Aug. 4, 1964 R. T. ELMES ETAL 3,143,175

VARIABLE PITCH PROPELLERS

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Fig. 2

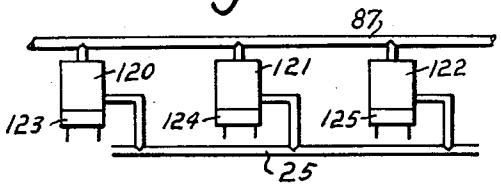


Fig. 1A.

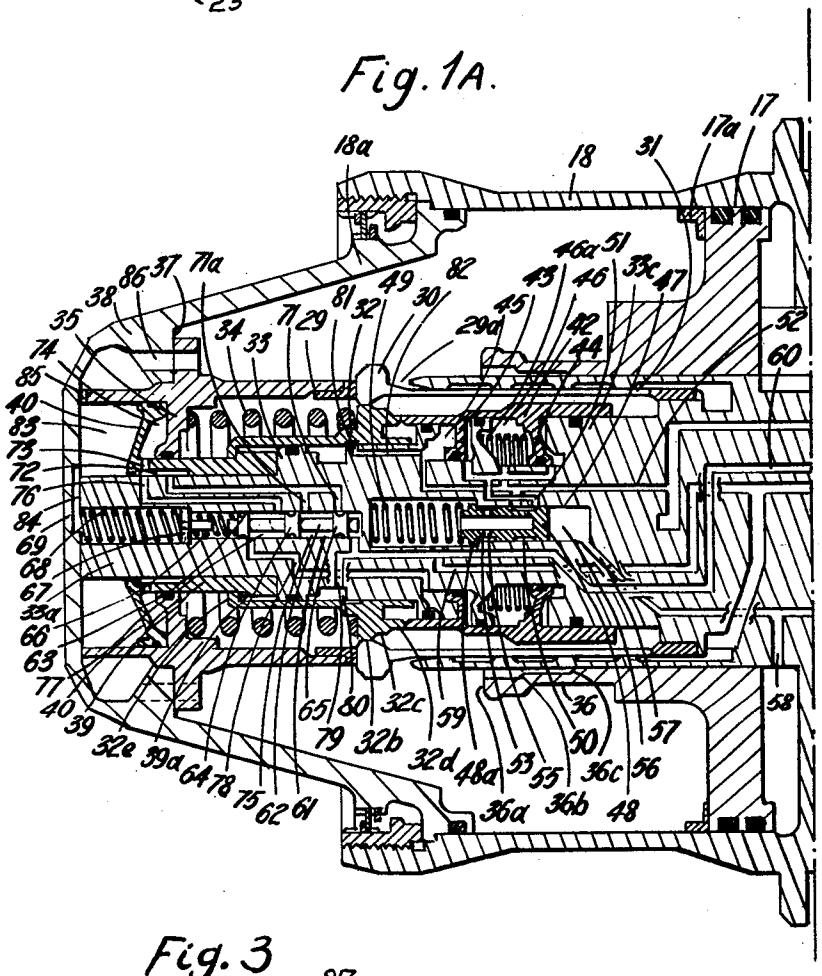
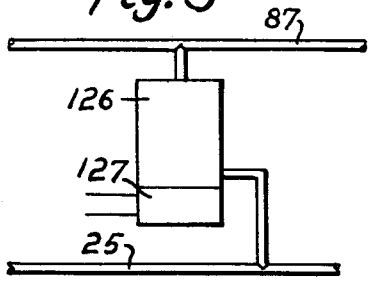


Fig. 3



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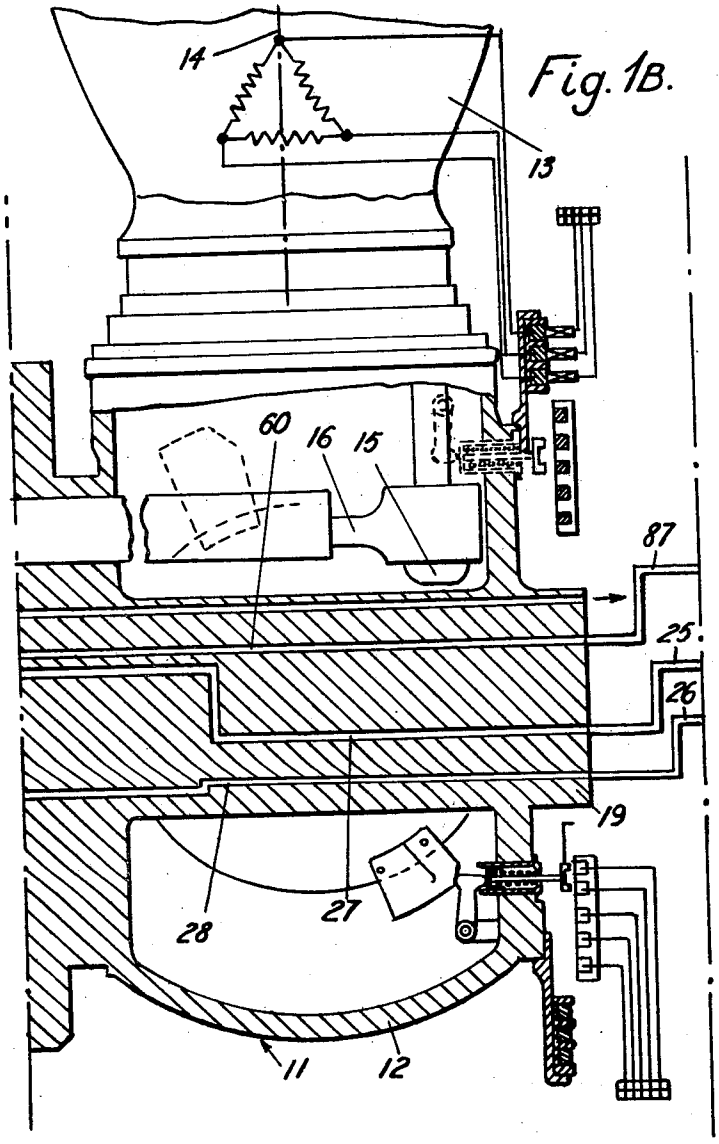


