March 7, 1944. C. KELLER 2,343,416

VARIABLE-PITCH PROPELLER

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Fig. 1.

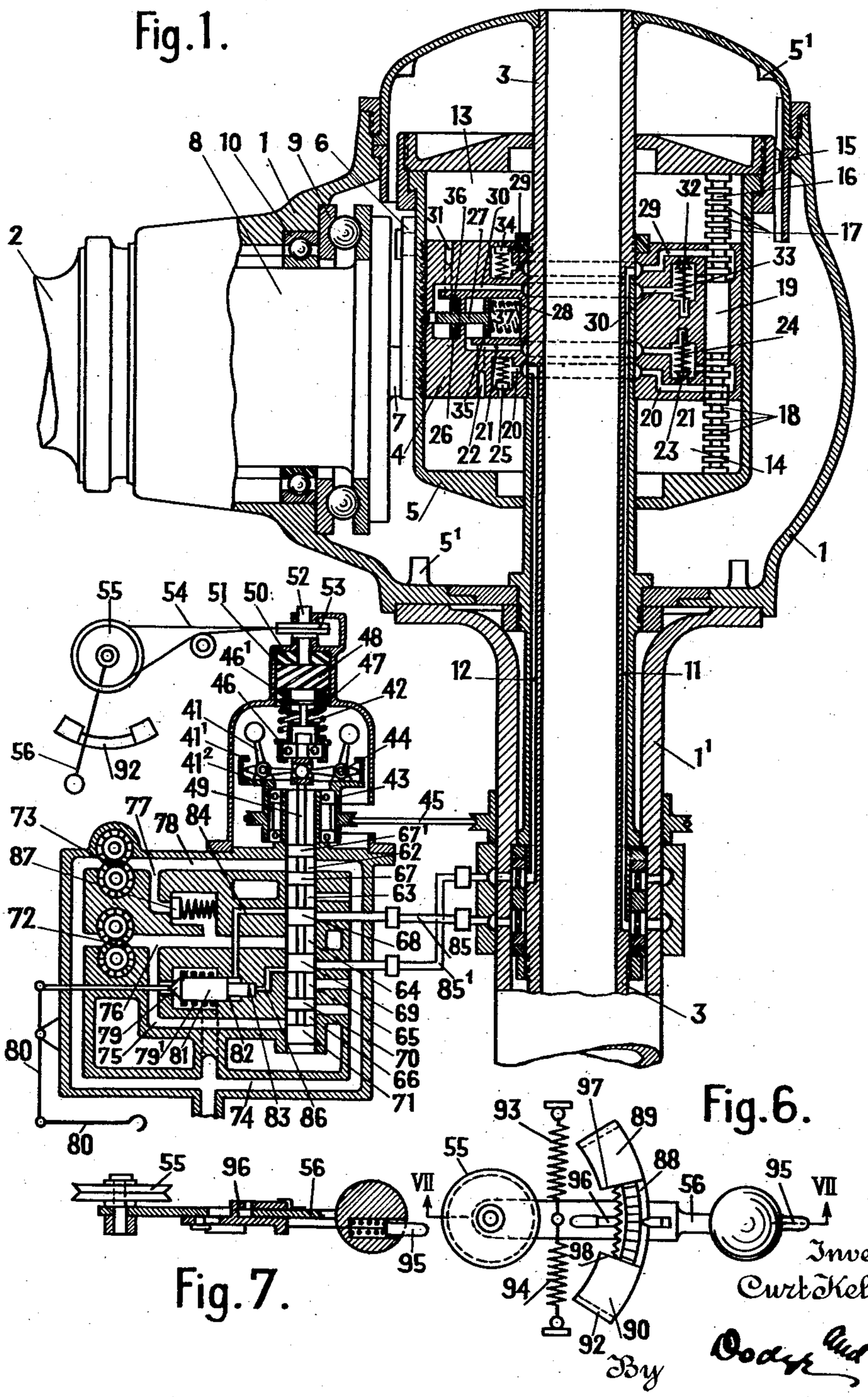

Fig. 6.

Fig. 7.

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Fig. 2.

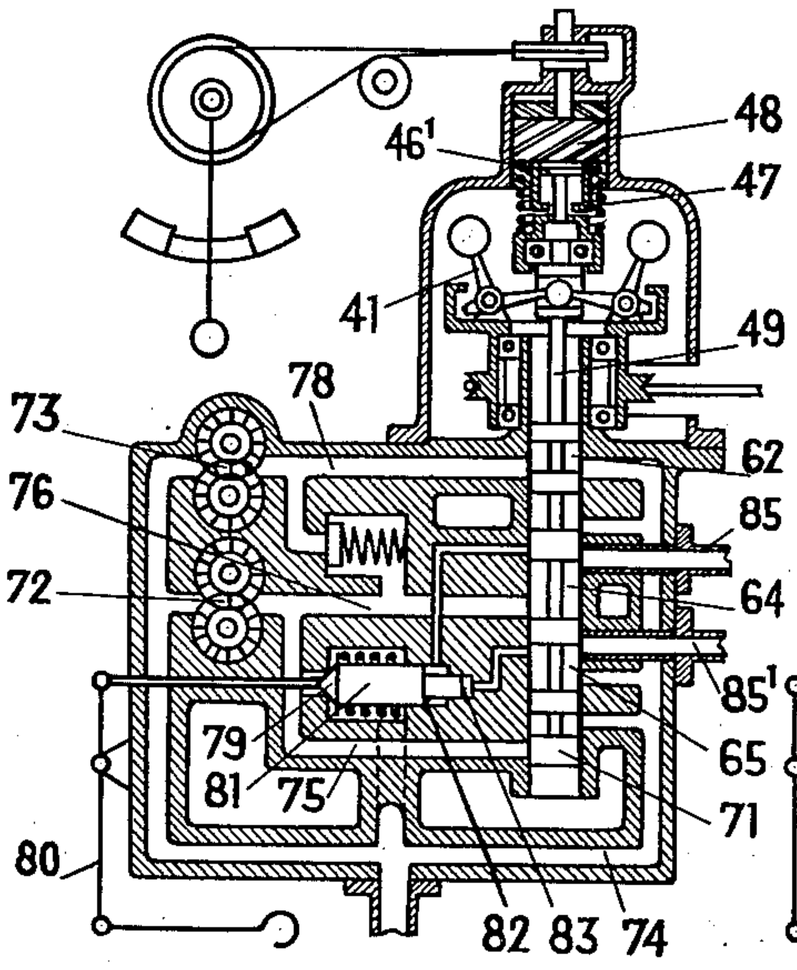

Fig. 3.

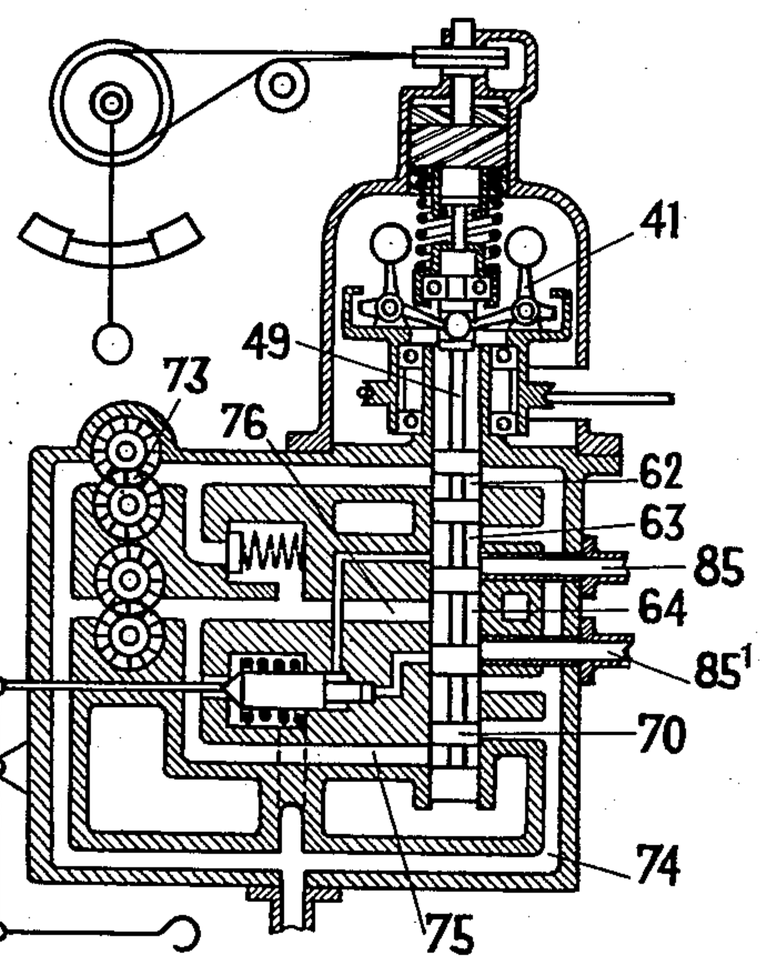

Fig. 4.

