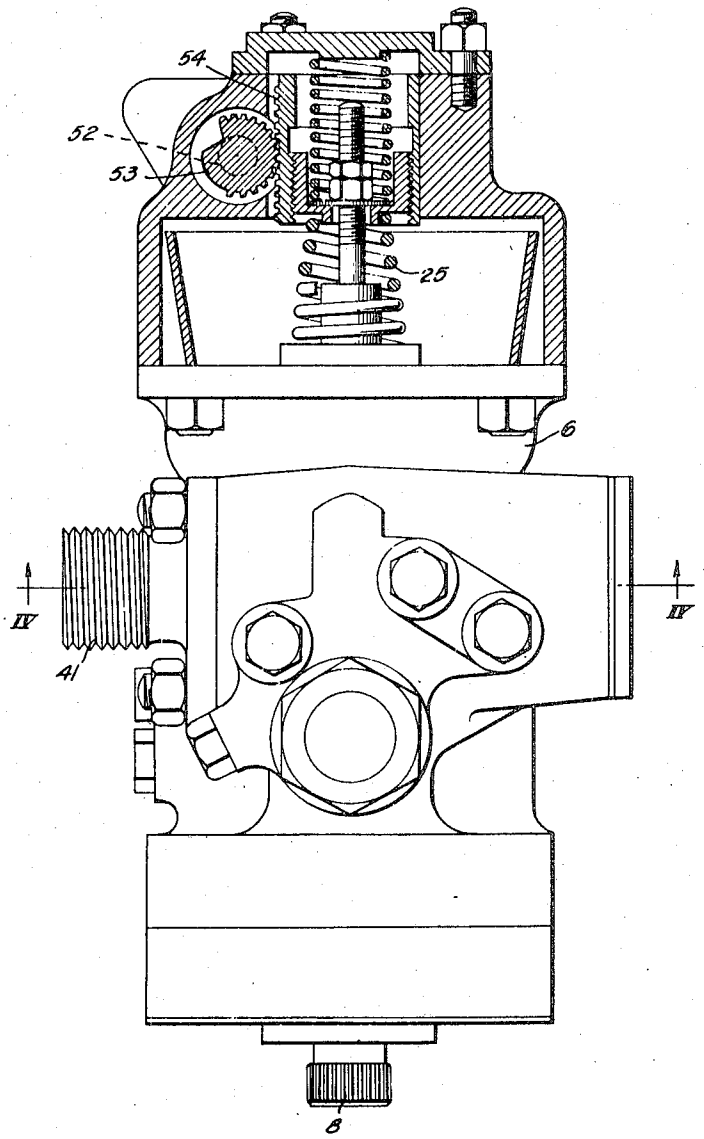
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VARIABLE PITCH AIRSCREW

Filed Aug. 2, 1943 3 Sheets-Sheet 3.

Fig. 3.




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Patented Feb. 15, 1949 2,461,791

# UNITED STATES PATENT OFFICE

2,461,791

## VARIABLE PITCH AIRSCREW

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Application August 2, 1943, Serial No. 497,082
In Great Britain May 8, 1942

15 Claims. (Cl. 170—160.2)

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This invention relates to a variable pitch propeller incorporating a double-acting hydraulically-operated ram, reciprocation of which is translated by suitable mechanism into rotation of the propeller blades each about its pitch-change axis. More particularly the invention is concerned with propellers in which the supply of hydraulic fluid to the ram is controlled by a governor-operated valve, which by movement under changing speed conditions directs the hydraulic pressure fluid through suitable porting selectively either to the inboard end or outboard end of the ram, the direction of pitch-change thus being determined by the direction of movement of the valve. For convenience in description and in the claims, such a propeller is hereinafter designated "a variable pitch propeller of the kind hereinbefore specified."

In such variable pitch propeller of the kind hereinbefore specified it has previously been proposed to arrange the porting associated with the governor-controlled valve so that when the engine speed falls below a predetermined value the valve moves to permit flow of hydraulic fluid (usually engine oil) to the outboard end of the ram to move it rearwards (assuming a tractor airscrew), the inboard end of the ram being at the same time connected to drain (usually the engine sump). The resultant operation of the ram moves the blades towards fine pitch, and the reduction in blade angle reduces load and tends to increase the engine speed. Conversely, increase in engine speed causes the governor to move the valve in the opposite sense from that just described, allowing hydraulic fluid from a pump to pass to the inboard end of the ram, thus moving it against the lower engine oil pressure acting on the outboard end of the ram. For feathering and unfeathering operations, hydraulic fluid from a high-pressure pump is applied to the ram independently of the porting associated with the control valve, the direction of pitch-change being determined by a reversing valve in the airscrew.