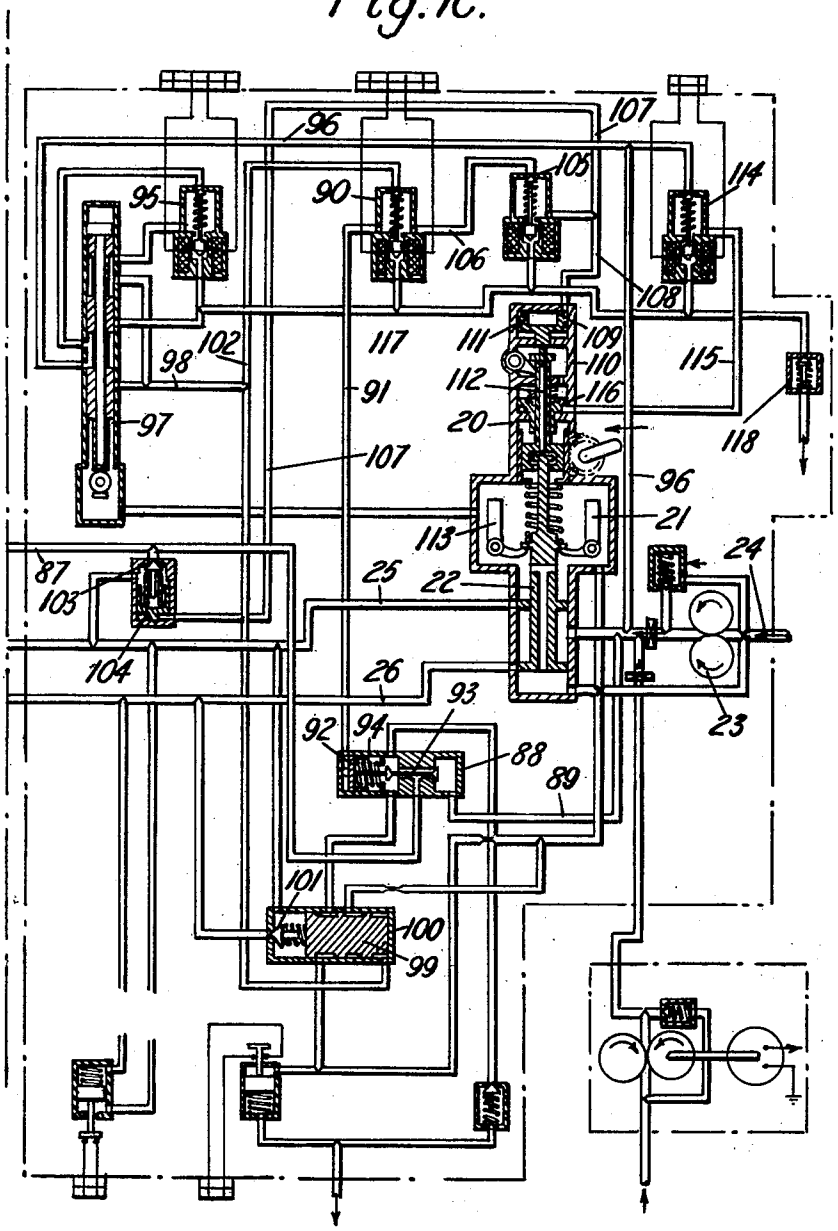
Fig. 1B.

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VARIABLE PITCH PROPELLERS

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Fig. 1C.



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VARIABLE PITCH PROPELLERS

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Filed Oct. 13, 1960, Ser. No. 62,485
Claims priority, application Great Britain Oct. 16, 1959
6 Claims. (Cl. 170—160.32)

This invention relates to variable pitch propellers.

