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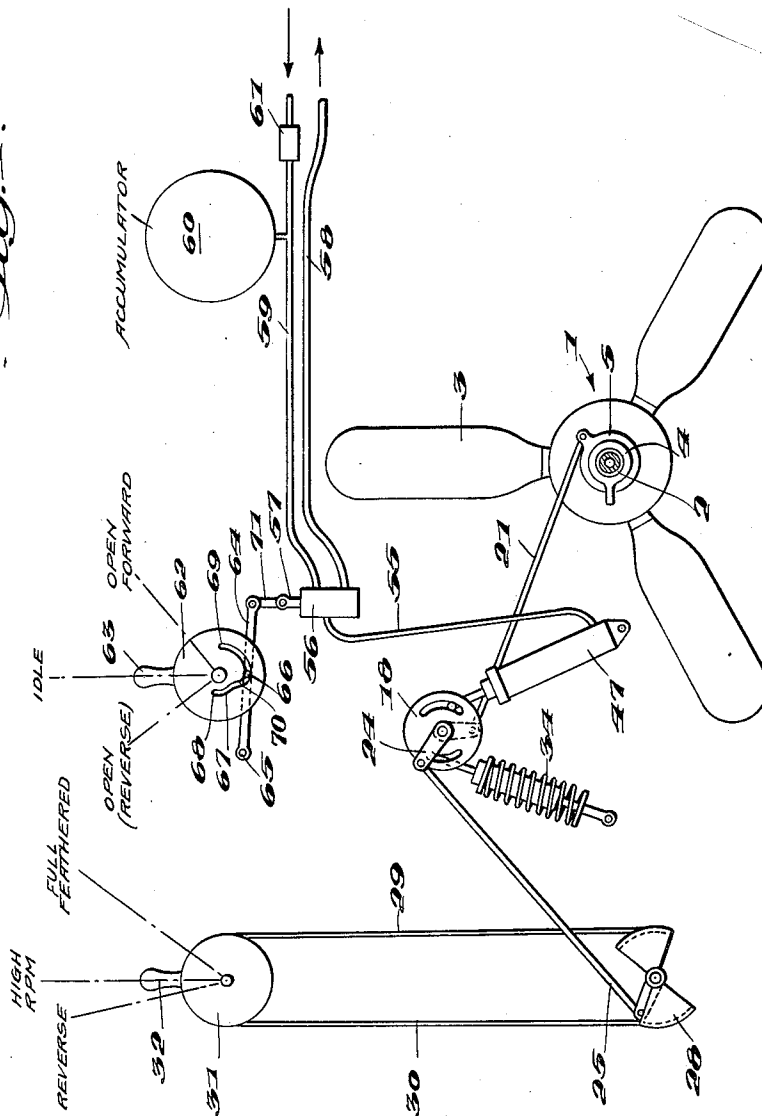
T. C. HILL ET AL

