Sept. 2, 1958 R. H. BRANDES 2,850,105

PROPELLER MECHANISM WITH MEANS TO VARY THE PITCH CHANGE RATE

Filed June 26, 1953 2 Sheets-Sheet 1

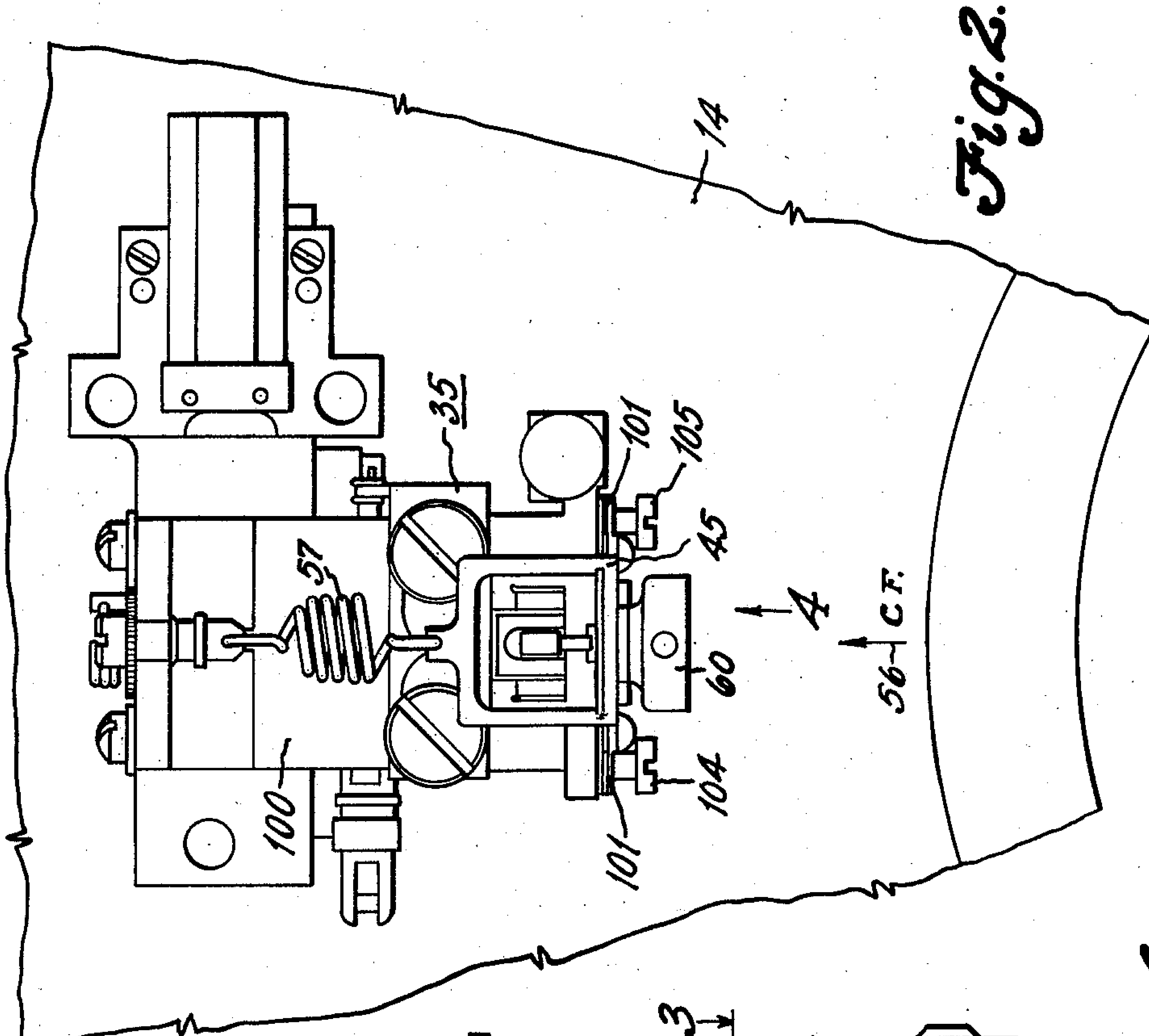


Fig. 2.