According to the present invention there is provided a variable pitch propeller having pitch control means comprising a hydraulic piston-and-cylinder motor connected to the propeller blades to alter the pitch thereof, a plurality of stops operable to prevent relative movement of the piston and cylinder, in a sense to fine the propeller pitch, beyond respective predetermined fine pitch settings, supply conduits for supplying pressure fluid to opposite ends of the cylinder of said motor, a source of pressure fluid, a further fluid conduit which is independent of said supply conduits and which is connected to said source, means for effecting successive increases in the pressure in said further fluid conduit, and withdrawal means for withdrawing said stops successively when said successive increases of pressure occur in said further fluid conduit.

One embodiment of the invention will now be described by way of example with reference to the accompanying diagrammatic sectional drawings in which the arrangement is shown broken into FIGURES 1A, 1B and 1C for convenience.

FIGURE 2 illustrates a modification, and

FIGURE 3 illustrates a second modification.

Referring to the drawings, the propeller is generally indicated by the reference numeral **11** and comprises a hub **12** which carries propeller blades **13** which are adjustable as to pitch about their longitudinal pitch change axes **14**. Each blade comprises a crank pin **15** at its root end coupled by a connecting rod **16** to the ram **17** of a pitch change motor. The ram **17** is slidable in a cylinder **18** to adjust the pitch of the propeller. The cylinder **18** is arranged coaxially with the driving shaft **19** of the propeller and in the nose portion of the hub **12**. The pitch adjustment is controlled by a constant speed unit generally indicated by the reference numeral **20**. This unit is of well-known construction and comprises a governor **21** and valve **22**. Associated with the governor **21** is a pump **23** which receives pressure fluid from the oil system of the associated engine through a conduit **24**, or alternatively draws it from a propeller sump fixed to the engine or forming part of the propeller hub structure.

The pump **23** delivers pressure fluid to the valve **22** which in turn controls the passage of the pressure fluid from the pump to the propeller pitch change motor by way of either conduit **25** or **26** depending upon the nature of the pitch change, that is whether the blades are moved to a coarser or finer pitch respectively. The conduits **25**, **26** communicate with ducts **27** and **28** passing through the hub **12** and leading to opposite sides of the ram **17**.

When the pressure fluid from the pump **23** is delivered by conduit **26** and duct **28**, the ram **17** is moved forwardly to bring the blades into finer pitch position, and when delivered by conduit **25** and duct **27**, the ram is moved rearwardly to bring the blades into a coarser pitch position.

The ram **17** is of annular form and slides on a stationary barrel **29** housing first, second and third stop means operative to prevent movement of the ram **17** relative to the cylinder **18** forwardly, that is to the left in the drawing, to adjust the propeller into a pitch less than a first predetermined pitch, a second predetermined pitch which is less than said first predetermined pitch and a third predetermined pitch which is less than said second

predetermined pitch, respectively. The stop means together comprise a ring of stops **30** which are mounted each upon one end of a resilient finger **31** secured at its other end within the barrel **29**, and are prevented from moving inwardly by a stop retaining member in the form of a ring **32** which is slidably mounted upon a core **33** within the barrel **29**. The ring **32** has a stepped outer periphery having a radially outer step **32***b*, a step **32***c* disposed radially inwardly of the step **32***b*. A radially inner step **32***d*, and a coil spring **34** is interposed between the ring and an inwardly directed flange **35** formed on the inner wall of the barrel **29**.

The stops **30** may lie in the path of movement of one or more of the shoulders **36***a*, **36***b* and **36***c* formed on the inner diameter of a stepped sleeve **36** projecting forwardly from and forming part of the ram **17** in dependence upon the position of ring **32** as hereinafter described. These shoulders normally limit the movement of the ram to the left in the drawing depending upon the position of the stops **30** as hereinafter described. The barrel **29** is provided with suitable slots **29***a* through which the stops **30** project radially outwardly, and extends forwardly beyond the stops. An external radial flange **37** engages with and is connected to a flange **38** integral with the forward end closure member **69** of the cylinder **18**.

The ring **32** is provided at its forward end with an inturned part or flange **32***e* which when the ring **32** is in its extreme rearward position engages a forwardly facing shoulder **39***a* formed on a sleeve **39**. The sleeve **39** has an annular jack piston **40** formed integrally therewith at its forward end, and is slidable upon a reduced diameter part **33***a* of the core **33**. The piston **40** works in a cylinder formed by the forward part of the barrel **29**, the flange **35** and the forward end closure member **69** of the cylinder **18**.

Slidably mounted on a part **33***c* of the core **33** to the rear of the ring **32** is a sleeve **42** having a pair of radially inwardly directed flanges forming annular jack pistons **43** and **44**, these pistons working respectively in annular peripheral recesses or cylinders **45** and **46** in the core **33**. A coil spring **46***a* is provided in the cylinder **46** urging the piston **44** rearwardly and the sleeve **42** extends forwardly into abutment with ring **32**.