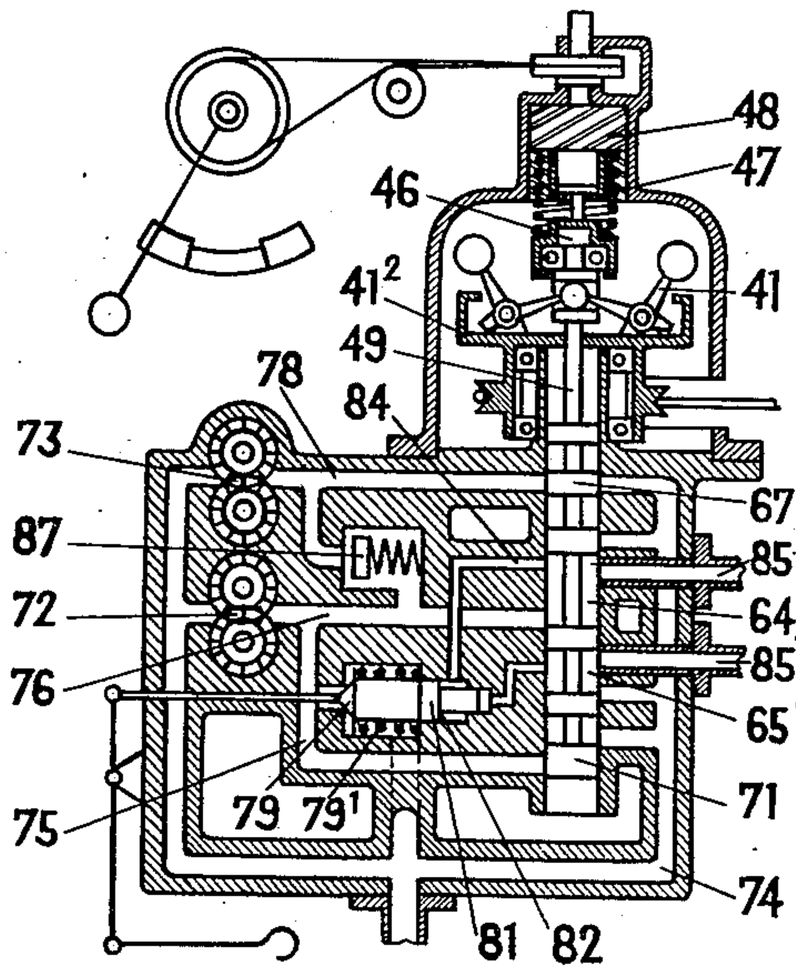

Fig. 5.

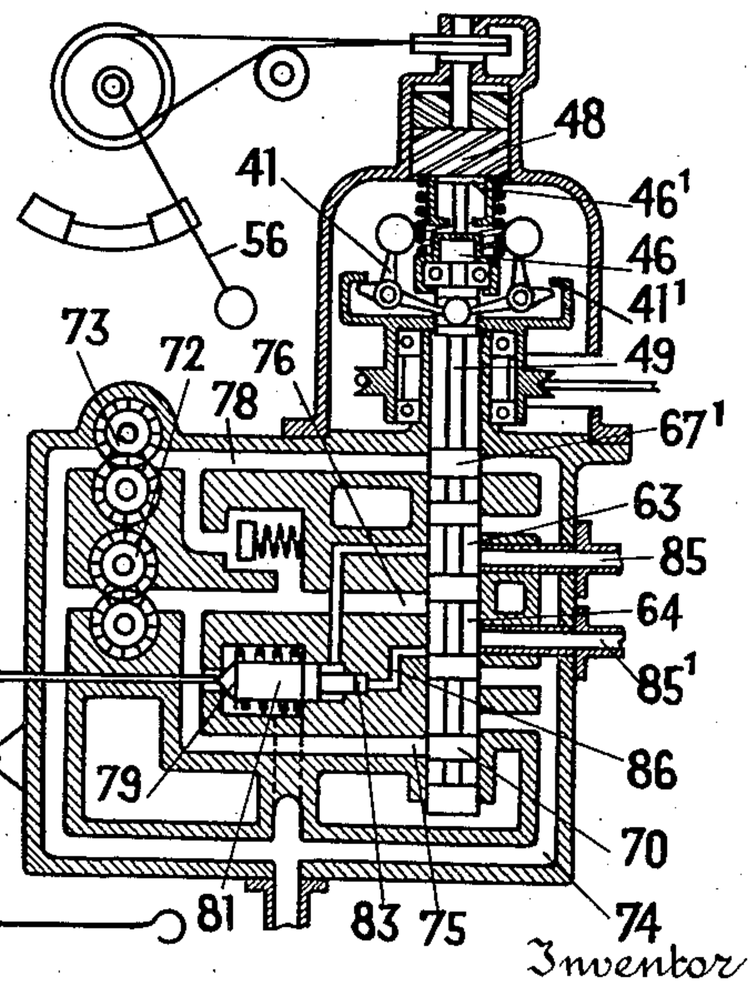

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Fig. 9.