In another construction it has been proposed to arrange the porting associated with the governor-controlled valve so that when the engine over-speeds the governor-controlled valve moves so that one end of the pitch-change ram is connected to the hydraulic fluid supply from the pressure side of a pump; whereas the other end

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of the ram is connected to the suction side of the pump. In such an arrangement, for feathering and unfeathering operations the governor-controlled valve is manually operable so as to ensure the hydraulic fluid being directed at will either to the inboard or outboard end of the ram, as required, to move the blades towards coarse or fine pitch.

According to the present invention it is proposed in a variable pitch propeller of the kind hereinbefore specified to arrange the governor-operated valve and its associated porting so that for an under-speed condition the outboard end of the ram is connected to low pressure actuating fluid supply (usually engine oil), and the inboard end of the ram is connected to drain; whereas, conversely, in the over-speed condition the outboard end of the ram is connected to drain while the inboard end is supplied with actuating fluid at intermediate pressure from a boost pump. Furthermore, in a preferred arrangement a high-pressure pump is provided to supply hydraulic fluid at high pressure for feathering and unfeathering operations, the arrangement being such that operation of the high-pressure fluid circuit controls cut-off valves in the normal pitch-change actuating fluid circuit to close off the normal actuating fluid circuit and permit high-pressure fluid-flow to the ram through the porting associated with the governor-operated valve to the outboard or inboard end of the ram, according to the position of the governor-operated valve, which for feathering and unfeathering operations is manually operated. It should be understood that while for convenience of description the words "inboard" and "outboard" have been used in a particular relation to the pressure system described, it is within the scope of the invention to have pressure on the outboard end of the ram, causing pitch-change towards coarse pitch. Moreover, high or low pressure may be used on either side of the ram.

It will be realised that the arrangement according to the present invention avoids the necessity for a reversing valve in the airscrew. Likewise, instead of high-pressure fluid being required for pitch-change towards both fine and coarse pitch positions, the arrangement according to the present invention enables pitch-changes towards fine pitch to be achieved by hydraulic fluid

(usually engine oil) of the low-pressure circuit; although in certain cases it may be desirable to use the same pressure source for pitch-change in both directions.

In order that it may be clearly understood and readily carried into effect, the invention is hereinafter described with reference to the accompanying diagrammatic drawings, of which:

Figure 1 is a sectional elevation of a governor-operated valve for a variable pitch propeller according to the present invention; for purposes of illustration and with connecting conduits indicated in chain lines, the associated airscrew is shown very diagrammatically and to a very much reduced scale;

Figure 2 is an inverted plan view looking in the direction of the arrow X on Figure 1;

Figure 3 is a side elevation partly sectioned looking in the direction of the arrow Y on Figure 1;

Figure 4 is a section taken looking downwardly at the line IV—IV on Figure 3; while

Figure 5 is a section taken looking rightwardly on the line V—V on Figure 1.

Referring now to the drawings, the body of the governor-operated valve is represented by the reference numeral 6. A ported sleeve 7 is located in a suitable drilling in the body 6 and is driven for rotation by the splined coupling 8, or equivalent driving member, from a suitable countershaft drive off the engine. The sleeve 7 defines with the drilling in which it is fitted the four annuli 9, 10, 11 and 12, of which the annulus 9 leads to the inboard end 13 of the pitch-change ram 14 through the connection 17; whereas the annulus 12 leads to the outboard end 15 of the ram through the connection 16. Of the annuli 10 and 11, 10 is supplied with boosted pressure engine oil by way of port 47, as later made clear, and 11 with low pressure oil (usually engine oil) by way of port 45, as will later be understood. The lower end of the sleeve 7 leads to drain (usually to the engine sump).