The core **33** has a central bore **47** which houses a piston valve **48** slidable therein. The bore is stepped to provide an increased diameter part. A flange **48***a* on the piston valve is arranged to abut the step in the bore to limit movement of the valve **48** in the rearward direction. A coil spring **49** is interposed between the flange **48***a* and the forward end of the bore **47**. The outer diameter of the piston valve **48** is provided with an annular recess **50** which, when the piston valve is in the rearward position (as shown in the drawing), places a passageway **51** in communication with a drain duct **52**. Passageway **51** is in communication with the cylinder **45** to the rear of the piston **43** and with the cylinder **46** to the rear of the piston **44**. Cylinders **45** and **46** are in communication with the drain passageway **52** at their forward ends.

The piston valve **48** is provided with a further annular recess **53** spaced forwardly from the annular recess **50** and in communication with the hollow interior of the piston valve **48** through ports **55**.

The chamber **56** to the rear of the piston valve **48** is in communication through a passageway **57** with the fine pitch duct **28**. The duct **28** also leads hydraulic fluid under pressure to the rearward, that is to say, the fine pitch side of the ram **17** through a branch duct **58**. The bore **47** forward of the piston valve **48** communicates with the coarse pitch duct **27** through a duct **59**. The duct **27** leads hydraulic fluid under pressure to the forward, that is to say, the coarse pitch side of the ram **17** and also through the branch duct **59** to the forward end of bore

47, the hollow interior of the piston valve 48 and through the ports 55 to the annular recess 53.

A duct 60 or "third oil line" passes through the hub in convenient manner and communicates at its forward end with the rearward end of a bore 61 disposed coaxially with and just forward of the bore 47. The bore 61 houses a valve spool 62 having three spaced lands 63, 64 and 65. The spool 62 is urged rearwardly by a first coil spring 66 interposed between land 63 and a vented stop member 67. The member 67 is itself urged rearwardly by a second coil spring 68 interposed between the forward face of the member and a suitable abutment forming part of the closure member 69 of the cylinder 18. Rearward movement of the member 67 is limited by the provision of a step in the bore 61.

Considering the spool 62 to be in its rearmost position (as shown) the land 65 closes over the end of a passageway 71 which, when the jack piston 40 is in its rearmost position also, opens at its other end into an annular chamber 72 formed on the inner diameter of the sleeve 39. A port 73 places the chamber 72 in communication with the chamber 74 formed on the rearward side of the jack piston 40. With the spool 62 in this position a branch passageway 71*a* places the annulus 75 formed between lands 64 and 65 in communication with the passageway 71. Also a passageway 76 which opens into the annular chamber 72 a predetermined distance forward of the passageway 71 is in communication with the annulus 77 formed between lands 63 and 64 of the spool 62. A drain passageway 78 at all times places the annulus 77 in communication with cylinder 45 and thus with the drain duct 52.

A passageway 79 branches from the forward end of the third oil line duct 60 and leads to an annular chamber 80 formed in the outer surface of the core 33 and bounded by the ring 32. The inner diameter of the ring is provided with an annular recess 81 which communicates with a drain channel 82, itself connecting through cylinder 45 to drain duct 52, to provide a means of lock indication in a manner fully disclosed in U.S. Patent No. 2,934,154.

The part of the bore 61 forward of the spool 62 is in communication with the chamber 83 on the forward side of the jack piston 40 through a passageway 84, while chamber 83 is in communication through ports 85 and 86 with the coarse pitch side of the ram 17.

The duct 60 communicates with a third oil line conduit 87 which communicates with the delivery side of the pump 23 through a valve device 88 provided in a conduit 89. The valve device 88 is opened to permit flow of hydraulic fluid into the third oil line only when a solenoid operated valve 90 is opened to transmit pressure fluid through a conduit 91 to displace a piston 92 connected with the valve member 93 of the device 88 against the effort of a coil spring 94.

In the system being described there are three other solenoid operated valves 95, 105 and 114 similar to valve 90. Of these, valve 95 receives pressure fluid through a conduit 96 taken from the delivery side of the pump 23 and passing through a by-pass valve unit 97. When the valve 95 is open pressure fluid passes through the unit 97 and conduit 98 to the underside of a piston 99 in a cylinder 100 thereby displacing the piston to gag the relief valve 101 of the fine pitch conduit 26 and thereby afford means for increasing the operating pressure in the fine pitch circuit. At this time the pressure fluid in conduit 98 is transmitted to the solenoid operated valve 90 through a conduit 102. As soon as valve 90 is opened pressure fluid passes through conduit 91 to open the valve device 88 and permit pressure fluid from conduit 89 to enter the third oil line conduit 87.