2,545,205

CONTROL SYSTEM FOR REVERSIBLE PITCH PROPELLERS

Filed May 26, 1949

3 Sheets-Sheet 1



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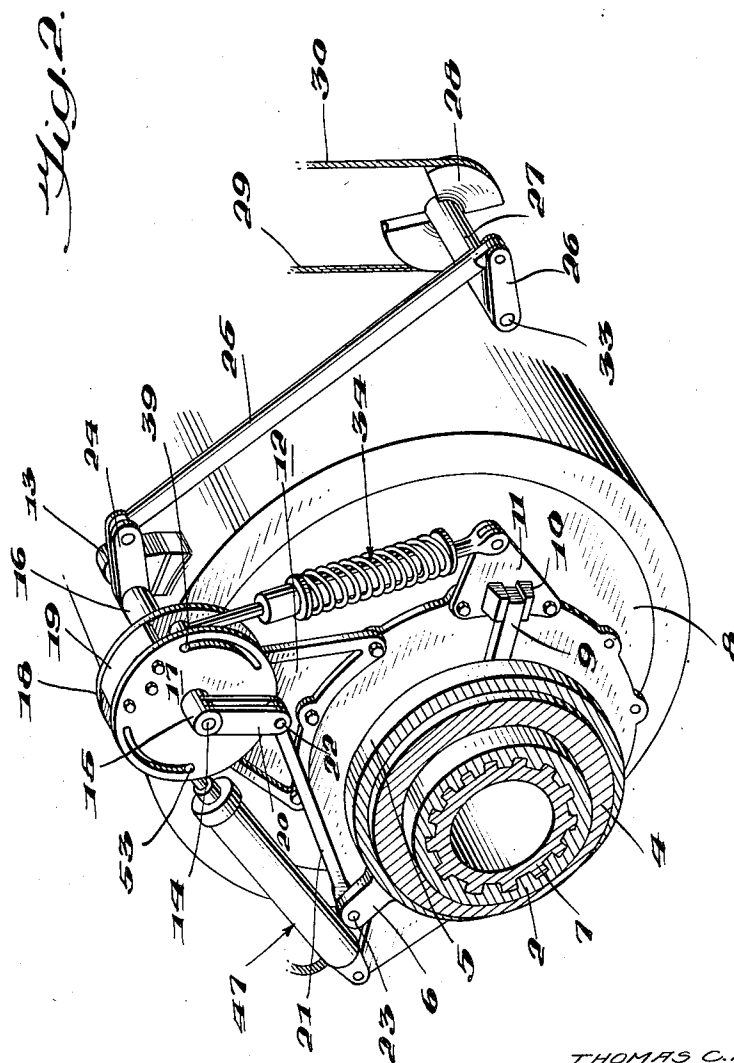
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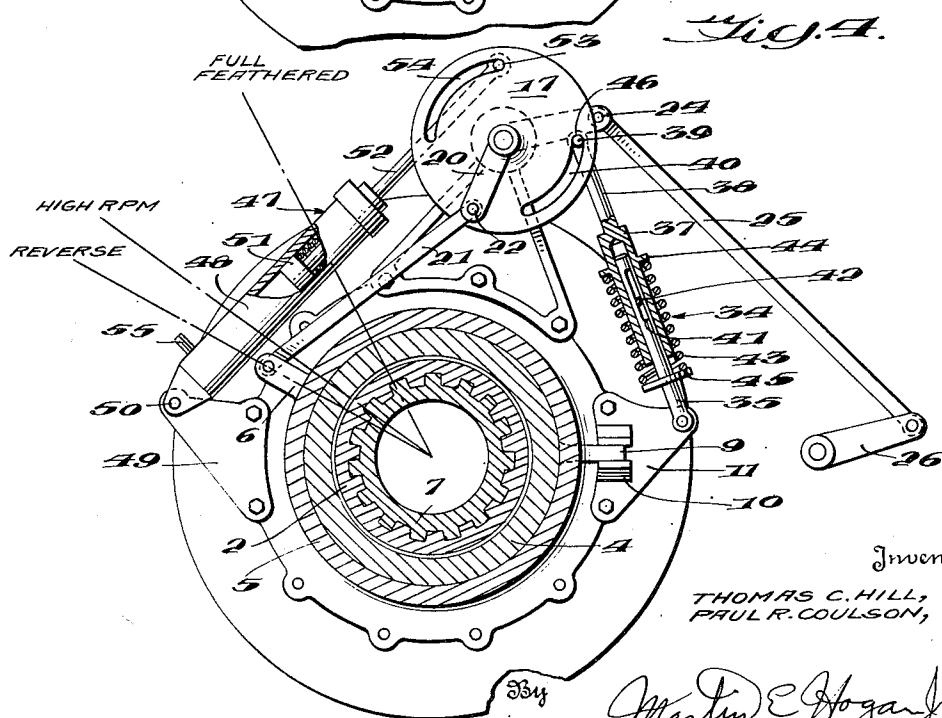
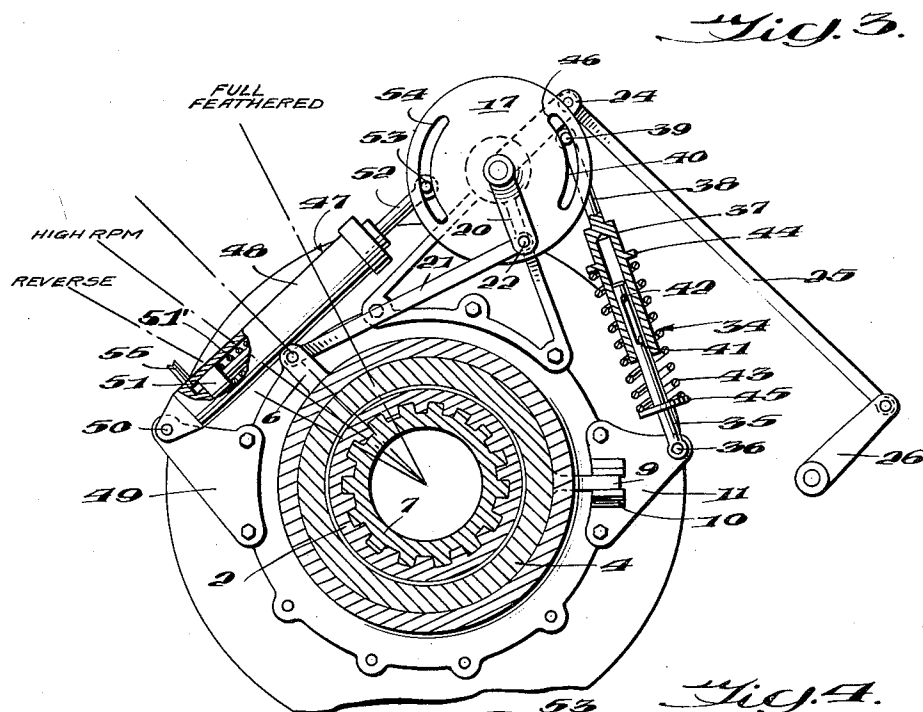
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CONTROL SYSTEM FOR REVERSIBLE PITCH PROPELLERS