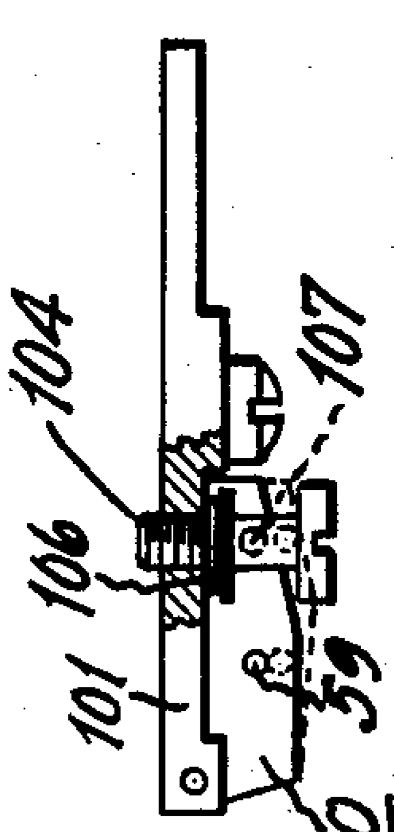


Fig. 3.

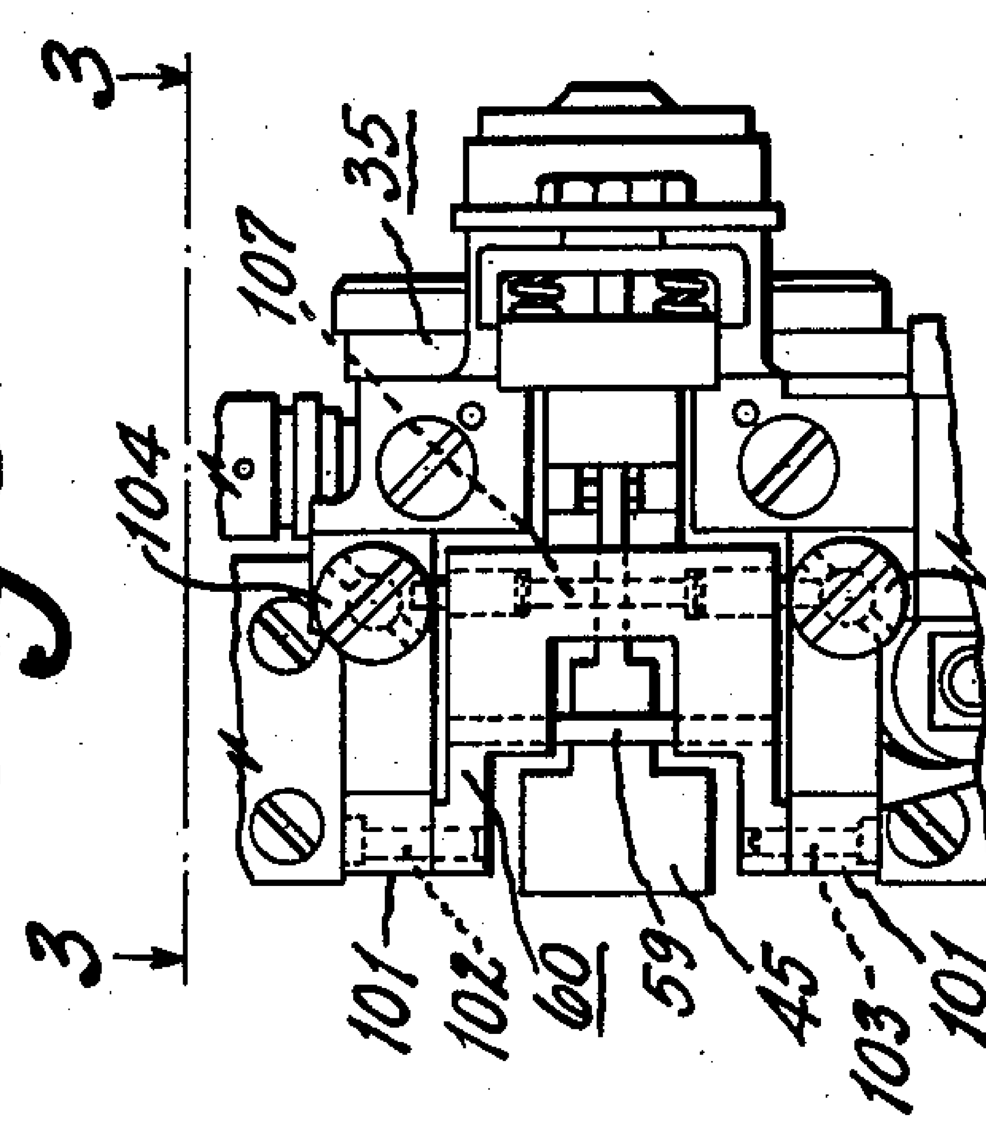


Fig. 4.