Selection of third oil line relief valve gagging is achieved by opening of a further solenoid operated valve 105 which receives pressure fluid only when valve 90 is open since the supply conduit 106 is taken from the outlet side of valve 90 to valve 105. When valve 105 is opened, then provided valve 90 also is open and valve 95 open (or alternatively by-pass valve unit 97 has been moved to a position in which valve 95 is by-passed and fluid delivery is direct from conduit 96 through conduits 98 and 102 to valve 90) then pressure fluid will pass into a conduit 107 which leads to the underside of piston 104 thereby to displace the piston and increase the loading in the spring of the third oil line relief valve 103. Hence the operating pressure in the third oil line 87 may be increased according to the new setting of the spring. At the same time pressure fluid passes from conduit 107 into a conduit 108 branched therefrom which communicates with a cylinder 109 formed at the upper end in the drawing of the casing 110 of the constant speed governor 21. Slidably mounted within the cylinder 109 is a piston 111 having a push rod 112 formed therewith. Under the hydraulic pressure acting upon it the piston 111 is displaced downwardly in the cylinder 109 and the push rod overrides the effect of the flyweights 113 of the governor and displaces the valve 22 downwardly such that the fine pitch pressure conduit 26 is fully opened to the delivery of pressure fluid from pump 23 and the coarse pitch pressure conduit 25 is opened to drain.

The fourth solenoid operated valve 114 is provided in the present system to provide for unreversing and also the automatic pitch coarsening function as fully described in our British Patent No. 790,226. This valve receives its pressure fluid supply from conduit 96 and when opened directs fluid through a conduit 115 to the underside of a piston 116 also in the governor casing 110. Consequent upward movement of this piston lifts the governor valve 22 such that full coarsening pressure is applied through conduit 25.

Thus in the system now described the solenoid operated valve 95 in providing for increased fine pitch pressure is capable of initiating withdrawal of the cruising pitch stop, the valve 90 in providing for operation of the third oil line at a first pressure level is capable of initiating withdrawal of the flight fine pitch stop, the valve 105 in providing for operation of the third oil line at a second higher pressure level is capable of initiating withdrawal of a superfine pitch stop and the valve 114 is capable of initiating automatic coarsening of the propeller blades.

Each of the solenoid operated valves 95, 90, 105 and 114 has drain connections which connect with a common drain conduit 117. This conduit is provided with a non-return valve 118 which maintains the pressure in the conduit at 5 lbs. per square inch.

When it is required to operate the first stop withdrawal means in order to render the first stop means inoperative, the solenoid of the valve 95 is energized to open the valve. This may be achieved by means of a control system as described in either co-pending U.S. application Serial No. 697,070 or U.S. Patent No. 2,994,385 in the case where the propeller is one of a number of propellers installed in an aircraft having a plurality of gas turbine engine driven propellers.

When it is required to operate the second stop withdrawal means in order to render the second stop means inoperative the solenoid of the valve 90 is energized to open the valve. This may be achieved only after touch down of the aircraft and is controlled by a master lever operable by the pilot. This lever is not free to move to its operative position until the throttle lever of the engine driving the propeller has been moved to a predetermined low throttle setting thus ensuring that the flight fine pitch stop cannot be withdrawn when the propeller is rotating above a predetermined r.p.m. Such a system is disclosed in U.S. application Serial No. 687,204.

Alternatively, however, the solenoid of the valve 90 may not be energized until an oleo switch associated with the aircraft undercarriage has closed consequent upon touch down of the aircraft.

When it is required to operate the withdrawal means in order to render the third stop means inoperative the solenoid of the valve 105 is energized to open the valve.

As with the second stop, this may be achieved only after touch down of the aircraft and is controlled by a further range of movement of the master lever beyond that for removal of the second stop.

Alternatively if the second stop is removable automatically on the closure of an oleo switch, then the master lever may only be operative for selecting withdrawal of the third stop.

The operation of the mechanism contained within the propeller hub **12** under the control of the solenoid operated valves **90**, **95** and **105** will now be described.

During normal flight the pitch change range of the propeller is limited in the pitch fining direction at a "flight cruise" position by the stops **30** which are held out in the path of the shoulders **36***a*, **36***b* and **36***c* by the step **32***b* of the ring **32**, this step then engaging with the ring of stops **30** and the shoulder **36***a* then cooperating with the stops **30** to form a flight cruise stop when the shoulder **36***a* comes up against rearward chamfers on the stops **30**. Under these conditions the ring **32** is in its extreme rearward position and is held in this position by the coil spring **34**. The flight cruise stop in the example being described corresponds to a 32 degree pitch angle of the propeller blades, and is provided to prevent undue windmilling speeds of the propeller occurring in the event of a failure of the constant speed unit controlling the pitch of the propeller allowing the propeller to fine off while the aircraft is moving at a high forward speed.