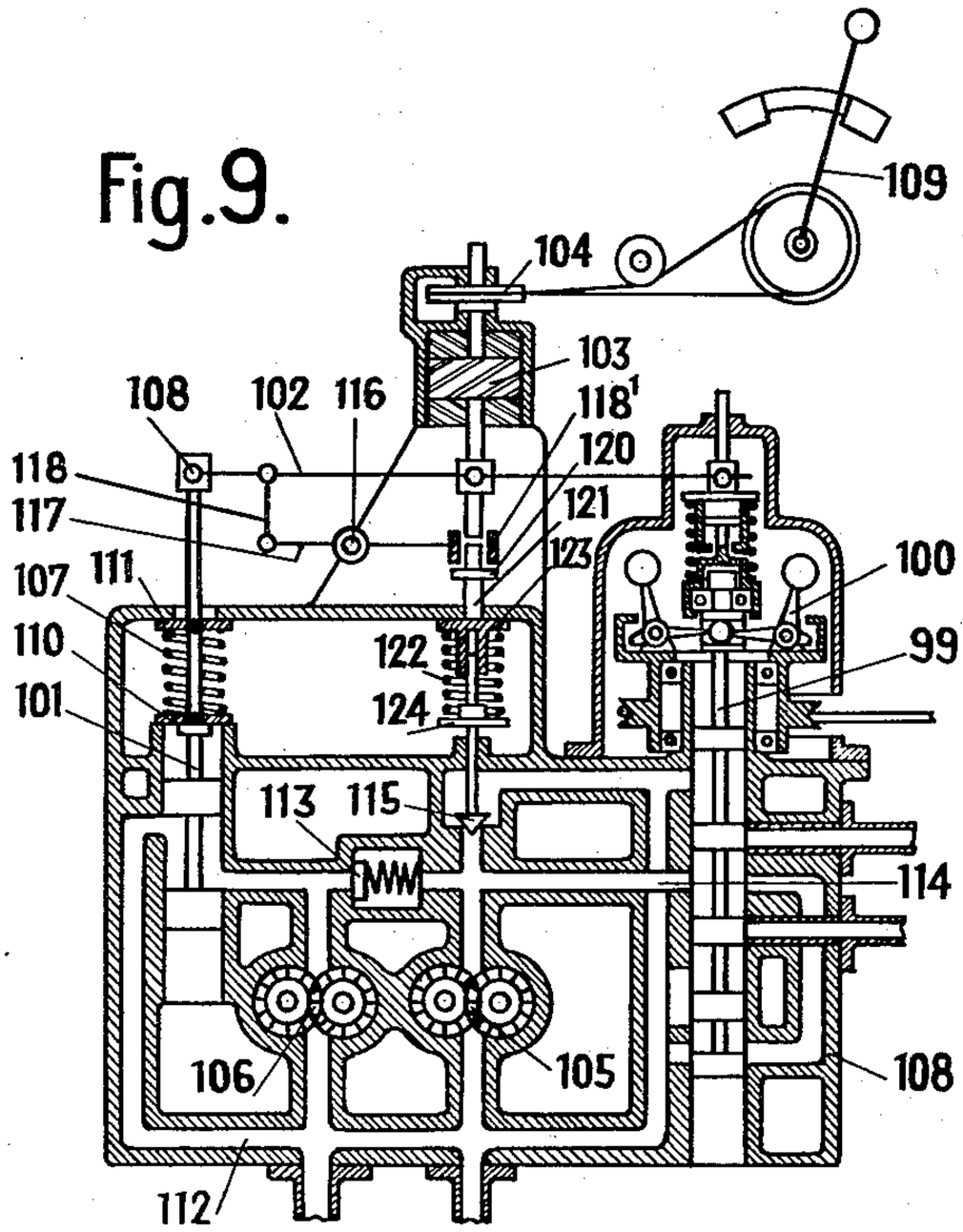


Fig. 11.

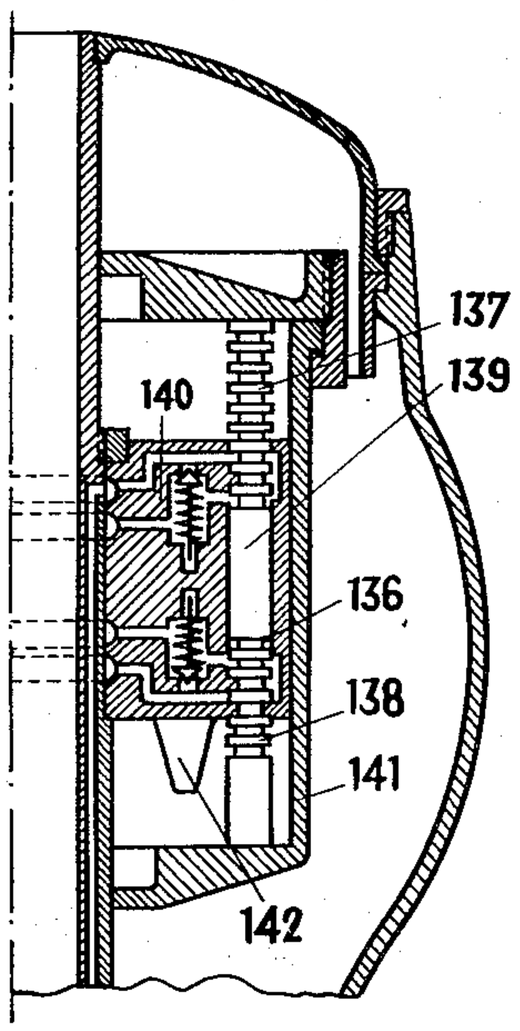


Fig. 8.

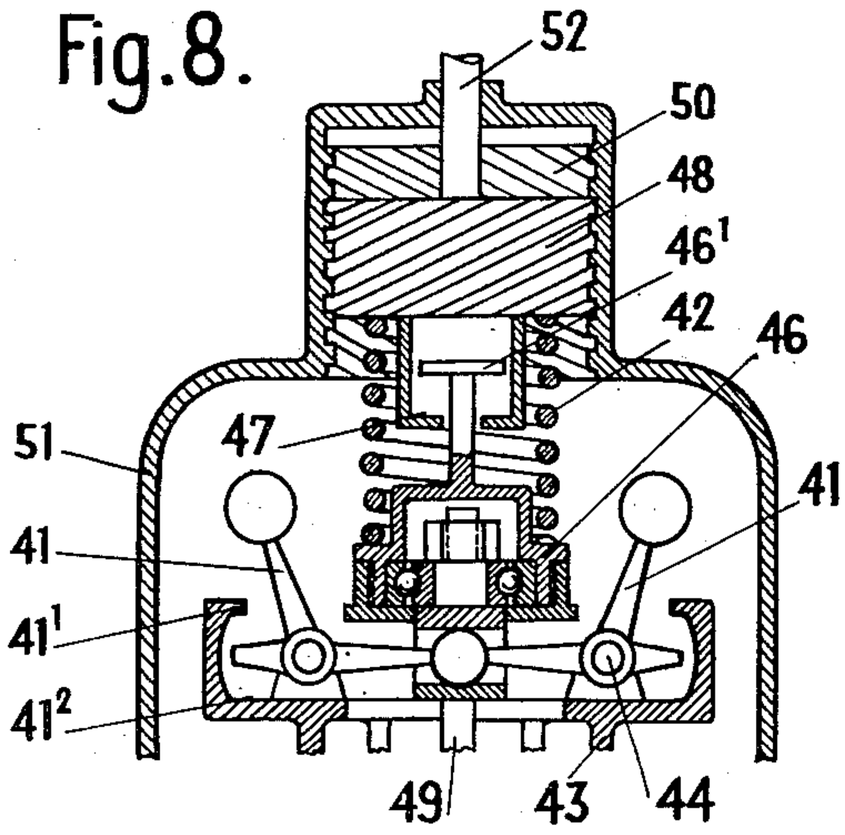
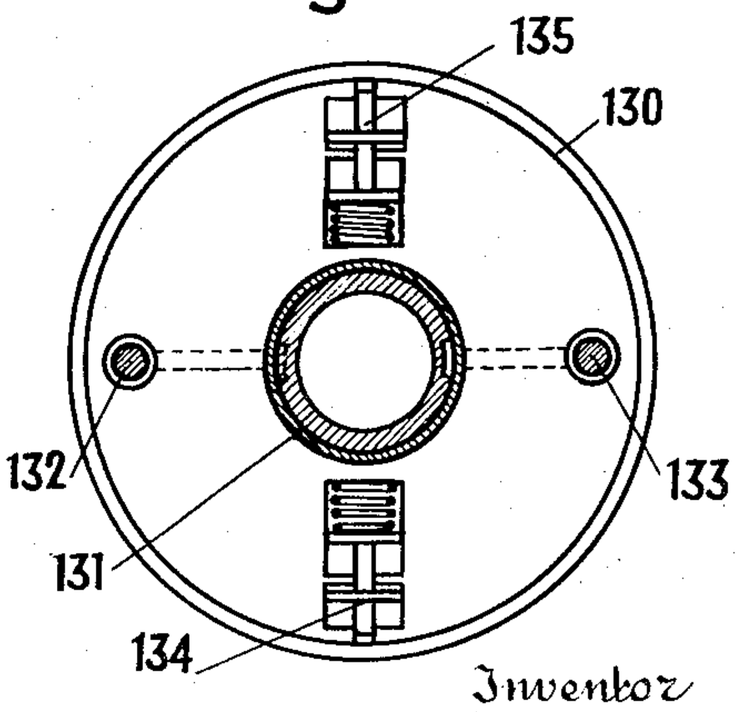


Fig. 10.