At its upper end the rotative sleeve 7 mounts the governor-weights 18 operatively associated with the governor-operated valve spindle 19, the lower end whereof is hollow and open to drain by way of sleeve 7, and which incorporates the four lands 20, 21, 22 and 23, and also the drain port 24 between the lands 20 and 21. It should be noted that its lower end, below the land 23, is in effect a further drain valve, when raised to clear the annulus 12. At operation in overspeed conditions, the governor-weights 18 are caused to swing out about their pivots and raise the governor-operated valve spindle 19 against the loading exerted by the spring 25; whereas for underspeed conditions the spring 25 is able to overcome the centrifugal loading exerted by the governor-weights 18 to move the spindle 19 downwardly.

The lands 20, 21, 22 and 23 are so spaced with respect to the co-operating annuli 9, 10, 11 and 12 that in the position shown in Figure 1, corresponding to constant speeding position for normal operation, all the annuli can be blanked-off from inter-communication. If, however, the engine speeds up, an overspeed condition occurs and the valve spindle 19 is raised, boosted engine oil from the annulus 10 being then free to flow to the annulus 9 between the lands 21 and 22 (then raised slightly from the Figure 1 position), and to the inboard end of the ram to coarsen the blade pitch and reduce engine speed appropriately by increasing the loading on the engine. Such



raising of the valve 19 also takes the land 23 clear of the annulus 12, so that in operation of the ram 14 for coarsening pitch, oil is permitted to flow to drain through the connection 16 and sleeve 7 past the raised land 23. Conversely, an underspeed condition resulting in lowering of the valve spindle 19 establishes communication between the engine oil annulus 11 and the annulus 12 connected to the outboard end 15 of the pitch-change ram to move the blades towards fine pitch and so relieving the load on the engine to permit it to speed up. Such downward movement of the valve spindle 19 puts the annulus 9, leading by way of connection 17 from the inboard end of the ram, into communication with drain through the port 24 between the lands 20 and 21 of the governor-operated valve spindle 19.

In regard to the delivery of oil to the annuli 10 and 11 for constant speeding operation of the airscrew, oil is fed from the engine to the constant speed unit booster gear pump inlet 26. The gear pump rotors are seen in Figure 1 at 27 and 28. The outlet from the gear pump in the arrangement shown is a continuation of the port blanked-off by the screw plug 29; see Figure 2. It will be observed that at the gear pump inlet there is a through port 31 so that the engine oil-flow is in fact sub-divided. A part goes to and through the booster pump, eventually to the port 47 and annulus 10, and another part by-passes the pump by way of port 31, eventually to the port 45 and annulus 11. Thus, oil at pressure supplied by the engine oil pump flows up the through port 31 of the gear pump rotor, through the port 32 into the feathering valve housing sleeve 33. The feathering valve housing sleeve 33 has the three annular grooves 34, 35 and 36 from which appropriate ports lead through into the bore of the sleeve, in which slides a feathering valve 37, which itself has lands 38, 39 and 40.

The feathering valve is hollow, being open at its end adjacent the feathering oil inlet 41, and having an outlet at its inner or closed end through the ports 42. Boosted engine oil from the gear pump rotors 27, 28, flows into the back of the feathering valve housing through the boosted engine oil port 43. The engine oil port 32 and the boosted engine oil port 43, and the general arrangement of the feathering valve 37, are more clearly seen with reference to Figure 4. It is to be understood that for normal operations in the constant speeding range the feathering valve 37 remains in the position in which it is shown in Figure 4, so that the annulus 44 permits the flow of engine oil from the feathering valve sleeve annulus 35 to the feathering valve sleeve annulus 34, from which latter engine oil can flow to the engine oil annulus 11 through the port 45 ((see Figure 4). On the other hand, the boosted engine oil entering the back of the feathering valve through the port 43 flows in through the inner end of the sleeve 33, through the ports 46, into the feathering valve sleeve annulus 36 from which it flows through the port 47 to the governor-operated valve annulus 10.

It follows, therefore, that under normal constant speeding conditions (corresponding to positions of parts in Figures 1 and 4) oil at the normal pressure supplied by the engine oil pump is always in communication with the engine oil annulus 11; whereas oil boosted by the gear pump above engine oil pressure is always available at the boosted engine oil annulus 10. While, therefore, if the engine is operating at a selected constant speed the governor-operated valve spindle 19 re-

mains in the position shown in Figure 1, if on the other hand there is a departure from the selected constant speed, the governor-operated valve spindle 19 is caused by the governor-weights 18 to rise or fall and direct oil appropriately to and from the pitch-change ram.