When it is required to adjust the propeller into a pitch less than 32 degrees, for example when preparing to land, the propeller is fined off on to the flight cruise stop. This is usually achieved by setting the datum of the constant speed unit controlling the pitch of the propeller so that the constant speed unit calls for a propeller pitch which is less than that set by the flight cruise stop. The fine pitch pressure relief valve is then gagged by energizing the solenoid of the valve unit **95**, as already explained. Thus when the shoulder **36***a* comes up against the stops **30** and the ram **17** is prevented from further movement in the pitch fining direction, the pressure on the fine pitch side of the hydraulic system of the pitch change motor is able to rise above the normal operating maximum value, the increased pressure transmitted to the chamber **56** overcoming the action of the spring **49** and displacing the piston valve **48** forwardly so as to open the passageway **51** to chamber **56**. Fluid under pressure is then delivered from the fine pitch conduit **26** and duct **28**, passageway **57**, chamber **56** and passageway **51** to chambers **45***b* and **46***b*, and the jack means comprising the pistons **43** and **44** is operated so that the sleeve **42** is displaced forwardly thereby pushing the ring **32** forwardly to bring the step **32***c* on the ring radially within the ring of stops **30**. Operation of the jack means as just described is accompanied by the exhaust of hydraulic fluid from the chambers **45***c* and **46***c* through the drain duct **52**.

The resilient fingers **31** constitute spring means which tend to urge the stops **30** into a position in which they lie in the path of movement of the shoulders **36***b* and the shoulder **36***c* but out of the path of movement of the shoulder **36***a*.

The sleeve **42** has a limited range of forward movement sufficient to displace the ring **32** from a first position in which the step **32***b* lies radially within the ring of stops **30** through a first range of movement to bring the ring to a position in which the stops spring onto the diameter **32***c* of the ring.

As soon as the ring **32** has been displaced as just described the ram **17** becomes free to slide over the stops **30** until the shoulder **36***b* on the ram comes up against the stops.

If, when the propeller has been fined off on to the flight cruise stop and the ring **32** has been displaced to its position as shown in the drawing, the constant speed unit is still demanding a finer propeller pitch, the ram **17** will immediately move forward over the stops **30** in the manner described, thus relieving the pressure in the fine pitch conduit **28** and duct **26** and therefore in chamber **56**. The valve **48** will consequently move back under the action of the spring **49** to its position as shown in the drawing. In these circumstances, however, the spring **34** is unable to return the ring **32** to its rearmost position since the stops **30** are prevented from moving outwardly by the sleeve **36** which is now enclosing the stops at its forward end.

The shoulder **36***b* cooperates with the stops **30** to form a flight fine pitch stop which, in the present example is set at a propeller pitch of 20 degrees. The flight fine pitch stop is operative to prevent pitch fining movement of the propeller to a pitch less than 20 degrees during all phases of flight, and is required to be removed, that is to say rendered inoperative, only after touch down of the aircraft in order that the propeller may be moved into a finer pitch range for the purposes of braking the aircraft on the runway by creating a desired degree of propeller drag.

In order to allow the propeller to fine off to a pitch less than 20 degrees, hydraulic fluid under pressure is permitted to enter the third oil line **87** and **60** when the solenoid of the valve **90** is energized and consequently the valve **93** is opened as previously explained. Fluid pressure is thus conveyed through duct **60** into the bore **61** at its rearward end to act on the rearwardly facing annular area of the land **65** of the valve spool **62**. In consequence the spool **62** is displaced forwardly in the bore **61** against the effort of the coil spring **66** so that the land **65** opens the end of the passageway **71** at the bore **61** to pressure fluid. At the same time the land **64** closes off the end of the passageway **76** at the bore **61**, thereby closing passageway **76** from its connection with drain passageway **78**. Thus pressure fluid is transmitted through chamber **72** and ports **73** to the chamber **74***a*, whereupon the jack piston **40** is operated and the sleeve **39** moves forwardly on the core **33** and the shoulder **39***a* engages behind the flange **32***e* whereafter the continued forward movement of the sleeve **39** displaces the ring **32** further forward through a second range of movement against the action of the spring **34** to bring the step **32***d* of the ring radially within the ring of stops **30** so that the shoulder **36***b* is free to force the stops inwardly on to the step **32***d* thereby freeing the ram **17** for further forward sliding movement in the cylinder **18**, and over the stops, to adjust the propeller into a still finer pitch range limited ultimately by the shoulder **36***c* on the ram when this shoulder comes up against the stops **30** this constituting a superfine pitch stop.

Following a predetermined forward displacement of the jack piston **40** the sleeve **39** closes off the end of passageway **71**, whereupon the fluid pressure applied in chamber **74** is cut off. Thus the piston **40** is hydraulically held in its new position. If leakage of oil from the chamber **74** is sufficiently great to cause the piston **40** to move rearwardly before such time as they sleeve **36** of the ram **17** moves further forwardly over the stops **30**, then the end of the passageway **71** will be cracked open to make up the losses and restore the piston **40** to its new position.