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UNITED STATES PATENT OFFICE

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CONTROL SYSTEM FOR REVERSIBLE
PITCH PROPELLERS

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9 Claims. (Cl. 170—135.74)

1

This invention relates to an improved control system for use with reversible pitch propellers.

With the adoption of reversible pitch propellers for use with modern aircraft, the problem of insuring against unwanted reversal of the pitch while still permitting manual control of the forward pitch setting thereof has assumed rather serious proportions. In such aircraft, the propellers are ordinarily located at a considerable distance from the pilot's cockpit. When a propeller is employed of the type having its pitch control means located on the propeller itself, it is therefore necessary to provide a rather long control cable or lever system extending from a suitable manual pitch control element in the pilot's cockpit to the pitch control means on the propeller. In such a system, there is inherently present sufficient lost motion, due to such factors as looseness of pivots, stretch of the cables, adverse expansion or contraction effects due to changes in temperature, etc., that it is practically impossible to insure that the setting of the pitch control means on the propeller will correspond with the setting of the manual pitch control element.

With a reversible pitch propeller of the above-mentioned type, a single control element is normally provided on the propeller, the position of which will control not only the forward pitch setting but also pitch reversal and there is normally provision for but very little movement of the control element on the propeller between its low forward pitch, high R. P. M. setting, employed for maximum thrust, and its reverse pitch setting. If there is any appreciable play in the control system, it is obvious that the pilot can never be certain, from the setting of his manual control lever in this critical range, whether the propeller is set for forward or for reverse pitch. Thus, there is considerable chance, where multi-engined airplanes are employed, that, with the same setting of the manual controls for the individual propellers, one propeller might be set for reverse pitch and another for low forward pitch, an obviously dangerous condition.