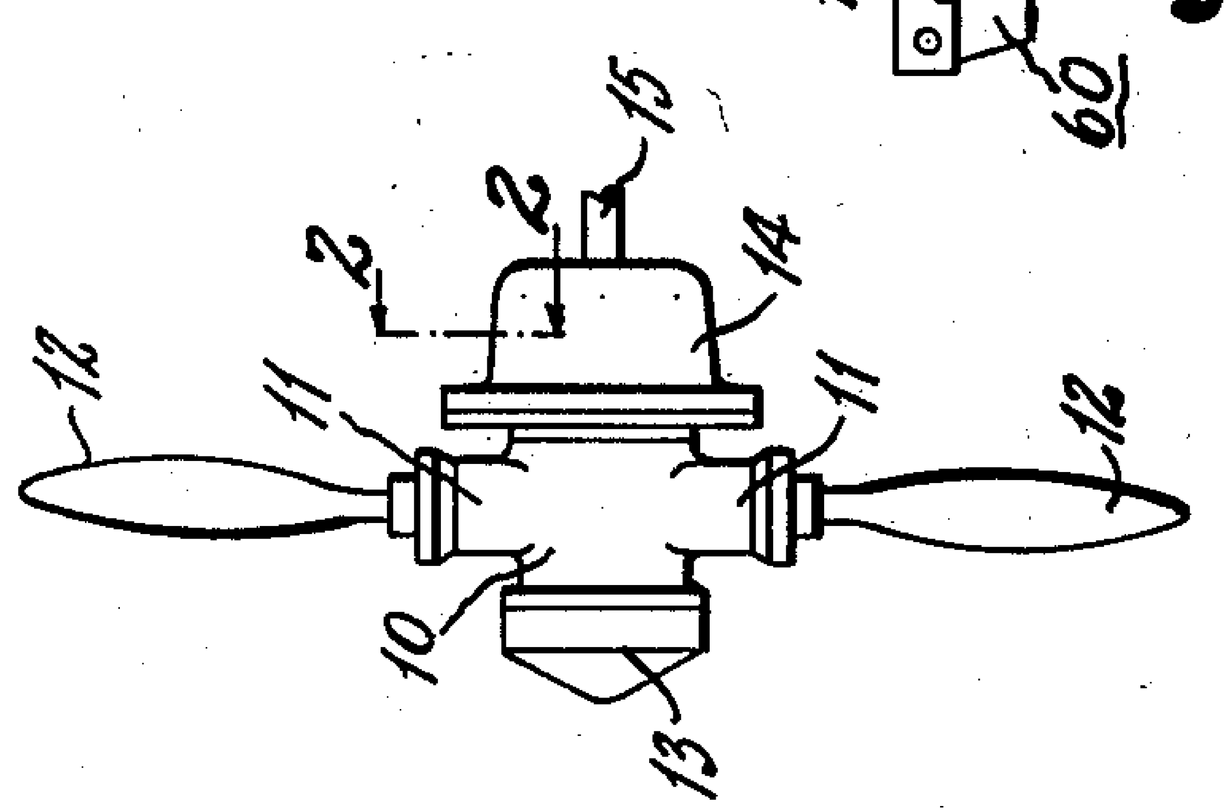


Fig. 1.