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2,343,416

UNITED STATES PATENT OFFICE

2,343,416

VARIABLE-PITCH PROPELLER

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Application May 10, 1940, Serial No. 334,443
In Switzerland June 22, 1939

10 Claims. (Cl. 170—163)

This invention relates to means for controlling hydraulically-actuated variable-pitch propellers, especially propellers for aircraft, the pitch-adjustment of which is not confined to a normal predetermined range but extends also beyond the limits of such range.

In order to keep the driving engine of propellers working at a constant speed, governing devices, which permit the pitch of the propeller blades to be adjusted within a normal predetermined and comparatively small range of about 15° to 30° are provided. In the case of propellers for aircraft, however, it is also necessary under certain conditions of flight to adjust the blades into more extreme positions, beyond this normal range of pitch-adjustment. Such positions are the feathered position (in which the blades are turned into the direction of flight) and the braking position. Adjustment of the propeller blades into the feathered position becomes necessary in the case of multi-engined aircraft when one of the engines cuts out. By bringing the blades of the propeller allotted to the inactive engine into the feathered position this propeller can be prevented from responding to the wind, due to the motion of the plane, and so driving the defective engine, to the possible detriment of the latter. The blades are brought into the braking position when it is required to obtain a negative propeller thrust, so as to reduce speed when diving or to reduce the length of the landing run.

The two extreme blade positions just discussed always involve a certain amount of risk when flying, if they cannot be attained with sufficient rapidity or without a deliberate action on the part of the pilot. In order to satisfy these requirements, devices have already been proposed to cause the propeller blades, from a particular position onwards, to offer a greater resistance to adjustment, so that a greater force has to be overcome, than is the case of the normal range of pitch-adjustment. In known constructions of this kind it has been necessary to provide additional means, which have to be operated separately by the pilot in order to adjust the blades beyond the normal predetermined range into more extreme positions. This requires a further manipulation on the part of the pilot and also involves an increase in weight, as well as a more complicated adjusting device which takes up a comparatively large amount of space.

The object of this invention is to provide a controlling device of the kind first referred to which will permit the propeller to be adjusted beyond the predetermined pitch-range into the braking position, on the one hand, and into the feathered position, on the other hand, each by the use only of the same means as are employed for varying the pitch within the limits of the normal predetermined range. By the means of the invention a pitch adjustment over a range of about 100° can be obtained with a minimum number of components, so that weight is reduced to a minimum, while the mechanism is very reliable in operation, of compact and simple construction and is easy to manipulate and to service. At the same time, the construction is such as to ensure with certainty that no adjustment of the blades beyond the predetermined normal pitch-range can take place inadvertently or through incorrect functioning of the system or in any way except by intentional manual operation. Thus, movement of the propeller blades into the braking position or into the feathered position is impossible without deliberate action on the part of the pilot.

The present invention meets the above requirements by providing at least one control member adapted to interrupt the supply of pressure medium to the pitch adjusting mechanism proper, when a limit of the predetermined range of pitch-adjustment is reached, further actuation of the said blade adjusting devices for the purpose of moving the blades beyond the said predetermined range into more extreme positions being then possible only after a higher hydraulic adjusting pressure is developed to open an auxiliary valve member for the hydraulic pressure medium.

The controlling device according to this invention also includes a governing member operated by the action of centrifugal force and a change-over member which controls the movements of the blades into their feathered and braking positions, these members being connected to each other in such a way that they can be adjusted by a deliberate operation on the part of the pilot to provide an augmented supply of pressure fluid at a higher pressure. In a controlling device of this kind, therefore, a single external and deliberate action enables a change-over to be made from the normal working range into either one of the extreme terminal positions of the blades.

The accompanying drawings show, partly in a simplified mode of representation, and by way of example, constructional embodiments of the subject matter of the invention. In these drawings,

Fig. 1 is a partial axial longitudinal section through a variable-pitch propeller for aircraft, to which the present invention is applied, the

parts of the device controlling the pitch of the blades being illustrated in the position which they assume when the propeller runs at a predetermined normal speed.

Figs. 2 and 3 show the positions of some of the parts of the pitch controlling device when the propeller is rotating at a speed above and below, respectively, the normal number of revolutions.

Fig. 4 shows the positions which some of the parts of the pitch controlling device assume when the propeller blades are adjusted to the fully-feathered position.

Fig. 5 shows the positions which the said parts assume when the propeller blades are adjusted to the braking position.

Fig. 6 shows a manually operable switching device which permits of the range pitch-control to be varied.

Fig. 7 is a section on the line VII—VII of Fig. 6.

Fig. 8 shows a detail of Fig. 1 on an enlarged scale.

Fig. 9 shows a second constructional embodiment of the pitch controlling device.

Fig. 10 shows in a transverse vertical section a modification of a detail.

Fig. 11 shows in a partial axial longitudinal section through a variable-pitch propeller a further modification of a detail.

Referring to the drawings, 1 denotes a hub casing, which is fixed to a driving shaft 1^1. This casing 1 supports the propeller blades 2 (only one of which is shown) and, at the same time, it encloses all the moving parts of the pitch adjusting mechanism proper. 3 denotes a central, hollow guide tube made in two parts (which, in this case, permits of firing through the hub), and on this tube 3 is fixed a piston 4, on which a double-acting control cylinder 5 is axially movable. Coupling links 6 connect the cylinder 5 with the respective pins 7 of the several blade holders 8. By means of the parts 6, 7, 8, therefore, longitudinal movement of the control cylinder 5 is converted into rotary motion of the propeller blades 2 which are supported in the hub. The blade holders 8 are each supported by a thrust bearing 9 and radial bearings 10 in the hub casing 1. The piston 4 which is fixed relatively to the guide tube 3 forms, together with the movable control cylinder 5, a servomotor.

The supply and exhaust of the pressure medium (preferably oil under pressure) to and from the cylinder chambers 13, 14, on opposite sides of the piston 4, are effected through two independent longitudinal passages 11, 12 formed in the walls of the central guide tube 3. According to the sense in which the blades are to be adjusted, the chamber 13 is connected, in a manner hereinafter more fully described, to a source of oil under pressure, while the chamber 14 is connected with an oil outlet, or vice versa. This produces endwise movement of the cylinder 5 and, therewith, a change in the angle of incidence of the blades 2. A spline 15 prevents the axially movable control cylinder 5 from rotating relatively to the hub casing 1.

For the purpose of hydraulically limiting the stroke of the cylinder 5 and, therewith, the rotary movement of the screw blades 2, within a predetermined range of pitch-adjustment, a control rod 16 is provided. This rod is arranged with its axis parallel with the axis of the propeller and, over parts of its length, it has groups or series of grooves 17, 18. It passes freely through the piston 4 and partakes in the axial movement of the cylinder 5. A part 19 of this control rod 16, lying between the two groups of grooves 17, 18 is made smooth; that is to say, it has no grooves in it. The longitudinal passage 12 in the guide tube 3 communicates with a port 20 in the piston 4, which is also provided with other ports 21 and 22 of which the port 22 opens into the chamber 14 of the control cylinder 5.

Communication between the ports 20 and 21 is controlled by the control rod 16, the grooved part 18 of which enables communication to be established whereas the smooth part 19 interrupts such communication.

23 denotes an overflow valve which is loaded by a spring 24 and, when in the open position, establishes another path of communication between the ports 20 and 21. A spring-loaded non-return valve 25 controls communication between the cylinder chamber 14 and the port 20. Communication between the ports 21 and 22 is controlled by a collar-like part 35 of a locking device 27 which is constructed in the form of a double piston. This locking device 27 is loaded by a spring 28, which tends to force it against the inner wall of the control cylinder 5, so as to prevent the latter from moving longitudinally. The longitudinal passage 11 in the guide tube 3 communicates with a port 29 in the piston 4 which also has other ports, designated 30 and 31, of which the port 31 opens into the chamber 13 in the control cylinder 5.