Attempts to prevent inadvertent pitch reversal by providing releasable stops at the manual control levers to normally prevent movement thereof beyond their low forward pitch positions are ineffective to overcome the difficulty, since with such an arrangement, it would frequently be impossible, due to the play in the control system, to shift the propeller pitch to the low forward pitch position necessary for takeoff. Moreover, if the propeller were set for reverse pitch, moving

2

the manual control lever to the low forward pitch position might not actually bring the propeller out of its reverse pitch setting due again to the play in the control system. On the other hand, if a releasable stop is provided at the propeller itself, while the former of these improper conditions would be cured, once the stop was released and the propeller set for reverse pitch, return of the manual control to low pitch setting might not restore the propeller control element to a position where it would move back beyond the stop once again resulting in the dangerous condition wherein the propeller was still set for reverse pitch despite the forward pitch setting of the manual control.

It is an object of this invention to provide an improved control system for a reversible pitch propeller of the above-mentioned type wherein the above difficulties are overcome.

It is a further object to provide in such a control system, a preloaded resilient stop adjacent the control element on the propeller, which stop will effectively prevent adjustment of the propeller to reverse pitch by means of the manual pitch control lever in the cockpit.

It is a further object of this invention to provide, in such a control system, a remotely controlled power actuator adjacent the propeller, which power actuator is capable, when energized, of overcoming the preloaded stop to shift the control element into its reverse pitch position.

Still another object is to place this power actuator under the control of the usual throttle control lever so that the pitch of the propeller can only be reversed by a deliberate control action of the pilot, quite independently of any actuation of the usual manual pitch control lever.

Further objects and advantages of this invention will become apparent from a reading of the following description and claims in view of the accompanying drawings.

In the drawings:

Figure 1 is a diagrammatic sketch of the propeller control system.

Figure 2 is an isometric view with certain parts in section.

Figure 3 is a fragmentary view showing the parts with the propeller in "forward pitch" position.

Figure 4 is a similar view showing the parts in "reverse pitch" position.

Referring first to Figure 1, there is shown a propeller 1 which includes a hub 2 carrying blades 3 which are angularly adjustable about their own axes to vary the pitch. This propeller

is of the conventional full feathering, reversible-pitch type having self-contained pitch adjusting mechanism incorporated therein. No attempt is made to show the details of this pitch adjusting mechanism except to point out that it includes a relatively stationary sleeve 4 and a sleeve 5 carried by the stationary sleeve for limited arcuate adjustment. Sleeve 5 includes a control arm 6 for positioning the sleeve 5 to control the pitch setting of the propeller. Sleeve 4 is supported from the hub 2 by suitable bearings (not shown) and is normally held stationary relative to the engine 8 by means of an arm 9 engaged between lugs 10 on a bracket 11 suitably attached to the nose of the engine. The hub 2 of the propeller is mounted on and splined to the drive shaft 7 of the engine as clearly shown in Figures 2, 3 and 4. For further details of a propeller of this general type, attention is directed to the patent to Martin et al. 2,352,336.

Referring to Figures 3 and 4, when arm 6 is moved clockwise from the line indicating the low forward pitch, high R. P. M. position, the forward pitch of the propeller will be increased. At the extreme limit of such clockwise motion, the setting of the propeller will be for full feathering. Movement of the arm counterclockwise from the high R. P. M. position will cause the blades to be shifted to the reverse pitch position.

For swinging the arm 6 between these various control positions, the following mechanism is provided. Supported by suitable brackets 12 and 13, rigidly carried by the nose of the engine, is a shaft 14. Mounted for rotation about this shaft are a pair of sleeves 15, 16 and a pair of discs 17 and 18 rigidly connected to said sleeves. Discs 17 and 18 are rigidly connected together in spaced relationship by spacer 19 rigidly fastened to said discs, bracket 12 extending into the space between the discs and into supporting relationship with shaft 14 therebetween. Rigid with sleeve 15 is a control lever 20 connected by link 21 to control arm 6 for adjusting the position of the latter. Members 15 to 20 are arranged to oscillate as a unit about the axis of shaft 14 and together constitute lever means for controlling the pitch adjusting mechanism. Link 21 is pivotally connected to lever 20 at 22 and control arm 6 at 23. At the rear end of sleeve 16 is another rigid lever 24 connected by link 25 to an operating lever 26 rigidly carried by sleeve 27. Rigid with sleeve 27 is a quadrant 28, in turn connected by flexible control cables 29 and 30 to a manual propeller pitch control member 31 having an actuating handle 32. Sleeve 27 is rotatably carried by a shaft 33 fixedly supported in any desired manner (not shown) relative to the engine.