The spring-loaded valve 48 (see Figure 1) is merely an overload pressure relief valve, in communication with gear pump delivery part 43, to relieve excessive pressure of boosted engine oil delivery from the gear pump rotors 27, 28.

The description has so far dealt only with the porting and valve arrangements as they operate under normal constant speeding conditions, in which two comparatively low oil pressures are concerned, namely: ordinary engine oil supplied by the engine oil pump, and the boosted engine oil discharged from the gear pump rotors 27 and 28 built into the constant speed unit. For feathering and unfeathering operations, however, oil is delivered past a manual control valve by an auxiliary high-pressure pump (neither shown herein) which supplies to the feathering control valve 37 through the feathering oil inlet 41. The feathering oil pump is driven independently of the engine, preferably electrically, and when feathering oil flows to the feathering control valve 37, the valve 37 is pushed back against the loading exerted by the compression spring 49. When feathering oil is not supplied to the inlet 41, compression spring 49 loads the feathering control valve 37 outwardly until the forward end of the feathering control valve 37 abuts the circlip or equivalent stop member 50, which thus defines the setting of the feathering control valve 37 for normal constant speeding operation.

When the feathering control valve 37 is forced inwardly by the pressure against it of oil entering inlet passage 41, the land 38 cuts off the supply of engine oil from port 35 to the feather valve annulus 34 and annulus 11 of the governor-operated valve; while, similarly, the land 40 at the back end of the feathering control valve also cuts off the supply of boosted engine oil from the port 43 to feathering valve annulus 36 and annulus 10 of the governor-operated valve (see Figure 4), but feathering oil is then permitted to flow from the inlet 41 through the ports 42 and 46 to the annulus 36, from which it then flows by way of port 47 to the governor-operated valve annulus 10, which has so far been designated the "boosted engine oil annulus." Thus, it is ensured that the feathering control valve 37 for feathering operations can be said to supply oil at higher pressure than the normal boosted engine oil to the annulus 10.

To enable feathering to be performed, mere delivery of high pressure oil to the annulus 10 is not alone sufficient; a further operation is necessary, namely, to adjust the governor-operated valve spindle manually, which operation is performed by a manual control lever remotely actuated by the pilot, usually coincidentally with admission of high pressure oil to the inlet 41, to turn the spindle 52 for operation of the rack-and-pinion gearing 53 and 54 (see Figures 1 and 3), which for feathering lifts the governor-operated valve spindle 19 to place the annulus 10, then supplied with high-pressure oil for feathering, in communication with the annulus 9 leading to the inboard end of the pitch-change ram by way of the connection 17.

For an unfeathering operation the engine is invariably stopped so that the governor-operated valve spindle 19 is pushed right down by the spring



25, upon return of manual control spindle 52 to automatic control position, in which position of the governor-operated valve spindle 19 the lands 22 and 23 serve to establish communication between the annuli 11 and 12. If the feathering oil high-pressure pump is then operated, oil from it enters the inlet 41, this time for unfeathering, until such time as the land 38 has cleared the port leading in from the annulus 34 of the feathering valve sleeve, and feathering oil then flows along the port 45, through the annulus 11 and the now-connected annulus 12 and pipe 16 to the outboard end of the ram. The feathering control valve 37 is thus in the same position for unfeathering operations as it is for feathering operations, but flow of oil from the feathering pump to the annulus 11 during the feathering operation is of no consequence because with the governor-controlled valve spindle 19 raised manually for the feathering operation the annulus 11 is blanked-off between the lands 22 and 23. Similarly, flow of high pressure oil to the annulus 10 during unfeathering operation is immaterial, because with the spindle 19 lowered for unfeathering the annulus 10 is blanked-off between the lands 21 and 22.

Figure 5 illustrates a minor constructional detail providing for adjustment of the down-limit position of the rack 53, for which purpose there is provided on the end of the spindle 52 the stop 55 the eventual limit position of which is dictated according to the position to which the cooperating stop bolt 56 is adjusted.

It is to be understood that the invention is applicable to airscrews capable of pitch change towards reverse pitch, and such an operation could be in place of or in addition to feathering operations. In the latter case it will be desirable to incorporate positive fine-pitch stops in the system.