Communication between the passages 29 and 30 is likewise controlled by the control rod 16 and in a manner similar to that described with reference to the ports 20 and 21, that is to say, the grooved part 17 of this control rod enables communication to be established between the ports 29 and 30 while the smooth part 19 interrupts such communication. 32 denotes an overflow valve, which is loaded by a spring 33 and, when in the open position, establishes another path of communication between the ports 29 and 30. A spring-loaded non-return valve 34 controls communication between the chamber 13 in the control cylinder 5 and the port 29. Communication between the ports 30 and 31 is controlled by a second collar-like part 26 of the locking device 27. The collar-like part 26 is pierced by a fine bore 36 while the collar-like part 35 is pierced by a fine bore 37. It is also to be remarked that the springs 24 and 33, which respectively load the overflow valves 23 and 32, are of such strength, that they only allow these valves to open when the pressure of the liquid in the ports 20 and 29, respectively, is considerably greater than that required to adjust the propeller blades within the normal predetermined range of pitch adjustment.

The means controlling the admission of a liquid under pressure to the longitudinal passages 11 and 12 and the outlet of such liquid from these passages, respectively, which means serve also to keep the speed of the engine driving the propeller constant under greatly varying outputs, comprise pendulum levers 41, which, when rotated, establish a state of equilibrium with a force exerted by a spring 42. The pendulum levers 41 are pivoted at 44 in a cylindrical casing 43 which is rotated by a cable transmission 45 from the shaft 1^1 driving the propeller. On the casing 43 are provided two stops 41^1, 41^2 for the pendulum levers 41. The latter are operatively connected to a governing spindle 49 adapted to be displaced axially by these levers 41.

According to the position of spindle 49 fluid under pressure for effecting adjustment of the blades 2 is allowed to flow into either one and simultaneously to be discharged from the other of the above mentioned longitudinal passages 11 and 12. The axial displacements of the governing spindle 49 are transmitted to a cup 46 (shown on an enlarged scale in Fig. 8) provided at its upper end with an extension 46^1 which is adapted to cooperate with two stops 47 and 48. The stop 48 is designed as a threaded piston engaging into a corresponding thread 50 of a surrounding hood 51. The latter is fixed relatively to the piston 48. The stops 47 and 48 prevent the governing spindle 49 from being moved, within the normal working range of the governing mechanism, by the action of centrifugal force or by the spring 42, to a greater extent than corresponds to the stroke prescribed for this spindle.

To a shaft 52 formed integral with the piston 48 is fixed a cable pulley 53 worked by a cable 54 which passes also over a pulley 55. The latter can be rotated by means of a hand lever 56 by a deliberate operation on the part of the pilot. By rotating the piston 48 by means of the hand lever 56 and the cable transmission 55, 54, 53, the force exerted by the spring 42 can be varied. This enables the centrifugal force exerted by the levers 41 to be brought into equilibrium with the force of the spring 42 in the mid-position of the governing spindle 49 for different numbers of revolutions of the casing 43. Thus the normal speed of the propeller can be adjusted to any desired value. The extension 46^1 of the cup 46 is so constructed, that within the normal working range of the control device, within which range the device acts as a centrifugal governor, the stop 47 and the piston 48 permit unhindered working of the governing spindle 49 under the influence of the pendulum levers 41.

The lower part of the governing spindle 49, as depicted in the drawings, is furnished with annular grooves 62, 63, 64, 65 and 66 and packing surfaces 67^1, 67, 68, 69, 70 and 71 forming in effect, a balanced piston valve. With the help of these parts an increased fluid supply at an increased pressure is afforded by two pumps 72 and 73 when required (and in a manner to be more fully described hereinafter). This augmented supply is delivered to the longitudinal passages 11 or 12 of the tube 3. The pumps 72 and 73 are housed in the same casing as the governing spindle 49 and take oil from a common suction branch 74, which may be connected either to the lubricating system of the engine or to a separate reservoir (neither of such sources being shown in the drawings). The pump 72 delivers into a pressure duct having two branches 75 and 76, while the pump 73 delivers into another pressure duct with two branches 77 and 78. An overflow or loaded relief valve 79, controlled by a spring 79^1, enables the pressure in the branches 75 and 76 to be kept constant; when the pressure rises above a prescribed value this valve permits parts of the fluid under pressure to flow off directly into the suction branch 74.

The same relief valve 79 can also be lifted by a deliberate action on the part of the pilot through a system of transmission rods and levers 80, in which case the whole of the liquid delivered by the pumps 72 and 73 can then flow directly into the suction branch 74, so that the hydraulically-actuated mechanism for varying the pitch is set out of action.

The relief valve 79 is rigidly connected to a piston 81, having two faces 82 and 83, which are of equal area and which do not communicate with each other spatially. Into the space bounded by the face 82 opens a channel 84, while a channel 86 opens into the space bounded by the piston face 83. A spring-loaded non-return valve 87 permits of an overflow of liquid from the branch 77 into the branch 76, while preventing reverse flow, from 76 into 77. The references 85 and 85^1 denote two conduits effecting a connection between the bore in which the governing spindle 49 is lodged and the longitudinal passages 11 and 12 of the tube 3, respectively.

The hand lever 56 for actuating the cable transmission 53, 54, 55 has three ranges of movement 88, 89 and 90 indicated on a plate 92, as shown in Fig. 6. Two springs 93 and 94 tend to hold the lever 56 in its mid-position. The range of movement 88 corresponds to the normal working range of the controlling device; within this range of control the propeller blades can only be adjusted within a predetermined normal range of pitch-adjustment. Within this range the lever 56 can be moved by hand into any desired intermediate position, in which it is self-locking. The range of movement 89 corresponds to that extreme position of the governing spindle 49, in which it initiates shifting of the propeller blades into the feathered position, while the range 90 corresponds to that position of the said governing spindle in which it initiates shifting of the propeller blades into the braking position. In order to shift into the ranges of movement 89 and 90, it is necessary to actuate a press button 95. This retracts a spring-controlled pawl 96 in a radial direction, through a distance equal to the radial length of a shoulder 97 or 98 of the plate 92. In the ranges of movement 89 and 90 the lever 56 is not self-locking. If it be released, the springs 93 and 94 tend to bring it back into its mid-position.

The above described controlling device works in the following manner:

In Fig 1 the various parts are shown in the position which they assume when the propeller is running at the normal predetermined speed. The governing spindle 49 is in its mid-position, in which the stops 47 and 48 do not affect its movement in any way and in which the annular groove 66 connects the branch 75 and the annular groove 62 connects the branch 78 directly with the suction branch 74. The release valve 79 and the non-return valve 87 are closed. The fluid delivering pumps 72 and 73 circulate the pressure fluid in closed cycles, so that none of it is delivered either into the longitudinal passage 11 or into the passage 12. The condition just described (and characterised by the short-circuiting of the pressure fluid) are those which, in practice, are likely to be maintained for the longest periods, as, for instance, in the case of commercial aircraft, in steady flight. Such a short-circuited condition with regard to the pressure fluid can be produced at any time by lifting the release valve 79, for which purpose the system of levers and rods 80 must be deliberately manipulated by the pilot.

If the speed of the propeller and of the engine which drives it rise above a predetermined normal value, the centrifugal force acting on the levers 41 overcomes the force exerted by the spring 42 and the parts then assume the position shown in Fig. 2, in which the governing spindle 49 has been shifted, compared with the position shown in Fig. 1, somewhat upward, the stops 47 and 48 still having no restraining influence on its

movement. The surface 71 of the governing spindle 49 now closes the branch 75 of the pressure duct of the pump 72, while the pump 73 is short-circuited, as before, through the annular groove 62 of the spindle 49. The pressure fluid passes from the branch 76, through the annular groove 64 and the conduit 85, into the longitudinal passage 11. At the same time, the annular groove 65 allows pressure fluid to escape from the longitudinal passage 12 and through the conduit 85^1 into the suction branch 74. These movements of the pressure fluid cause the propeller blades 2 to be adjusted to a steeper pitch, the result being that the propeller absorbs more power. Consequently, the driving engine is slowed down until it again reaches the normal predetermined speed, thus bringing the governing spindle 49 back again into its mid-position.