It can thus be seen that by means of the above structure, movement of the handle 32 will tend to cause a corresponding movement of control arm 6 to vary the pitch of the propeller. However, to prevent inadvertent movement of the control arm 6 to the reverse pitch position, a stop means 34 is provided. This stop means comprises a telescopic assembly including a rod 35 pivoted at 36 to bracket 11 and a sleeve 37 slidable thereon and having its upper end formed as a rod 38. A transverse pin 39 is carried by the upper end of rod 38 and rides within arcuate slots 40 in discs 17 and 18. Rod 38 is slotted at 41 and a pin 42 rigid with sleeve 37 is engaged within this slot to limit the extension of the assembly. A preloaded compression spring 43, arranged exterior of the sleeve 37 between flanges 44 and 45 on the sleeve 37 and rod 35

respectively, tends always to maintain the stop means fully extended with the pin 42 at the upper end of slot 41. With the parts in high R. P. M. position, the relationships are such that the upper end of the slot 40 will engage pin 39 to oppose further clockwise motion of the control lever 20. The preloading of the spring is such that the normal degree of pilot effort attainable at handle 32 is not sufficient to overcome the spring to permit movement of the controls to reverse position. Movement of the control lever between high R. P. M. and feather positions is, however, unrestricted within the limits of the system since under these conditions, pin 39 will ride freely in slots 40. Thus, under normal conditions, the pilot can set his propeller control handle in any desired position in the forward pitch range.

To reverse the propeller, a power actuator 47 is provided, having sufficient force to overcome the spring of the stop assembly. This actuator is shown as a fluid pressure cylinder 48 pivotally connected at 50 to a suitable bracket 49 carried by the nose of the engine. Within the cylinder is slidably mounted a piston 51 having a piston rod 52 carrying at its outer end a transverse pin 53 slidable in a second pair of arcuate slots 54 in discs 17 and 18. A light return spring 51' is provided within the cylinder to return the piston 51 to the lower end of the cylinder upon release of fluid pressure therein. Pressure fluid for operating the actuator is supplied by a conduit 55 under the control of a valve 56 having a valve plunger 57. The valve itself is conventional and is so arranged that when the plunger is in its lower position conduit 55 will be in fluid communication with exhaust line 58, while, with the plunger raised, conduit 55 will be placed in communication with pressure line 59 connected to a suitable source of fluid pressure (not shown). Pressure line 59 includes an accumulator 60 and a check valve 61 to insure operation in the event of failure of the main supply system.

Valve plunger 57 is controlled by a cam 62 rigidly connected with the conventional throttle handle 63 used for controlling the speed of the airplane engine. No details of the throttle control system per se are shown since they form no part of the present invention. However, as is usual where reversible pitch propellers are employed, the throttle control system would be so arranged (as by the use of a suitable cam, for example) that movement of the handle 63 in either direction from a neutral engine or idling position would open the throttle. A lever 64 is fulcrumed at 65 and carries a follower 66 which rides in the cam slot 67 of the cam 62. As shown in Figure 1, this cam slot includes arcuate portions 68 and 69 connected together by a camming portion 70. The outer end of lever 64 is pivotally connected by link 71 to the plunger 57. The shape of the cam slot is such that when the throttle handle 63 is moved forwardly from idle position, lever 64 will remain stationary holding plunger 57 in its lower position. Upon movement of the control handle 63 toward reverse position, however, the cam follower 66 will first ride along the camming portion 70 of the cam slot causing the lever 64 to swing upwardly to raise plunger 57 to admit fluid pressure to the cylinder 47. This upward swinging of lever 64 occurs at the beginning of the reverse movement of the throttle handle 63 while the throttle itself is still in substantially closed or idle position. Upon continued movement of the handle in reverse direction (to reopen the throttle), fol-

5

lower 66 will merely ride along the arcuate portion 68 of the cam slot thus maintaining the plunger in its raised position.