What I claim is:

1. In combination with a hydro-controllable variable-pitch propeller having a pitch-changing ram operable through a normal range of pitch-increase and decrease, but within that range being operable under the influence of a low-pressure source only in the pitch-decreasing sense, and by a higher-pressure source only in the pitch-increasing sense, and being further operable through a feathering and unfeathering range of said propeller, beyond such normal range of pitch-change, under the influence of a still higher-pressure source, a low-pressure fluid source and a higher-pressure fluid source appropriate to such operations, respectively, a casing having ports connected, one to one end of the ram, another to the opposite end of the ram, and a third to drain, and for connection to said respective pressure sources, valve means cooperating with said ports, governor means operatively connected to said valve means to effect movement thereof in one direction upon lowered speed to deliver low-pressure fluid to the pitch-decreasing end of the ram while connecting the opposite end of the ram to drain, and conversely, in the opposite direction, to deliver higher-pressure fluid to the pitch-increasing end of the ram for operation of the ram in pitch-increasing sense, while connecting the latter's opposite end to drain, upon increased speed.

2. Control means for a hydro-controllable variable-pitch propeller such as has a pitch-changing ram operable through a normal range of pitch-change, but in the pitch-decreasing sense,

only, under the influence of low-pressure differential between a low-pressure fluid source and a drain, as applied to the opposite ends of said ram, and also operable through such normal range, but in the pitch-increasing sense, only, by a higher-pressure differential between a higher pressure source and a drain, and further operable through a feathering range beyond such normal range of said propeller, under the influence of a still higher-pressure differential between a sill higher-pressure fluid source and such drain, as applied similarly to the opposite ends of said ram; said control means comprising a casing having ports for connection, one to the pitch-increasing end of the ram, another to the pitch-decreasing end of such ram, and a third to drain, and having further ports for connection to the respective low-, higher-, and still higher-pressure sources, valve means cooperating with said ports, governor means operatively connected to said valve means to effect movement thereof in one direction upon lowered speed to deliver fluid from the low-pressure inlet port to that port which is connected to the pitch-decreasing end of the ram, while connecting to drain that port which is connected to the opposite end of the ram; and conversely, in the opposite direction, to deliver fluid from the higher-pressure inlet port to that port which is connected to the pitch-increasing end of the ram, while connecting to drain that port which is connected to the opposite end of the ram, upon increased speed.

3. The combination of claim 1, including a booster pump receiving oil from the engine and supplying it to the appropriate casing port for higher pressure operation.

4. The combination of claim 1, including a feathering valve interposed between the low pressure and higher pressure sources and the governor-controlled valve and its ports, said feathering valve being operable to maintain communication normally between said sources and the governor-controlled valve, but to cut such communication when shifted, means to supply the still higher high pressure oil to said feathering valve to shift it, and thus to esablish communication between such still higher high pressure supply and the governor-controlled valve and its ports, and means operable at will to shift the governor-controlled valve to admit the still higher pressure oil by way of the governor-controlled valve to the ram, for operation of the variable-pitch propeller within the feathering range.

5. The combination of claim 2, wherein the still higher pressure fluid source is arranged operatively for connection to the ram to operate the latter within the feathering range of said propeller, the control means further comprising a feathering valve disposed in operative connection with the low-pressure and higher-pressure inlet ports to the governor-controlled valve, operable to regulate fluid supply to the latter from the respective sources, said feathering valve cooperating with said ports and operable to maintain such communication normally, but to cut such communication when shifted; a port for the supply of still higher pressure fluid to said feathering valve to shift it, and thus to admit high pressure fluid to said casing, and means operable at will to shift the governor-controlled valve to admit such still higher pressure oil therepast to the ram for operation of the variable-pitch propeller within the feathering range.