The adjustment of the blades 2 to a steeper pitch is effected in the following manner: The oil under pressure admitted to the longitudinal passage 11 of the tube 3 passes through the port 29 and by way of the grooves 17 in the rod 16, into the port 30 and thence through the port 31 into the chamber 13 in the control cylinder 5. This latter will, therefore, be moved upward, liquid under pressure passing out of the chamber 14 past the opened non-return valve 25 into the port 26 and thence into the longitudinal passage 12. Since the control rod 16 takes part in the longitudinal movement of the cylinder 5, its smooth part 19 will, in the course of the longitudinal movement in question be brought into a position in which it will interrupt communication between the ports 29 and 30. This corresponds to one of the terminal positions of the normal predetermined range of pitch-adjustment. As soon as this interruption has taken place, the spring 28 can force the locking device 27 outwards, as the fine bore 37 in the part 35 of the device 27 allows the enclosed oil to escape. Thus the control cylinder 5 is now locked. A similar locking action also takes place when the supply of oil under pressure through the longitudinal passage 11 is interrupted for any reason, at any time. Further displacement of the cylinder 5 upward, beyond the positioned mentioned, so as to bring the blades into the fully-feathered position for example, is only possible when by a deliberate action on the part of the pilot on the lever 56 the governing spindle 49 has been shifted into the position in which pressure medium at a higher pressure than is needed for the pitch-adjustment within the above mentioned normal predetermined range is supplied to the longitudinal passage 11.

If the propeller blades 2 are to be adjusted into the feathered position, the governing spindle 49 must be brought into the position shown in Fig. 4, and if the propeller blades are to be adjusted into the braking position said spindle 49 must be moved into the position shown in Fig. 5. On movement of the piston 48 into the position shown in Fig. 4, the stop 47 carries with it the cup 46 and this, in its turn, carries with it the governing spindle 49 until the pendulum levers 41 are arrested by the stop 41^2. When the various parts are in the positions shown in Fig. 4, the action of the pendulum levers 41 is eliminated and the spindle 49 works simply as a change-over valve (with no automatic restoring action), its packing surface 67 shutting off the branch 78 and its packing surface 71 shutting off the branch 75. Closure of the branch 78 results in the liquid delivered by the pump 73 opening the non-return valve 87, so that the volume of liquid delivered by the pump 73 is added to that delivered by the pump 72. The pressure prevailing in the annular groove 64 reacts through the channel 84 upon the surface 82 of the piston 81. The action of the spring 79^1 on the release valve 79 is thereby supplemented, so that a greater pressure is now required to open this valve.

Thus, when the additional source of pressure 73 cuts in, its pressure will be brought to bear on the release valve 79, which determines the magnitude of the fluid pressure in the controlling device. Consequently the pressure in the branch 76 will rise to a higher value than it can attain when only the spring 79^1 acts on the valve 79.

Oil under pressure passes through the groove 64 and the conduit 85 into the longitudinal passage 11, while oil in the longitudinal passage 12 is released through the conduit 85^1 and the annular groove 65 into the suction branch 74. The oil under pressure, now delivered through the passage 11 to the mechanism of adjustment for the propeller blades flows under increased pressure and in greater volume, thus effecting rapid movement of the blades 2 into their feathered position.

When the parts are in the position shown in Fig. 5, which position they assume when intiating adjustment of the propeller blades to the braking position, the extension 46^1 on the cup 46 bears against the stop piston 48, while the pendulum levers 41 are arrested by the stop 41^1. The packing surface 67^1 now shuts off the branch 78 and the packing surface 70 shuts off the branch 75, so that the volumes delivered by the pumps 72 and 73 are added together in the branch 76. The pressure prevailing in the annular space 64 reacts through the channel 86 upon the face 83 of the piston 81. The pressure of the additional pump 73, therefore, again takes effect on the release valve 79, which determines the magnitude of the fluid pressure in the controlling device. Thus the closing force acting on this valve is increased, so that a higher pressure is now required to open it. The branch 76 is connected, through the annular grooves 64 and the conduit 85^1, with the passage 12 and the passage 11 is connected through the conduit 85 and the annular groove 63 with the suction branch 74. Under the influence of the increased liquid pressure and with the increased volume delivered the propeller blades 2 are rapidly adjusted into the braking position, in which they remain as long as the hand lever 56 is held in the range of movement 90.

When the higher pressure of the liquid supplied, in a manner above described, to the passage 11 is capable of opening the overflow valve 32, the liquid can flow through this valve out of the port 29 and, by-passing the control rod 16, can enter the port 30, with the result that the locking device 27 is moved inward far enough to permit the pressure medium to flow from the port 30 into the port 31 and so into the cylinder chamber 13. The resulting further movement of the control cylinder 5 upward, is, owing to the higher pressure of the actuating liquid, more rapid than in the case of the normal predetermined range of pitch-adjustment. The longitudinal movement of the cylinder 5 to the left can be finally arrested by a stop 5^1, and if, when this extreme position is reached, the pressure in the passage 11 be also reduced, the device 27 will lock the cylinder 5 in that position also.

If, on the other hand, the speed of the propeller and its driving engine drop below a pre-

determined figure, the force exerted by the spring 42 overcomes the centrifugal force acting on the pendulum levers 41 and the parts then assume the position shown in Fig. 3. The surface 70 of the spindle 49 then shuts off the pressure branch 75 from the suction branch 74. The pump 73 is still short-circuited through the annular groove 62. Pressure oil can now pass through the annular groove 64 and the conduit 85^1, from the branch 76 into the passage 12 while, through the conduit 85 and annular groove 63 pressure oil is released from the passage 11 to pass into the suction branch 74. The result of these movements of the pressure fluid is to bring about a reduction in the pitch or angle of incidence of the propeller blades, so that the power absorbed by the propeller decreases and the engine driving same therefore speeds up again to the predetermined number of revolutions causing the pendulum levers 41 to return the governing spindle 49 to its mid-position.

The pressure oil supplied to the longitudinal passage 12 passes from this into the port 20 and thence, past the grooves 18, into the port 21 and, after the locking device 27 has moved inward, through the port 22 into the cylinder chamber 14. The cylinder 5 is thus moved downward until the smooth part 19 of the rod 16 masks the ports 20 and 21. In order to permit further downward movement of the cylinder 5, from the position just described, an increase in the oil pressure must be brought about by a deliberate shifting of the hand lever 56 into the range 89 or 90, the increased oil pressure opening the overflow valve 23, whereupon the oil under this higher pressure, passes from the port 20, through the opening uncovered by the said valve 23, into the port 21 and thence through the port 22 into the chamber 14. The other reactions which take place should be clear from what has been stated, at greater length, above, so that any more detailed description of them at this stage would be superfluous.

The controlling device described has the advantage that it does not permit motion of the propeller blades 2 beyond a predetermined normal range of pitch-adjustment without deliberate manipulation of the hand lever 56. On the other hand the propeller blades 2 return automatically and positively from the more extreme positions to the normal range of pitch-adjustment when the lever 56 is released. All the operations are controlled by the governing spindle 49, which acts sometimes as a speed governing device and sometimes only as a change-over member which can be actuated manually and which then enables more extreme positions of the blades to be reached.