The operation of the control system of this invention is believed to be apparent from the preceding description. Assuming that the parts are in their adjusted positions shown in Figure 3 wherein the propeller is set at a medium forward pitch, the pilot can vary the forward pitch setting as desired by manual operation of the control handle 32. For example, if he desires to feather the propeller, he will swing handle 32 in the proper direction (to the right in Figure 1) to produce, through the action of cables 29, 30, a counterclockwise swinging of lever 26 shown in Figure 3 and a corresponding counterclockwise swinging of the lever means 17 and 20. Link 21 will move the arm 6 of the pitch adjusting mechanism in a clockwise direction to its feathered position and the mechanism within the propeller hub will cause the desired change of pitch of the propeller. Neither the stop 34 nor the actuator 47 will interfere in any way with such manual control of the propeller pitch within the forward pitch range, since pins 39 and 53 will ride freely in their respective slots 40 and 54. Movement of the pitch control handle 32 in the opposite direction will, however, be limited by the engagement of the end 46 of the slot 40 with the pin 39 of the stop 34 when arm 6 reaches the high R. P. M. position. As was above set forth, the spring 43 is so preloaded as to effectively prevent movement of the control lever beyond this high R. P. M. position by manual operation of the control handle 32.

If for example, upon landing, the pilot desires to set the propeller for reverse pitch to assist in braking the airplane, he has merely to swing the throttle control lever 63 rearwardly (counterclockwise, in Figure 1) from the idle position, in which it would normally be at that particular time. With the throttle lever in the idle position, the motor will already be throttled down to a relatively low speed of rotation suitable for pitch reversal. As the handle 63 first begins to move rearwardly from its idle position, and before the throttle control system has moved sufficiently to reopen the throttle materially, camming portion 70 of the slot 67 will cause lever 64 to swing upwardly to actuate valve 57 so as to admit pressure fluid from pressure line 59 to the actuator 47. As the piston rod 52 of the actuator moves outwardly, the cross pin 53 will engage the end of slot 54 at whatever position the latter is in at that particular time (depending upon the setting of the manual pitch control lever 32) and will thereafter rotate the lever means 17, 20 in a clockwise direction as viewed in Figure 3, shifting the control arm 6 of the pitch control mechanism past the high R. P. M. position to its reverse pitch setting against the resistance of the resilient stop 34. It should be noted that at the time that the control arm 6 reaches the high R. P. M. position shown in Figure 3, the end 46 of slot 40 will also engage the cross pin 39 of the stop 34, which would normally prevent further movement. However, the actuator develops sufficient force to overcome the preloading of the resilient stop 34 and compress the spring 43 thereof and is therefore able to move the parts to the reverse pitch position, as clearly indicated in Figure 4.

When it is desired to return the propeller to a forward pitch setting, the throttle handle 63 will be returned from its reverse open position

6

to its idle position. Such movement of the throttle will first slow the motor and then cam lever 64 downwardly to shift valve 57 so as to block the high-pressure line 59 and connect the cylinder 47 with the exhaust line 58. As soon as the pressure within the cylinder 47 is thus released, spring 43 will again expand so as to extend the stop member 34 to its normal position shown in Figure 3. During this extension of the stop member, pin 39 will, by its engagement with the end 46 of the slot 40, cause counterclockwise swinging of the control lever means 17, 20 to restore the arm 6 to its high R. P. M., low forward pitch position.