6. In combination with a variable pitch airscrew incorporating a fluid motor shiftable in one direction to coarsen the pitch and in the opposite direction to reduce the pitch, a conduit connected to each end of said fluid motor, and means separate from the airscrew to control fluid flow through said conduits, said control means including a casing having two ports communicating with the respective conduits, and having a branched inlet for low pressure fluid, an inlet for high pressure fluid, and a drain connection, a booster pump receiving oil from one branch of the low pressure inlet and arranged to deliver fluid at intermediate pressure within the casing, the casing having adjoining ports arranged for communication, respectively, with the second low pressure branch and with the intermediate pressure source, a valve connected to drain and cooperating with said ports to afford communication alternatively between either such pressure port and one or the other conduit, whilst connecting the other conduit to drain, governor-controlled means operable to shift said valve to compensate automatically for overspeed or underspeed of the airscrew, a feathering valve in said casing biased to close off communication normally between the high pressure inlet and the intermediate and low pressure ports, and hence to the fluid motor, and in such position being interposed in the flow passages between the low pressure and intermediate pressure sources and the corresponding casing ports, but said feathering valve being arranged for communication with the high pressure inlet to be shifted operatively under the influence of high pressure, when admitted, to cut off communication between the low and intermediate pressure sources and the casing ports, and to place the high pressure source in communication therewith instead, and means arranged to override the governor-controlled means at will to shift said governor-controlled valve, coincidentally with automatic shifting of the feathering valve under the influence of high pressure admission, to afford communication between one or the other casing pressure port and a corresponding conduit, while connecting the other to drain, for feathering or unfeathering under the influence of high pressure.

7. In combination with a variable-pitch propeller having a pitch-changing ram operable through a normal range of pitch-increase and decrease, and through an abnormal feathering and unfeathering range of said propeller beyond such normal range of pitch-change, a low-pressure fluid source connected for communication with the ram for operation thereof within such normal range, a boosted-pressure fluid source connected likewise for communication with the ram for operation within such abnormal range, valve means interposed between said ram and the respective pressure sources, and having four ports and a drain outlet, of which ports one connects to the pitch-increasing end of the ram and another to its pitch-decreasing end, a third connects to the low-pressure source, said ports being arranged in predetermined spaced relationship, and the fourth to the boosted-pressure source, a governor-controlled valve member operatively associated with said ports, and having a plurality of spaced lands arranged, relative to said ports, to connect the low-pressure supply port with the pitch-decreasing end of the ram, and the opposite end of the ram to the drain outlet, by movement of said element in one direction relative to said ports, upon lowered speed, and to connect the boosted-pressure supply port with the pitch-increasing end of the ram, and the latter's opposite end to

the drain outlet, by movement of said element in a different direction relative to said ports, upon increased speed.

8. Control means for use in a hydro-controllable variable-pitch propeller control system such as has a pitch-changing ram operable through a normal range of pitch-change under the influence of a low-pressure differential between a low-pressure fluid source and a drain, as applied to the opposite ends of said ram, and also operable through an abnormal range beyond such normal range under the influence of a boosted-pressure differential between a boosted-pressure source and such drain, as applied similarly to the opposite ends of said ram; said control means comprising a casing having a drain outlet and four ports arranged in predetermined spaced relationship for connection, one to the pitch-increasing end of the ram, another to the pitch-decreasing end thereof, a third to the low-pressure source, and the fourth to the boosted-pressure source; a governor-controlled valve means received within said casing, movable relative to said ports, said valve means being constructed and arranged in said casing to connect the low-pressure supply port with that port which connects with the pitch-decreasing end of the ram, and to connect to the drain outlet that port which connects with the opposite end of the ram by speed-actuated movement of said valve means in said casing in one direction, upon lowered speed, and to connect the boosted-pressure supply port with that port which connects with the pitch-increasing end of the ram, by speed-actuated movement of said valve means in said casing in the opposite direction, and to connect to the drain outlet that port which connects with the opposite end of the ram, upon increased speed.

9. In combination with a variable-pitch propeller having a pitch-changing ram operable through a normal range of pitch-increase and decrease, and through an abnormal feathering and unfeathering range of said propeller beyond such normal range, a low-pressure fluid source, a boosted-pressure fluid source, and a high-pressure fluid source, a casing having a drain outlet and four ports arranged therein in predetermined spaced relationship, of which ports one connects to the pitch-increasing end of the ram and another to its pitch-decreasing end, a feathering valve organized and arranged to control admission by way of the third and fourth ports, and normally biased to effect connection between the low-pressure source and the third port, and between the boosted-pressure source and the fourth port, valve means cooperating with said casing ports, speed responsive means operatively connected to said valve means to effect movement thereof in one direction upon lowered speed to connect the low-pressure source with the pitch-decreasing end of the ram and the opposite end of the ram to drain, and conversely, in the opposite direction, to connect the boosted-pressure source with the pitch-increasing end of the ram and the opposite end of the ram to the drain outlet, upon increased speed, means to supply high-pressure fluid from the corresponding source to said feathering valve, to shift the latter, and thereby to cut off communication between the casing ports and the low- and boosted-pressure sources, and to connect the high-pressure source with the corresponding casing ports, and manual means to shift said governor-controlled valve.