Propeller blade switches are provided such that as the ram moves into this still finer pitch range the solenoids of the valves **90** and **95** are de-energized and thus the valve **93** is closed and the third oil line is communicated with drain. As soon as this occurs the spool **62** moves rearwardly in the bore **61** under the effort of coil spring **66** thereby communicating chamber **74** with drain through port **73**, chamber **72**, passageway **76**, annulus **77**, passageway **78**, chamber **45** and duct **52**. Thus the spring **34** will tend to push the ring **32** back to its rearmost position. This is however prevented by the ram which holds the stops **30** inwardly on the step **32***d* of the ring. As soon as the pitch of the propeller is coarsened to an angle greater than 20 degrees, however, the spring **34** becomes free to push the ring **32** rearwardly to bring the stop onto

the step 32*c* of the ring 32 thereby resetting the flight fine pitch stop, whilst coarsening movement to an angle greater than 32 degrees allows the flight cruise stop to be reset, the spring 34 pushing the ring 32 to its rearmost position together with the sleeve 42, and the ring 32 forcing the stops 30 outwardly into the path of movement of the shoulder 36*a*.

From the foregoing description it will be seen that the jack means comprising the pistons 43 and 44 is operable independently of movement of the jack piston 40, and vice versa. It will also be seen that the jack piston 40 is operable by hydraulic fluid under pressure supplied through the "third oil line" to displace the ring 32 from its rearmost or first position through both its first and second ranges of movement if desired. The jack means comprising the piston 40 may therefore be actuated to render both the flight cruise stop and the flight fine pitch stop inoperative in one operation.

As previously explained, the shoulder 36*c* cooperates with the stops 30 to form a superfine pitch stop which in the present example is set at a propeller pitch of zero degrees. The superfine pitch stop is operative to prevent pitch fining movement of the propeller below the zero degree position into the reverse pitch range and is required to be removed, that is to say rendered inoperative only when the aircraft is on the ground for the purpose of braking the aircraft on the runway by reversing the propeller pitch.

In order to allow the propeller to move below the zero degree position the three solenoids respectively of the valves 95, 90 and 105 are all energised, the first (95) to effect hydraulic supply to the valve 90, the second (90) to open the valve 93 to permit pressure fluid to pass into the third oil line, and the third (105) to effect displacement of the piston 104 to gag the relief valve 103, as previously described.

The pressure in the third oil line is thus conveyed through duct 60 into the bore 61 at its rearward end to act on the rearwardly facing annular area of the land 65 of the valve spool 62. In consequence the spool 62 is displaced forwardly in the bore 61 against the effect of the coil spring 66 so that the land 65 opens the end of the passageway 71 at the bore 61 to pressure fluid. The spool 62 moves until it abuts the vented stop member 67 whereupon as previously explained the piston 40 moves forwardly until the end of the passageway 71 opening into the chamber 72 is closed off by the step at the rearward end of the annular chamber 72. Thus the fluid pressure supply to the chamber 74 is cut-off and the pressure in passageway 71, duct 60 and conduit 87 builds up. The extent of build up is limited only by the new gagged blow-off setting of the relief valve 103, this being of the order of 600 p.s.i. Hence with the now increased operating pressure communicated to the rearward end of the bore 61, the valve spool 62, spring 66 and stop member 67, are displaced bodily forwardly against the effort of the coil spring 68 until the land 64 fully opens that end of the passageway 76 which enters the bore 61. Thus the higher pressure fluid already communicated through passageway 71*a* to annulus 75 is now in communication through passageway 76 and chamber 72 with the chamber 74*a* so that a rapid displacement of the jack piston 40 in the forward direction now occurs.

This forward movement of the piston 40 and of the sleeve 39 displaces the ring 32 further forwardly against the action of the spring 34 to bring the step 32*d* forward and clear of the stops 30 so that the shoulder 36*c* is free to force the stops inwardly into the space immediately rearward of the ring 32, thereby freeing the ram 17 for further forward sliding movement in the cylinder 18, and over the stops, to adjust the propeller into the reverse pitch range, where in the example being described at an equivalent ram position of −15 degrees, the ram abutment 17*a* comes up against the shoulder stop 18*a* formed in the cylinder 18.

Propeller blade switches are provided such that as the ram moves into reverse pitch the solenoids of the valves 90, 95 and 105 are de-energized and thus the valve 93 is closed and the relief valve 103 is ungagged, the third oil line then being placed in communication with drain.

As soon as this occurs the spool 62 moves rearwardly in the bore 61 under the effort of coil springs 66 and 68 thereby communicating chamber 74 with drain through port 73, chamber 72, passageway 76, annulus 77, passageway 78, chamber 45*c* and duct 52. Thus the spring 34 will tend to push the ring 32 back to its rearmost position. This is however prevented by the ram which holds the stops 30 fully inwardly into the space rearward of the ring 32.

By the provision of three stops at 32 degrees, 20 degrees and zero degrees the pilot is able to select aerodynamic braking by the blades at zero degrees where a relatively long landing run is not objectionable or alternatively may select full reverse pitch braking at −15 degrees where a relatively short landing run is desirable. Also the zero degree stop provides a suitable low pitch position for starting of the engine, this being of particular importance in propeller turbine engines in which the propeller system is directly coupled with the compressor system.

The system hereinbefore described by way of example has referred to the provision of means for increasing the third oil line pressure once only. It may however be very desirable to increase this pressure say three times to give four levels of pressure operation and the system so arranged to remove a similar number of stops. Thus the system is basically a step by step follow up system.