The constructional embodiment shown in Fig. 9 differs from the one already described mainly by the fact that a governing member 99, which is moved by the action of pendulum levers 100, and a change-over member 101, which enables the blades to be adjusted into their feathered and braking positions, are constructed as two separate units, though housed in the same casing 108. The members 99 and 101 are coupled by a lever 102 and can be adjusted by a threaded piston 103 which is operatively connected with this lever and has a pulley 104 mounted on it for a cable transmission adapted for manual operation by a hand lever 109. By an intentional manipulation of this lever 109 an additional source of pressure, in the form of a pump 106, can be added to the pressure source or pump 105 which supplies the fluid pressure required for adjustment of the propeller blades within the normal range of pitch-adjustment. A powerful spring 107 ensures that the end 108 of the lever 102 acts as a fixed fulcrum as long as the propeller and its driving engine run at a normal predetermined speed, the change-over piston 101 being held in such a case in the mid-position shown in Fig. 9. On the rod of the change-over piston 101 are mounted two plates 110 and 111 which serve to compress the spring 107. When the spring 107 is compressed by the plate 110, or 111, the change-over piston 101 cuts off the direct passage of the fluid delivered by the pump 106 to the suction branch 112 and, consequently, the delivery of the pump 106 is added to that of the pump 105. The fluid under pressure can now get past the non-return valve 113 into the pressure duct 114. An overflow or release valve 115 determines the magnitude of the liquid pressure in the controlling system.

To the lever 102 is jointed a rod 118, which is articulated in its turn to a lever 117 having its fulcrum at 116. The lever 117 carries a sleeve 118^1 adapted to be pressed against a plate 120 which is fixed to a rod 121 arranged immediately below the shaft of the piston 103. The reference 122 denotes a spring bearing at one end against a plate 123 also fixed to the rod 121 and at the other end against a plate 124 fixed to the shaft of the valve 115. When the lever 102 is deliberately operated by the pilot so as to swing downward about its pivot 108, the shaft of the piston 103 is pressed against the rod 121 which is forced in its turn against the shaft of the valve 115. Again, when the said lever 102 is swung upward about its pivot 108, the sleeve 118^1 is pressed against the plate 120 of the rod 121. In both cases the spring 122 is compressed, whereby the loading on the valve 115 is increased. This involves a rise in the liquid pressure within the controlling device, so that a greater volume of pressure medium and an increased hydraulic pressure are available for the adjustment of the propeller blades beyond the normal predetermined range of pitch-adjustment.

In order to secure greater cross sectional areas of flow and a more symmetrical arrangement, two or more control rods arranged parallel with the axis of the propeller, moving with the axially displaceable cylinder and passing through the stationary piston may be provided, as shown in Fig. 10 in a transverse vertical section. In this figure the reference 130 denotes the displaceable cylinder and 131 the propeller shaft made in two parts whilst the references 132 and 133 denote two control rods and the references 134 and 135 locking means for the cylinder 130.

Under certain circumstances it suffices for the blades to be adjustable to only one extreme terminal position (e. g., to the braking position). In such a case it is necessary, if the control member be constructed, as shown in Fig. 11, in the form of a rod 136 with two groups of grooves 137 and 138 and a smooth portion 139 between them, for this smooth portion 139 to come into action only when the one limit of the predetermined normal range of pitch-adjustment is reached. When the other limit of this range is reached, movement of the axially displaceable cylinder 141, and thus of the means proper effecting the adjustment of the blades beyond this limit is prevented by a stop 142 on the fixed piston 140.

The invention may also be applied to ships'

propellers, to propeller wheels for rotary machines, e. g., blowers and turbines with adjustable rotor blades, and on similar machines.

What is claimed is:

1. In a variable-pitch propeller in combination, a hub, a plurality of blades arranged on said hub for adjustment about their longitudinal axis, means displaceable by the action of a hydraulic pressure medium and comprising a piston arranged coaxially to said hub and a cylinder coaxially displaceable relative to said piston and operatively connected to the blades for effecting the adjustment thereof, ports in the piston for the admission and exhaust of hydraulic pressure medium to and from the cylinder chambers on opposite sides of this piston, a rod with two groups of grooves and a smooth part between these latter, said rod being mounted for movement with the cylinder in a direction parallel to the axis of the propeller shaft and passing through said piston, the admission and exhaust of pressure medium through the ports in the piston being permitted by the groups of grooves in the control rod or cut-off by the smooth part thereof according to the relative position of the piston and the displaceable cylinder, and auxiliary valve members for the hydraulic pressure medium allowing of by-passing said control rod for the purpose of supplying further pressure medium to the one or the other of the cylinder chambers in order to effect a further adjustment of the blades, any by-passing of said control rod being possible only after increased hydraulic adjusting pressure has been able to open one of said auxiliary valve members.

2. In a variable-pitch propeller in combination, a hub, a plurality of blades arranged on said hub for adjustment about their longitudinal axis, means displaceable by the action of a hydraulic pressure medium and comprising a piston arranged coaxially to said hub and a cylinder coaxially displaceable relative to said piston and operatively connected to the blades for effecting the adjustment thereof, ports in the piston for the admission and exhaust of pressure medium to and from the cylinder chambers on opposite sides of this piston, a rod mounted for movement with the cylinder in a direction parallel to the axis of the propeller shaft and passing through said piston, the admission and exhaust of the pressure medium through the ports in the piston being controlled by said rod in dependence on the relative position of the piston and the displaceable cylinder, and spring-loaded overflow valves arranged in said piston and which, when the admission of pressure medium to the cylinder chambers has been shut off by the control rod and after the pressure of the hydraulic medium has been increased, open to allow pressure medium to by-pass the control rod and to flow into a chamber of the displaceable cylinder on the one or the other side of the piston, so as to produce a further movement of the cylinder and thus a further adjustment of the propeller blades.

3. In a variable-pitch propeller in combination, a hub, a plurality of blades arranged on said hub for adjustment about their longitudinal axis, means displaceable by the action of a hydraulic pressure medium and operatively connected to said blades, an operation of said means effecting an adjustment of the blades and thus a variation of the propeller pitch, a source of hydraulic pressure supplying liquid under pressure to said blade-adjusting means, an additional source of hydraulic pressure also adapted to supply liquid under pressure to said blade-adjusting means, a member determining the magnitude of the hydraulic pressure acting upon the blade adjusting means, a governing member operated by the action of centrifugal forces and a change-over member, both these members controlling the distribution of the hydraulic pressure medium to said blade-adjusting means, a further member adapted to interrupt the supply of hydraulic pressure medium to said blade-adjusting means when a limit of a normal predetermined pitch range is reached, auxiliary valve means for the hydraulic pressure medium, which permit a further actuation of said blade-adjusting means for the purpose of moving the blades beyond that predetermined pitch range only after increased hydraulic adjusting pressure has been able to open said auxiliary valve means, and means connecting said governing member and said change-over member in such a way that they can be adjusted by a deliberate manual operation for the purpose of connecting said additional source of hydraulic pressure to said other source of hydraulic pressure, said member determining the magnitude of the hydraulic pressure acting on the blade-adjusting means being thereby acted upon in such a way as to increase the hydraulic pressure, so that a greater quantity of pressure medium and an increased hydraulic pressure are available for adjusting the blades beyond the said normal predetermined pitch range.

4. In a variable-pitch propeller in combination, a hub, a plurality of blades arranged on said hub for adjustment about their longitudinal axis, means displaceable by the action of a hydraulic pressure medium and operatively connected to said blades, an operation of said means effecting an adjustment of the blades and thus a variation of the propeller pitch, a source of hydraulic pressure supplying liquid under pressure to said blade-adjusting means, an additional source of hydraulic pressure also adapted to supply liquid under pressure to said blade-adjusting means, a member determining the magnitude of the hydraulic pressure acting upon the blade-adjusting means, a governing member operated by the action of centrifugal forces and a change-over member, both these members controlling the distribution of the hydraulic pressure medium to said blade-adjusting means, a further member adapted to interrupt the supply of hydraulic pressure medium to said blade-adjusting means when a limit of a normal predetermined pitch range is reached, auxiliary valve means for the hydraulic pressure medium, which permit a further actuation of said blade-adjusting means for the purpose of moving the blades beyond that predetermined pitch range only after increased hydraulic adjusting pressure has been able to open said auxiliary valve means, means connecting said governing member and said change-over member in such a way that they can be adjusted by a deliberate manual operation for the purpose of connecting said additional source of hydraulic pressure to said other source of hydraulic pressure, and means allowing the pressure of the cut-in additional source of acting on the member determining the magnitude of the hydraulic pressure medium, to increase the hydraulic pressure, so that a greater quantity of pressure medium and an increased hydraulic pressure are available for adjusting the blades beyond the said normal predetermined pitch range.