10. Control means for use in a hydro-controllable variable-pitch propeller control system such as has a pitch-changing ram operable through a normal range of pitch-decrease under the influence of a low-pressure differential as between a low-pressure fluid source and a drain, as applied to opposite ends of such ram, and through a like range of pitch-increase under the influence of a higher-pressure differential as between a boosted-pressure fluid source and a drain, as applied similarly to opposite ends of such ram, and through an abnormal feathering and unfeathering range of said propeller beyond such normal range under the influence of a high-pressure differential as between a high-pressure source and a lower pressure in such ram; said control means comprising a casing having a drain outlet and four ports arranged therein in predetermined spaced relationship, for connection, one to the pitch-increasing end of the ram, another to the pitch-decreasing end of the ram, a third normally to the low-pressure source, and the fourth normally to the boosted-pressure source, a feathering valve arranged for direct connection to the high-pressure source, and interposed in advance of the ports of said casing between the boosted-pressure and low-pressure sources and the corresponding casing ports, said feathering valve being biased to normally maintain open the latter two connections, but upon subjection to the high-pressure source being shiftable to cut off communication between the low-pressure and boosted-pressure sources and said casing ports, and to establish communication between said ports and the high-pressure fluid connection, valve means in said casing and cooperating with the several casing ports and drain outlets, governor means operatively connected to said valve means for movement thereof in one direction upon lowered speed to connect the low-pressure port with that port which is connected to the pitch-decreasing end of the ram, and the port which is connected to the opposite end of the ram to drain, and conversely, in the opposite direction, to connect the boosted-pressure port with that port which is connected to the pitch-increasing end of the ram, and the port which is connected to the opposite end of the ram to drain, upon increased speed, and manual means to shift said governor-controlled valve independently of governor action for operations within the feathering range.

11. Control means for use in a variable-pitch airscrew control system such as incorporates a pitch-changing hydro-controllable ram shiftable through a normal range of coarsened and reduced pitch, and through an abnormal range, beyond such normal range, for airscrew feathering and unfeathering operations; said control means comprising a casing having two ports arranged for connection to the respectively opposite ends of such ram, and a drain outlet, and having also a high pressure inlet, and a branched inlet for low-pressure fluid, the two branches terminating in a normally low-pressure supply port, and a normally intermediate-pressure supply port, respectively, a booster pump interposed in one branch of said inlet and arranged to deliver fluid at boosted pressure to said intermediate-pressure port, and the second branch being connected to said low-pressure port, a valve connected to drain and cooperating with said ports to afford communication alternatively between either such presssure port and one or the other of the ports connected to the opposite ends of the ram, and to drain the other of such ram-connected ports, governor-controlled means operable to shift said valve to compensate automatically for overspeed

or underspeed of the airscrew, a feathering valve in said casing disposed and biased to close off communication normally between the high pressure inlet and the intermediate- and low-pressure ports, and hence to the ram, and in such position being interposed in the flow passages between the low-pressure inlet and the intermediate-pressure pump and the corresponding casing ports, but said feathering valve being arranged for communication with the high-pressure inlet to be shifted under the influence of high-pressure fluid, when admitted, to cut off communication between the low- and intermediate-pressure branches and the casing ports, and to place the high-pressure inlet in communication with such ports instead, and independent valve adjusting means operable to override the governor-controlled means by adjustment at will to shift said governor-controlled valve, to afford communication between one or the other casing pressure port and a corresponding ram-connected port, whilst connecting the other ram-connected port to drain, for feathering or unfeathering under the influence of high-pressure fluid automatically shifting said feathering valve.

12. In a controllable-pitch airscrew having blades mounted for pitch-changing movements, a fluid-actuated blade-moving motor having opposite fluid-receiving ends, a low-pressure fluid source and a higher pressure fluid source, a sleeve having four axially spaced ports opening into its axial bore, one of said ports communicating with one end of the blade-moving motor, and an adjacent port communicating with said low-pressure source, a third port communicating with the other end of said motor, and the adjacent fourth port communicating with said higher-pressure source, a drain outlet, a governor-operated valve slidable in the bore of said sleeve in accordance with airscrew speed, and having axially spaced lands cooperating with said sleeve's port, operable to prevent communication between adjacent ports, and further operable upon reciprocation of the valve to establish communication selectively between one or the other of said motor-connected ports and that pressure fluid supply port which is adjacent thereto, and between the other of said motor-connected ports and said drain outlet.