INVENTOR.
ROY H. BRANDES
BY
Craig V. Morton
ATTORNEY

PROPELLER MECHANISM WITH MEANS TO VARY THE PITCH CHANGE RATE

Filed June 26, 1953 2 Sheets-Sheet 2

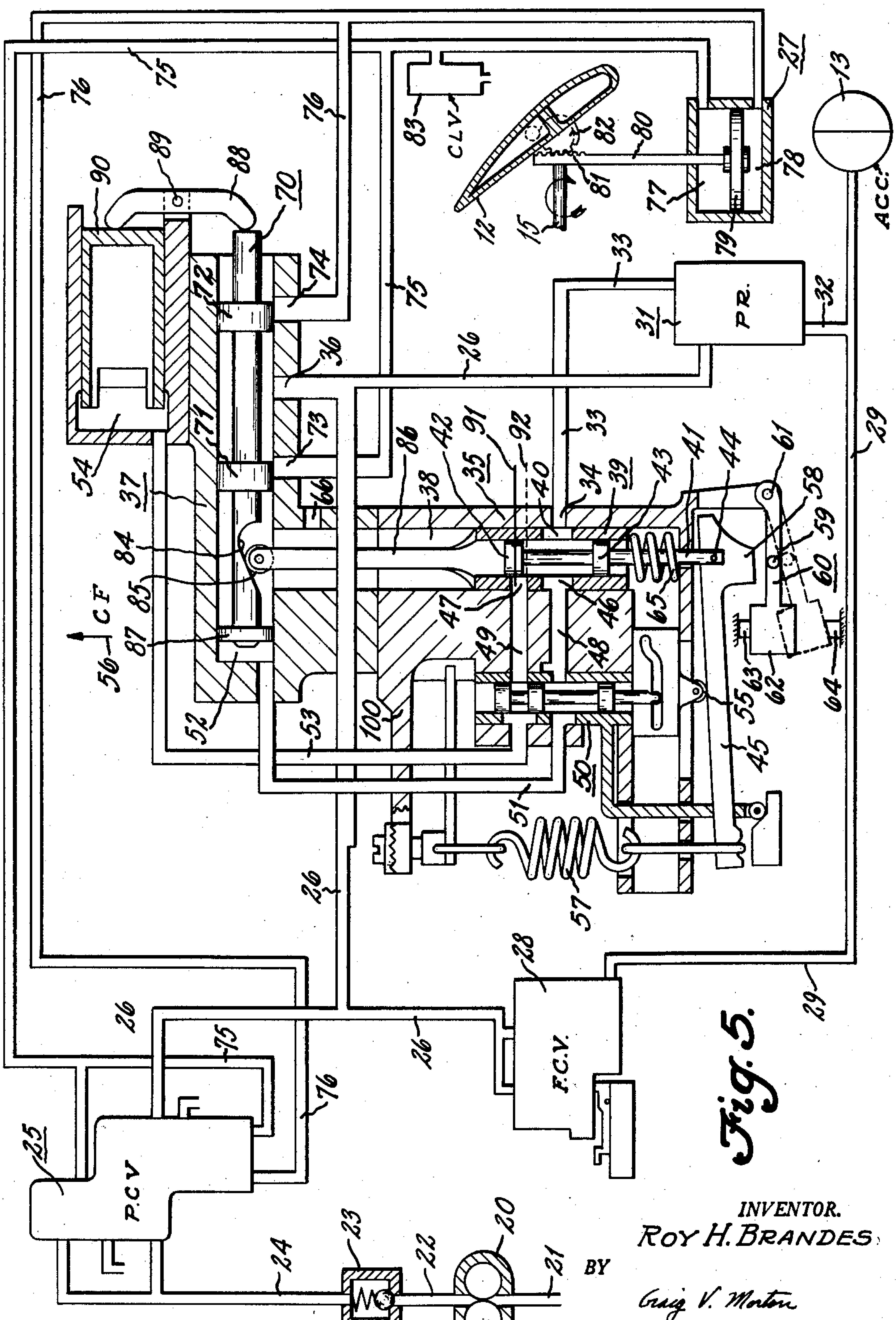


Fig. 5.

INVENTOR.
ROY H. BRANDES

BY Craig V. Morton

ATTORNEY

United States Patent Office 2,850,105
Patented Sept. 2, 1958

1

# 2,850,105

## PROPELLER MECHANISM WITH MEANS TO VARY THE PITCH CHANGE RATE

Roy H. Brandes, Dayton, Ohio, assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Application June 26, 1953, Serial No. 364,374

10 Claims. (Cl. 170—160.21)

The present invention relates to variable pitch propellers, and more particularly to a fluid pressure system for adjusting the pitch position of propeller blades.

Heretofore, fluid pressure systems for adjusting the pitch positions of propeller blades have been of two distinct types. In one type fluid pressure is developed by mechanically driven pumps during propeller rotation, and by electric motor driven pumps when the propeller is stationary. In the other type an accumulator is employed to store fluid under pressure developed by the mechanically driven pumps during propeller rotation, which stored pressure fluid may be used to effect pitch changes when the propeller is rotating slowly, or is stationary. This invention pertains to a system of the latter type and relates specifically to means for increasing the rate of blade angle change by increasing the flow capacity of a control valve when accumulator pressure fluid is employed to effect pitch adjustment. It has been observed that the pressure potential of fluid available for pitch adjustment when the propeller is rotating at normal propeller angular velocities, is appreciably higher than the pressure potential of fluid stored in an accumulator, and, hence, if the same flow rate is employed when using accumulator pressure fluid as is employed when the propeller is rotating and the pumps are supplying fluid under pressure, the rate of blade angle change will either be excessive during propeller rotation, or inadequate when the propeller is stationary, or rotating at a low angular velocity. Accordingly, among my objects are the provision of a propeller pitch adjusting mechanism including means for varying the rate of blade angle change; the further provision of mechanism of the aforesaid character including means for automatically increasing the rate of blade angle change below a predetermined rotational speed of the propeller; and the still further provision of centrifugally actuated means for varying the flow capacity of a control valve in a fluid pressure system for adjusting the pitch position of the propeller blades.