5. In a variable-pitch propeller in combina-

tion, a hub, a plurality of blades arranged on said hub for adjustment about their longitudinal axis, means displaceable by the action of a hydraulic pressure medium and operatively connected to said blades, an operation of said means effecting an adjustment of the blades and thus a variation of the propeller pitch, a source of hydraulic pressure supplying liquid under pressure to said blade-adjusting means, an additional source of hydraulic pressure also adapted to supply liquid under pressure to said blade-adjusting means, a member determining the magnitude of the hydraulic pressure acting upon the blade-adjusting means, a governing member operated by the action of centrifugal forces and a change-over member, both these members controlling the distribution of the hydraulic pressure medium to said blade-adjusting means, a common casing housing the governing member and the change-over member, a further member interrupting the supply of hydraulic pressure medium to said blade-adjusting means when a limit of a normal predetermined pitch range is reached, auxiliary valve means for the hydraulic pressure medium, which permit a further actuation of said blade-adjusting means for the purpose of moving the blades beyond that predetermined pitch range only after increased hydraulic adjusting pressure has been able to open said auxiliary valve means, and means connecting said governing member and said change-over member in such a way that they can be adjusted by a deliberate manual operation for the purpose of connecting said additional source of hydraulic pressure to said second source of hydraulic pressure, said member determining the magnitude of the hydraulic pressure acting on the blade-adjusting means being thereby acted upon in such a way as to increase the hydraulic pressure, so that a greater quantity of pressure medium and an increased hydraulic pressure are available for adjusting the blades beyond the said normal predetermined pitch range.

6. In a variable-pitch propeller in combination, a hub, a plurality of blades arranged on said hub for adjustment about their longitudinal axis, means displaceable by the action of a hydraulic pressure medium and operatively connected to said blades, an operation of said means effecting an adjustment of the blades and thus a variation of the propeller pitch, a pump supplying liquid under pressure to said blade-adjusting means, an additional pump also adapted to supply liquid under pressure to said blade-adjusting means, a member determining the magnitude of the hydraulic pressure acting upon the blade-adjusting means, a governing member operated by the action of centrifugal forces and a change-over member, both these members controlling the distribution of the hydraulic pressure medium to said blade-adjusting means, a common casing housing said two pumps and the governing and change-over members, a further member interrupting the supply of the liquid under pressure to said blade-adjusting means when a limit of a normal predetermined pitch range is reached, auxiliary valve means for the liquid under pressure, which permit a further actuation of said blade-adjusting means for the purpose of moving the blades beyond that predetermined pitch range only after increased hydraulic adjusting pressure has been able to open said auxiliary valve means, and means connecting said governing member and said change-over member in such a way that they can be adjusted by a deliberate manual operation for the purpose of connecting the additional pump to said second pump, said member determining the magnitude of the hydraulic pressure acting on the blade-adjusting means being thereby acted upon in such a way as to increase the hydraulic pressure, so that a greater quantity of liquid and an increased hydraulic pressure are available for adjusting the blades beyond the said normal predetermined pitch range.

7. In a variable-pitch propeller in combination, a hub, a plurality of blades arranged on said hub for adjustment about their longitudinal axis, means displaceable by the action of a hydraulic pressure medium and operatively connected to said blades, an operation of said means effecting an adjustment of the blades and thus a variation of the propeller pitch, a source of hydraulic pressure supplying liquid under pressure to said blade-adjusting means, an additional source of hydraulic pressure also adapted to supply liquid under pressure to said blade-adjusting means, a member determining the magnitude of the hydraulic pressure acting upon the blade-adjusting means, a governing member and a change-over member combined in a single spindle controlling the distribution of the hydraulic pressure medium to said blade-adjusting means, a further member adapted to interrupt the supply of the hydraulic pressure medium to said blade-adjusting means when a limit of a normal predetermined pitch range is reached, auxiliary valve means for the liquid pressure medium, which permit a further actuation of said blade-adjusting means for the purpose of moving the blades beyond that predetermined pitch range only after increased hydraulic adjusting pressure has been able to open said auxiliary valve means, means allowing of shifting said spindle by a deliberate manual action for the purpose of connecting said additional source of hydraulic pressure to said second source of hydraulic pressure, and means allowing the pressure of the cut-in additional source to act on said member, which determines the magnitude of the hydraulic pressure that operates the blade-adjusting means, to increase the hydraulic pressure, so that a greater quantity of pressure medium and an increased hydraulic pressure are available for adjusting the blades beyond the said normal predetermined pitch range.

8. The combination of a propeller having adjustable blades; a hydraulic cylinder and piston motor connected to adjust said blades through the normal range of pitch adjustment and also through an excess range beyond said normal range, the working space of said motor which tends to move the blades into said excess range having three communicating ports connected in parallel, namely, a normal supply port, a by-pass supply port, and an exhaust flow port; means rendered active by the functional motion of the motor to close the normal supply port at a point in the working stroke of the motor corresponding to the normal range of pitch adjustment; a loaded valve in said by-pass port, said valve opening in the direction of supply flow to said working space; a check valve in the exhaust port arranged to open in the direction of exhaust flow; primary regulating means controlling the supply and release of hydraulic fluid to said ports at pressures insufficient to open said loaded valve; secondary regulating means controlling the supply of hydraulic fluid to said ports at a pressure sufficient to open said loaded valve; means re-

sponsive to the speed of rotation of the propeller connected to operate said primary regulating means; and manually operable means having two ranges of action in one of which it adjusts said speed responsive means to modify its controlling action, and in another of which it operates said secondary regulating means.

9. The combination of a propeller having adjustable blades; a hydraulic cylinder and piston motor connected to adjust said blades through the normal range of pitch adjustment and also through an excess range beyond said normal range, the working space of said motor which tends to move the blades into said excess range having three communicating ports connected in parallel, namely, a normal supply port, a by-pass supply port, and an exhaust flow port; means rendered active by the functional motion of the motor to close the normal supply port at a point in the working stroke of the motor corresponding to the normal range of pitch adjustment; a loaded valve in said by-pass port, said valve opening in the direction of supply flow to said working space; a check valve in the exhaust port arranged to open in the direction of exhaust flow; primary regulating means controlling the supply and release of hydraulic fluid to said ports at pressures insufficient to open said loaded valve; secondary regulating means controlling the supply of hydraulic fluid to said ports at a pressure sufficient to open said loaded valve; means responsive to the speed of rotation of the propeller connected to operate said primary regulating means; and manually operable means having two ranges of action in one of which it adjusts said speed responsive means to modify its controlling action, and in another of which it suspends the action of said speed responsive means and actuates said secondary regulating means.

10. The combination of a propeller having adjustable blades; a cylinder and piston motor connected to adjust said blades through a normal pitch-varying range and through an additional range in at least one direction, said motor being characterized by dual supply ports leading in parallel to at least one working space, one of said dual supply ports being so arranged that motion of the piston to the end of the normal pitch adjusting range entails closure of such supply port, whereby the range in motion of the piston may be limited to such normal adjusting range; a loaded valve arranged to control flow through the second of said supply ports and adapted to open in the direction of supply flow; a first pump for delivering hydraulic fluid under pressure; a second pump for delivering hydraulic fluid under pressure; pressure limiting means adjustable selectively to limit the pressure of fluid delivery to two intensities, one insufficient and the other sufficient to open said loaded valve; and a controller having at least two characteristically different ranges of motion, in one of which ranges it disconnects one pump, adjusts the pressure limiting means to establish the lower intensity and connects the other pump to deliver to said dual ports under control of said pressure limiting means and of said controller, and in the other of which ranges it sets the pressure limiting means to establish the higher intensity and connects both pumps to deliver under control of the pressure limiting means to said dual ports.

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