With the above arrangement, it is obvious that only by a deliberate action on the part of the pilot, that of moving the throttle control handle in a reverse direction beyond its normal motor idling position, can the pitch of the propeller be reversed, thus substantially eliminating the danger of inadvertent pitch reversal. Yet the pilot retains complete manual control of the propeller pitch within its forward pitch range. Moreover, failure of the hydraulic control system will at the most result in the inability to put the propellers into reverse pitch and will in no way affect the usual manual adjustment in the forward range. If the hydraulic system should fail while the propellers are set for reverse pitch, escape of fluid from the cylinder 47 would instantly permit the resilient stop 34 to restore the parts to the high R. P. M., forward pitch setting. Any play or lost motion in the manual control system extending from the manual control lever 32 to the control means adjacent the propeller would have no serious effect. The pilot could always quickly return the propeller from any setting in the forward pitch range to its high R. P. M. setting by merely moving handle 32 in the proper direction until further movement was prevented by the stop, without any danger of inadvertently reversing the pitch.

While but one form of control system has been shown and described, it is obvious that many modifications and substitutions could be made without departing from the spirit and scope of the appended claims.

We claim as our invention:

1. In combination with an engine having manual throttle control means therefor, a propeller of the reversible-pitch type driven by said engine and including pitch adjusting mechanism for varying the pitch thereof, lever means for controlling said pitch adjusting mechanism, mounted for movement within a forward pitch range to vary the forward pitch setting of said propeller and movable beyond one limit of the forward pitch range to a reverse pitch position for reversing the pitch of said propeller, manual control means for moving said lever means, stop means positioned to oppose movement of said lever means beyond said one limit, a power actuator operatively connected to said lever means and operative when energized to move said lever means to reverse pitch position against the opposition of said stop means, said manual throttle control means being movable in opposite directions from a neutral, engine-idling position, and means controlled by the movement of said manual throttle control means in a predetermined direction from said neutral position to energize said actuator to reverse the pitch of said propeller.

2. In combination with a propeller of the reversible-pitch type having pitch adjusting mech-

7

anism for varying the pitch thereof, lever means for controlling said pitch adjusting mechanism, mounted for movement within a forward pitch range to vary the forward pitch setting of said propeller and movable beyond one limit of the forward pitch range to a reverse pitch position for reversing the pitch of said propeller, manual control means for moving said lever means, resilient stop means positioned to oppose movement of said lever means beyond said one limit, and a power actuator operatively connected to said lever means and operative when energized to move said lever means to reverse pitch position against the opposition of said resilient stop means.

3. In combination with a propeller of the reversible-pitch type having pitch adjusting mechanism for varying the pitch thereof, lever means for controlling said pitch adjusting mechanism, mounted for movement within a forward pitch range to vary the forward pitch setting of said propeller and movable beyond one limit of the forward pitch range to a reverse pitch position for reversing the pitch of said propeller, manual control means for moving said lever means, resilient stop means positioned to oppose movement of said lever means beyond said one limit, said resilient stop means being so preloaded as to effectively prevent movement of said lever means to reverse pitch position by said manual control means and a power actuator operatively connected to said lever means and operative when energized to move said lever means to reverse pitch position against the opposition of said resilient stop means.

4. In combination with a propeller of the reversible-pitch type having pitch adjusting mechanism for varying the pitch thereof, lever means for controlling said pitch adjusting mechanism, mounted for movement within a forward pitch range to vary the forward pitch setting of said propeller and movable beyond one limit of the forward pitch range to a reverse pitch position for reversing the pitch of said propeller, manual control means for moving said lever means, resilient stop means positioned to oppose movement of said lever means beyond said one limit, said resilient stop means being so preloaded as to effectively prevent movement of said lever means to reverse pitch position by said manual control means, a power actuator operatively connected to said lever means and operative when energized to move said lever means to reverse pitch position against the opposition of said resilient stop means, said resilient stop means being effective to return said lever means to a position within said forward pitch range upon deenergization of said actuator.

5. In combination with a propeller of the reversible-pitch type having pitch adjusting mechanism for varying the pitch thereof, lever means for controlling said pitch adjusting mechanism, mounted for movement within a forward pitch range to vary the forward pitch setting of said propeller and movable beyond one limit of the forward pitch range to a reverse pitch position for reversing the pitch of said propeller, manual control means for moving said lever means, stop means positioned to oppose movement of said lever means beyond said one limit, and a power actuator operatively connected to said lever means and operative when energized to move said lever means to reverse pitch position against the opposition of said stop means.