The aforementioned and other objects are accomplished in the present invention providing centrifugally actuated means responsive to the speed of propeller rotation for determining the maximum port area of a control valve available for directing fluid flow to a servo-motor to effect an adjustment in the pitch position of propeller blades in one direction. Specifically, the rate of blade angle change in the decrease pitch direction is varied by the mechanism of this invention to enable the propeller blades to be moved from the full feathered position to any blade angle position in the positive thrust range with the requisite rapidity. The mechanism comprises a two-position stop operatively associated with a flow controlling valve for determining the maximum flow port area available for the flow of pressure fluid to blade angle changing means in a decrease pitch direction. The mechanism functions to restrict the rate of flow through the control valve to the pitch changing means in a decrease pitch direction above a predetermined rotational speed of the

2

propeller. However, when the speed of a propeller drops below the predetermined rotational speed, the mechanism is automatically operable to remove the restriction to thereby permit increased flow rates to the blade angle changing means in the decrease pitch direction.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred embodiment of the present invention is clearly shown.

In the drawings:

Fig. 1 is a perspective view of a variable pitch propeller incorporating the mechanism of this invention.

Fig. 2 is an enlarged fragmentary sectional view taken on line 2—2 of Fig. 1.

Fig. 3 is a view, partly in section and partly in elevation, taken generally along line 3—3 of Fig. 4.

Fig. 4 is a fragmentary view taken in the direction of arrow 4 in Fig. 2.

Fig. 5 is a schematic diagram of a fluid pressure system for controlling a variable pitch propeller incorporating the mechanism of this invention.

With particular reference to Fig. 1, a variable pitch propeller is shown including a hub **10** having a plurality of radially extending blade sockets **11** in which propeller blades **12** are supported for rotation about their longitudinal axes. An accumulator **13** is attached to and rotates with the propeller hub **10**. A regulator assembly **14** is, likewise, attached to the hub **10** and rotates therewith. The propeller hub **10** is operatively connected to a shaft **15**, which is operatively connected to any suitable prime mover, not shown, for imparting rotation to the propeller assembly. The propeller construction may be generally of the type disclosed in the Blanchard, et al. Patents 2,307,101 and 2,307,102, wherein a fluid pressure system for actuating torque units disposed within the root sections of the blades, is housed within the regulator **14**.

The present invention is disclosed herein in conjunction with the propeller control system disclosed and claimed in copending application, Serial No. 273,806, filed February 28, 1952, in the name of Moore, et al. now U. S. Patent No. 2,745,500. With particular reference to Fig. 5, a partially schematic and block diagram of the fluid pressure system disclosed in the aforementioned application is shown incorporating the two-position stop mechanism of the present invention. The fluid system includes a pump **20**, which is mechanically driven during propeller rotation. The pump is disposed within the regulator **14**, and has an inlet **21** and an outlet **22**, which communicates through a check valve **23** with a conduit **24**. The conduit **24** has branch conduits connected to a pressure control valve assembly **25**. The pressure control valve assembly **25** controls the pressure potential of fluid within a high pressure conduit **26** in accordance with the demands of a pitch changing servo-motor **27**. As the specific construction and operation of the pressure control valve assembly **25** is disclosed in the aforementioned copending application, and forms no part of this invention, the operation thereof will not be described in detail herein. The high pressure conduit **26** communicates with a feathering control valve assembly **28**, which controls the flow of pressure fluid from the accumulator, or pressure storage chamber **13** through conduit **29**. The high pressure fluid conduit **26** also communicates with a pressure reducing and accumulator charging valve assembly **31**, one portion of which controls the flow of fluid to the accumulator **13** through the conduit **32**, and another portion of which supplies reduced fluid pressure to conduit **33**, that connects with port **34** of a speed sensitive valve assembly **35**. The high pressure conduit **26** also communicates with a supply port **36** of a servo actuated distributor valve **37**.

The speed sensitive value **35** includes a housing **100** having a chamber **38** within which a sleeve **39** is supported for reciprocable movement. The sleeve **39** has a port opening **40**, which is always in communication with port **34**. The speed sensitive valve assembly **35** also includes a plunger **41** having spaced lands **42** and **43**, the plunger being pivotally connected at **44** to a lever **45**. The sleeve **39** is also provided with port openings **46** and **47**. Port opening **46** is always in communication with port opening **40** by reason of the annular channel between lands **42** and **43** of the plunger **41** so that low pressure fluid is always supplied to a passage **48** in the valve housing.