As in the arrangement described above, the jack piston 40 may be provided with a stepped movement simply by a valve coaxially arranged in co-operation with it. In this case for each position of the valve the piston would have a unique follow-up position, the valve itself being positioned in dependence on the pressure in the third oil line 87.

In some such arrangements, as indicated in FIGURE 2, a number of different relief valves 120, 121, 122, having different settings to each other are incorporated in the third oil line 87 and are operated by solenoids 123, 124, 125 to bring the appropriate relief valve into effective operation.

In other such arrangements each step in pressure in the third oil line 87 is controlled by a solenoid operating a relief valve which is disposed in the third oil line and which is capable of being gagged a desired number of times to provide the different pressures. For example, as indicated in FIGURE 3, the relief valve may comprise a pressure modulating device 126 of known type having a progressive action under the control of an electromagnetic device 127. In this case selection of stop withdrawal would depend on the extent of energization of the electromagnetic device 127. Fluid from the third oil line which passes through the relief valve or valves is led through the coarse pitch conduit 25 to drain.

The system described also refers to the provision of an increased fine pitch pressure arrangement for stop withdrawal. This feature does not form part of the present invention but is merely described in order to show how the invention may be applied to a propeller system of the two-lock type as already disclosed in U.S. Patent Nos. 3,024,848 and 2,934,153. Thus the invention may be employed in systems relying only on a single independent line for stop withdrawal.

We claim:

1. A variable pitch propeller having pitch control means comprising a hydraulic piston-and-cylinder motor connected to the propeller blades to alter the pitch thereof, a plurality of stops operable to prevent relative movement of the piston and cylinder, in a sense to fine the propeller pitch, beyond respective predetermined fine pitch settings, supply conduits for supplying pressure fluid to opposite

ends of the cylinder of said motor, a source of pressure fluid, a further fluid conduit which is independent of said supply conduits and which is connected to said source, means for effecting successive increases in the pressure in said further conduit, and withdrawal means for withdrawing said stops successively when said successive increases of pressure occur in said further fluid conduit.

2. A variable pitch propeller as claimed in claim 1, wherein the means for effecting successive increases in the pressure in said further condiut comprises a relief valve disposed in said further conduit and means selectively operable to adjust the pressure at which the relief valve operates.

3. A variable pitch propeller as claimed in claim 1, wherein the means for effecting successive increases in the pressure in said further conduit comprises a plurality of relief valves disposed in the conduit and set to operate at different pressures.

4. A variable pitch propeller having pitch control means comprising a hydraulic piston-and-cylinder motor connected to the propeller blades to alter the pitch thereof, a plurality of stops operable to prevent relative movement of the piston and cylinder, in a sense to fine the propeller pitch, beyond respective predetermined fine pitch settings, supply conduits for supplying pressure fluid to opposite ends of the cylinder of said motor, a source of pressure fluid, a further fluid conduit which is independent of said supply conduits and which is connected to said source, means for effecting successive increases in the pressure in said further conduit, an auxiliary piston-and-cylinder motor whereof the piston is engageable with the stops to withdraw them successively with said successive increases in pressure in the further conduit, a spring-loaded valve in said further conduit which valve provides a plurality of spaced ports and a valve member which is movable against the spring loading by different amounts in response to successive increases of pressure in the further conduit to open said ports in succession, said ports serving when opened by the valve member to permit fluid from the further conduit to flow therethrough to act on the piston of the auxiliary motor in a sense to withdraw the stops, and follow-up means connected to move with the piston of the auxiliary motor and operative to close off the ports opened by the valve member.

5. A variable pitch propeller having pitch control means comprising a hydraulic piston-and-cylinder motor connected to the propeller blades to alter the pitch thereof, two supply conduits for supplying pressure fluid to respective ends of the cylinder of said motor, a source of pressure fluid, a third fluid conduit which is independent of said two supply conduits and which is connected to said source, at least two stops operable to prevent relative movement of the piston and cylinder, in a sense to fine the propeller pitch, beyond respective predetermined fine pitch settings, selectively operable means for effecting successive increases in the pressure in said third conduit, an auxiliary piston-and-cylinder motor whereof the piston is enagageable with the stops to withdraw them successively with said successive increases in pressure in the third conduit, a spring-loaded valve in said third conduit, which valve provides port means for the respective stops and a valve member controlling the port means, the port means for each stop being spaced from that for each other stop, the valve member being movable against the spring loading by different amounts in response to said successive increases of pressure in the third conduit to open said port means in succession, and each port means serving when opened by the valve member to permit pressure fluid from the said third conduit to flow therethrough to act on the piston of the auxiliary motor to withdraw the stop associated with that port means, and follow-up means connected to move with the piston of the auxiliary motor and operative to close off the port means opened by the valve member as the movement of the piston of the auxiliary motor withdraws the associated stop.

6. A variable pitch propeller as claimed in claim 2, comprising solenoid means operatively connected to the relief valve.

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