6. In combination with an engine having man-

8

ual throttle control means therefor, a propeller of the reversible-pitch type driven by said engine and including pitch adjusting mechanism for varying the pitch thereof, lever means for controlling said pitch adjusting mechanism, mounted for movement within a forward pitch range to vary the forward pitch setting of said propeller and movable beyond one limit of the forward pitch range to a reverse pitch position for reversing the pitch of said propeller, manual control means for moving said lever means, resilient stop means positioned to oppose movement of said lever means beyond said one limit, a fluid pressure actuator operatively connected to said lever means and operative upon the application of pressure fluid thereto to move said lever means to reverse pitch position against the opposition of said resilient stop means, and a fluid pressure supply system including a valve for controlling the flow of pressure fluid to or from said actuator, said throttle control means being movable in opposite directions from a neutral engine-idling position, and said valve being operatively connected to said throttle control means so that movement of the throttle control means in a predetermined direction from said neutral position will operate said valve to cause the application of pressure fluid to said actuator and movement of the throttle control means back to neutral position will operate said valve to release the pressure fluid from said actuator.

7. In combination with an engine having an output shaft and a propeller of the reversible-pitch type mounted on said output shaft for rotation therewith, said propeller including pitch adjusting mechanism for varying the pitch thereof, lever means mounted upon said engine adjacent said propeller and operatively connected to said pitch adjusting mechanism, said lever means being mounted for movement within a forward pitch range to vary the forward pitch setting of said propeller and movable beyond one limit of said range to a reverse pitch position for reversing the pitch of said propeller, remotely located manual control means operatively connected to said lever means for moving said lever means, preloaded resilient stop means mounted on said engine in position to be operatively engaged by said lever means when the latter is at said limit of the forward pitch range and adapted to effectively prevent movement of said lever means to reverse pitch position by said manual control means, a power actuator carried by said engine and adapted when energized to move said lever means to reverse pitch position against the opposition of said resilient stop means, and separate manual control means for selectively energizing and deenergizing said actuator.

8. In combination with a propeller of the reversible-pitch type having pitch adjusting mechanism for varying the pitch thereof, lever means for controlling said pitch adjusting mechanism, said lever means being mounted for movement in one direction from a low forward pitch, high R. P. M. position to increase the forward pitch of said propeller and being movable in the opposite direction from said high R. P. M. position to a reverse pitch position for reversing the pitch of said propeller, manual control means for moving said lever, resilient stop means adapted to be operatively engaged by said lever means when the latter is in said high R. P. M. position and adapted to oppose movement thereof to reverse pitch position, and a power actuator oper-

actively connected to said lever means and adapted, when energized, to move said lever to reverse pitch position against the opposition of said resilient stop means, said resilient stop means being effective to return said lever means to its high R. P. M. position upon deenergization of said actuator.

9. In combination with an engine having manual throttle control means therefor, a propeller of the reversible-pitch type driven by said engine and including pitch adjusting mechanism for varying the pitch thereof, lever means for controlling said pitch adjusting mechanism, mounted for movement within a forward pitch range to vary the forward pitch setting of said propeller and movable beyond one limit of the forward pitch range to a reverse pitch position for reversing the pitch of said propeller, manual control means for moving said lever means, resilient stop means positioned to oppose movement of said lever means beyond said one limit, a fluid pressure actuator operatively connected to said lever means and operative upon the application of pressure fluid thereto to move said lever means to reverse pitch position against the opposition of said resilient stop means, and a fluid pressure supply system including a valve for controlling the flow of pressure fluid to or from said actuator, said throttle control means being movable in op-

posite directions from a neutral engine-idling position, and said valve being operatively connected to said throttle control means so that movement of the throttle control means in a predetermined direction from said neutral position will operate said valve to cause the application of pressure fluid to said actuator and movement of the throttle control means back to neutral position will operate said valve to release the pressure fluid from said actuator, said resilient stop means being effective to return said lever means to the position at said limit of its forward range upon release of pressure fluid from said actuator.

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