Land **42** of the plunger **41** controls the flow of low pressure fluid through port **47** of the sleeve to a passage **49** in the valve housing. Passage **48** is connected through a selector valve assembly, designated generally by the numeral **50**, to a conduit **51**, which communicates with a servo chamber **52** of the distributor valve **37**, while passage **49** is connected through the selector valve assembly **50** to a conduit **53**, which communicates with a second servo chamber **54** of the distributor valve **37**. The function of the selector valve assembly will not be described in detail inasmuch as it forms no part of the present invention except for the fact that it is employed to control actuation of the servo-motor **27** to move the propeller blades **12** to the feathered position and back to a positive thrust position in the governed speed regime.

Lever **45** has associated therewith a movable fulcrum **55**, about which the plunger **41** of the speed sensitive valve tends to move the lever under the urge of centrifugal force under the direction of arrow **56**. Upward movement of the plunger **41** is opposed by a tension spring **57**, one end of which is attached to the end of lever **45**, and the other end of which is attached to the stationary valve housing **100** of the speed sensitive valve **35**. The speed of propeller operation in the governor speed regime may be varied by adjusting the position of fulcrum **55**, by which the mechanical advantage of lever **45** may be varied.

The lever **45** includes an abutment portion **58**, which is adapted to engage a stop pin **59**. It is apparent that when the thrust of spring **57** exceeds the thrust of centrifugal force in the direction of arrow **56**, the spring **57** will pivot the lever **45** about the fulcrum **55** and move the plunger **41** downwardly relative to the sleeve **39**, as viewed in Fig. 5. The stop pin **59** is carried by a lever **60**, one end of which is pivoted at **61** to a portion of the speed sensitive valve housing **100**, and the other end of which is schematically shown as carrying a weight **62**, which is responsive to the thrust of centrifugal force. During normal rotational speeds of the propeller, the thrust of centrifugal force in the direction of arrow **56** is sufficient to maintain lever **60** with its weight **62** against a stop **63** in opposition to the force of the spring **57**. Thus, during normal rotational speeds of the propeller the lever **60** and the stop pin **59** are in the full line position, as shown in Figure 5. It will be appreciated that within the normal rotational speed range of the propeller, the propeller speed can be less than the speed setting of the governor valve, and hence the spring **57** will pivot the lever **45** about the fulcrum **55** so that the abutment portion **58** moves toward the stop pin **59**. Moreover, if the rotational speed of the propeller is sufficiently below the speed setting of the governor, the abutment portion **58** will engage the pin **59**, in which instance the governor valve is supplying maximum decrease pitch flow to the servo motor **27** as determined by the stop pin **59**.

However, if the rotational speed of the propeller drops below the normal rotational speed range, for instance below 600 R. P. M., the force of the spring **57** acting through lever **45** and abutment **58** on the stop pin **59** will overcome the thrust of centrifugal force in the direction of arrow **56**, and the arm **60** with its weight **62** will be moved to the dotted line position of Figure 5. In the dotted line position, as shown in Figure 5, the weight **62** engages a second stop **64**. When the lever **60** is in the dotted line position as shown in Figure 5, the lever **45** under the urge of spring **57** can pivot about the fulcrum **55** and thus move the plunger **41** downwardly as viewed in Figure 5 so that the governor valve will supply a greater decrease pitch flow to the servo motor **27**. Accordingly, when the rotational speed of the propeller is above 600 R. P. M. the maximum decrease pitch flow to the servo motor **27** is less than the maximum decrease pitch flow to the servo motor **27** when the rotational speed of the propeller is below 600 R. P. M.



The servo actuated distributor valve **37** includes a plunger **70** having spaced lands **71** and **72** that cooperate with ports **73** and **74**, respectively. Port **73** is connected by a conduit **75** to an increase pitch chamber **77** of the servo-motor **27**, while port **74** is connected by a conduit **76** to a decrease pitch chamber **78** of the servo-motor **27**. The servo-motor **27** is shown schematically as including a cylinder within which a reciprocable piston **79** capable of fluid pressure actuation in either direction, is disposed. The piston **79** includes a rod portion **80**, which projects through an end wall of the servo-motor cylinder and has formed thereon a rack **81**. The rack **81** meshes with a blade pinion **82** such that reciprocable movements of the piston **79** will move the blade **12** about its longitudinal axis so as to vary the pitch position thereof. The conduits **75** and **76** also communicate with the pressure control valve assembly **25** in a manner more fully disclosed in the aforementioned copending application, Serial No. 273,806. The conduit **75** also communicates with a constant leak valve assembly **83**, the function of which is, likewise, disclosed in the aforementioned application.