13. In combination, a hydraulically controllable variable-pitch propeller having blades mounted for pitch-changing movements, a pitch-changing ram operatively connected to said blades to effect pitch changes thereof in a range between fine-pitch and feathering positions selectively by hydraulically actuated movements of said ram in one direction or reversely, a portion of said range including coarse pitch operating position, a low-pressure fluid source connected to supply low-pressure fluid to one end of said ram to effect a decrease in pitch of said blades, an intermediate-pressure fluid source connected to supply intermediate-pressure fluid to the other end of said ram to effect an increase in pitch of said blades, and a high-pressure fluid source connected to supply high-pressure fluid to the latter end of said ram to effect feathering of said blades, and control valve means interposed operatively in said fluid connections to restrict passage of fluid therein to said ram from said sources selectively, said valve means including means having a first port opening to the pitch-decreasing end of said ram, a second port opening to the pitch-increasing end of said ram, a third port communicating with said low pressure source, and a fourth port, a valve passage common to said intermediate and high pressure sources, opening from said fourth port, said passage branching between said intermediate and high pressure sources, a first valve element normally closing the branch communicating with said high pressure source and operable automatically in response to high-pressure fluid from said high-pressure source to open such branch while closing the branch of said passage from said intermediate-pressure source, and at the same time to interrupt the fluid connection between said low-pressure source and said ram, said high-pressure source being normally ineffective to deliver high pressure fluid to said valve means, and a governor actuated valve element coacting with said ports, operable automatically in response to propeller rotation speed selectively to establish intercommunication between said first and third ports while isolating said second and fourth ports, with a decrease in propeller speed below a selected value, and to establish intercommunication between said second and fourth ports while isolating said first and third ports with an increase in propeller speed above a selected value, to regulate speed of said propeller by blade-pitch control thereof between fine and coarse pitch under normal operating conditions, whereunder said high pressure source is ineffective to deliver fluid to said valve means, and independent control means connected operatively to said second valve element to effect positioning thereof establishing intercommunication between said second and fourth ports, thereby to enable feathering of said propeller by delivery of high pressure fluid to said valve means and to said ram, said valve means having a fluid drain passageway therein placed into communication selectively with the respective ends of said ram by the control movements of said second valve element.

14. The combination as defined in claim 13 wherein the valve means includes a housing structure defining therein a bore operatively receiving the second valve element and further defining the four valve ports opening into such bore, said ports being arranged in successive spaced relation, the first port lying adjacent to the third port, and the second port lying adjacent to the fourth port, said second valve element having a plurality of lands spaced apart in the direction of spacing of said ports, and coacting with the bore wall and said ports, movement of which element in such direction selectively establishes and breaks communication between the adjacent pairs of ports between said lands, as aforesaid.

15. The combination as defined in claim 13 wherein the valve means includes a sleeve element defining therein a cylindrical bore operatively receiving the second valve element and further defining the four valve ports formed through the sides of such sleeve, opening into such bore, said ports being arranged in successive spaced relation, the first port lying adjacent to the third port, the second port lying adjacent to the fourth port, and the fourth port lying adjacent to the third port, said second valve element being tubular and having at least four spaced lands coacting with the bore wall and said ports, spaced apart in the direction of spacing of said ports, movement whereof in such direction selectively establishes and breaks communication between the pairs of ports in two of the spaces between said lands, as aforesaid, and wherein the bore space between lands nearest said first port communicates with the tubular opening of the tubular valve element to afford drainage therethrough

by registering of such lands with said first port, while communication between said first and third ports is interrupted by a land.

ROBERT HENRY WARDE.


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## Certificate of Correction

Patent No. 2,461,791. February 15, 1949.

ROBERT HENRY WARDE

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 9, lines 34 to 36, claim 8, strike out the words and comma "by speed-actuated movement of said valve means in said casing in the opposite direction," and insert the same in line 37, after "ram,"; column 11, line 41, claim 12, for "port" read *ports*;

and that the said Letters Patent should be read with these corrections therein that the same conform to the record of the case in the Patent Office.

Signed and sealed this 2nd day of August, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
*Assistant Commissioner of Patents.*