The plunger **70** of the distributor valve **37** includes a cam surface **84** on which a cam follower **85** rides, the cam follower being connected by means of a rod **86** to the sleeve **39** of the speed sensitive valve. The cam follower **85** is maintained in engagement with the cam surface **84** by means of a spring **65**. The plunger **70** also includes a servo piston **87** exposed to the pressure fluid in servo chamber **52** for effecting movements of the plunger **70** to the right, as viewed in Fig. 5. The opposite end of the plunger **70** is engaged by one end of a rocker arm **88** pivoted at **89**, the other end of which is engaged by a piston **90** exposed to the pressure fluid in servo chamber **54**. As piston **90** is of larger area than piston **87**, it is apparent that a lower pressure potential in chamber **54** will be required to move plunger **70** to the left, as viewed in Fig. 5, than will be required in chamber **52** to move the plunger **70** to the right.

It has been observed that during propeller rotation at normal angular velocities, the pump **20** maintains a pressure potential between 1000 and 1500 p. s. i. in the conduit **26**. However, when the angular velocity of the propeller drops below 600 R. P. M., the pressure potential developed and the flow produced by the pump **20** is insufficient for effecting pitch changing movements of the blades **12** out of the feathered position with sufficient rapidity. In accordance with the teachings of the aforementioned copending application, when the pilot desires to feather or unfeather the propeller blades, the feathering control valve assembly **28** and the selector valve **50** are actuated so as to condition the accumulator **13** for connection with the conduit **26**, in the event the pressure potential in conduit **26** is less than the pressure potential of fluid stored in the accumulator **13**, and connect conduits **51** and **53** to passage **48** for feathering or to passage **48** and drain, respectively, for unfeathering. Normally, the accumulator **13** has sufficient storage capacity to supply enough fluid flow to move the blades throughout at least one complete range of pitch change movement, that is, from the negative low angle to full feather and return. However, the pressure potential of fluid stored in the accumulator is appreciably less than the pressure developed by pump 20 during propeller rotation at normal speeds, it being established that the pressure potential of fluid stored in the accumulator is approximately 500 p. s. i.

Consequently, it is manifest that as the rate of blade angle change is proportional to the quantity of pressure fluid flowing per unit time to the servo-motor 27, when the pressure potential of the fluid is decreased, the flow rate will, likewise, be decreased through a given size orifice, or port area. However, the flow rate, and hence, the rate of blade angle change, can be varied by varying the flow port area so that the same, or greater, flow rates can be achieved at reduced pressure potentials. This result is accomplished in the present invention by the centrifugally actuated stop pin 59 for the speed sensitive valve plunger 41, to insure an adequate rate of pitch change when pressure fluid of reduced pressure potential, is being used to effect pitch adjustment toward a decrease pitch position.

Referring again to Fig. 5, the full line 91 indicates the lowermost position, which the upper surface of land 42 of plunger 41 can assume with the stop pin 59 in the solid line position. These conditions obtain when the angular velocity of the propeller is above 600 R. P. M., for example. However, when the angular velocity of the propeller drops below 600 R. P. M., for example, the weight 62 will move the lever 60 about its pivot point 61 so that the stop pin 59 is moved to the dotted line position of Fig. 5, wherein the upper surface of land 42 of the plunger 41 may move to the dotted line 92. Thus, it is apparent that when the propeller is rotating about 600 R. P. M., the opening of port 47 to the passage 38 and drain port 66 is restricted, while below a rotational speed of 600 R. P. M., the port 47 may be opened fully to drain, as indicated by the dotted line 92.

Downward movement of the plunger 41 from the position shown in Fig. 5, results in movement of the plunger 70 to the right such that port 73 will be connected to drain through port 66 and port 74 will be connected to the supply port 36, inasmuch as the servo chamber 54 is connected to drain through conduit 53, passage 49 and ports 47 and 66, while chamber 52 is connected to the low pressure conduit 33 through conduit 51, passage 48 and ports 46 and 40. Thus, high pressure fluid from conduit 26 will be supplied to the decrease pitch chamber 78 of the servo-motor through conduit 26, while the increase pitch chamber 77 will be connected to drain through conduit 75 and ports 73 and 66. It will be observed that inasmuch as the area of piston 90 is appreciably greater than the area of piston 87, in restricting the drain flow from servo chamber 54, the plunger 70 may never reach a position where port 74 is fully open. In actual practice the arrangement is such that the control port 74 is only opened sufficiently to produce a blade angle change rate of about 5° per second in a decrease pitch direction with a pressure potential between 1000 and 1500 p. s. i. in conduit 26. Thus, if the pressure potential in conduit 26 falls to say 500 p. s. i. due to propeller rotation below 600 R. P. M., the restriction of port 47 in permitting flow from servo chamber 54 to drain will result in an inadequate rate of pitch change in the decrease pitch direction. However, below 600 R. P. M. the stop pin 59 will have moved to the dotted line position, thereby permitting the port 47 to be fully opened whereby the low pressure fluid in servo chamber 52 will move the plunger 70 to a position where port 74 is substantially fully open. In this manner it has been observed that the rate of blade angle change with a pressure potential of approximately 500 p. s. i. can be increased to approximately 8° per second. In this manner the propeller blades can be moved out of the full feathered position and into any position of the governed speed regime with the desired rapidity, when the propeller is stationary, or rotating below a predetermined speed, for example, 600 R. P. M. Sleeve 39 operates in a follow-up relation with respect to the operation of plunger 41. Inasmuch as the valve assembly 35 merely controls the position of the distributor valve plunger 70, while the distributor valve plunger 70 controls the rate of blade angle change, it will be appreciated that when the pin 59 is in its downward position, the plunger 41 can move downwardly a greater distance thereby permitting the distributor valve plunger 70 to move to a position wherein port 74 is fully open. However, due to the follow-up relation between the plunger 41 and the sleeve 39, when the pin 59 is in its upper position, as shown in Fig. 5, the distributor valve plunger 70 cannot be moved to a position wherein port 74 is fully open to the supply port 36.

With particular reference to Figs. 2 through 4, the structural embodiment of the speed sensitive valve assembly 35 will be described. As is shown in Fig. 2, the housing 100 of the speed sensitive valve assembly 35 is mounted on the front plate of the regulator 14 so that the speed sensitive plunger 41 is located on a radius from the center of rotation and thereby responds to the thrust of centrifugal force in the direction of arrow 56. As is shown, the tension spring 57 has one end attached to the housing 100 and the other end attached to the lever 45. The housing 100 includes a bifurcated plate portion 101 to which the bifurcated end portion of the speed responsive weighted lever 60 is pivotally attached by trunnions 102 and 103. The lever 60 carries the stop pin 59, which limits the downward movement of the lever 45 in Fig. 2. The plate member 101 has secured thereto a pair of screw devices 104 and 105 having shims 106 between the threaded portion and the head portion to define the limits of movement of a cross pin 107 carried by the lever 60. As shown in solid lines in Fig. 3, the cross pin 107 is in engagement with the shims 106, which represents the position lever 60 will assume under the thrust of centrifugal force due to propeller rotation above 600 R. P. M. When the speed of propeller rotation falls below 600 R. P. M., the lever 60, which includes sufficient mass so as to be responsive to centrifugal force, will move in a clockwise direction about its trunnions, as is viewed in Fig. 3, to the dotted line position where the ends of cross pin 107 will abut the lower side of the headed portions of the screw devices 104 and 105. It is apparent that clockwise movement of the lever 60, as is viewed in Fig. 3, will lower the position of stop pin 59, thereby permitting the lever 45 to move downwardly a greater distance under the thrust of spring 57.

From the foregoing, it is apparent that the present invention provides means for automatically increasing the flow capacity of a valve mounted in a centrifugal field, when the rotating structure to which the valve is attached rotates below a predetermined angular velocity. In this manner, the flow rate in the decrease pitch direction can be maintained at the requisite value with reduced pressure potential when the propeller is stationary, or substantially stationary.

While the embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. A fluid pressure system for controlling the pitch position of propeller blades including in combination, a rotatable propeller having blades mounted for rotation about their longitudinal axes, fluid pressure operated means operatively connected with the blades for adjusting the pitch position thereof in either direction, a source of fluid pressure for actuating the pitch adjusting means, valve means connected to the source and to the pitch adjusting means for controlling the application of pressure fluid to said pitch adjusting means for varying the pitch position of said blades in either direction, and cen-

trifugally actuated means operatively associated with said valve means and operable to limit the maximum rate of pitch adjustment in the decrease direction above a predetermined propeller speed.

2. In combination with a variable pitch propeller having blades mounted for rotation about their longitudinal axes to different pitch positions, fluid pressure operated means operatively connected to said blades for adjusting the pitch position thereof in either direction, a source of fluid pressure for actuating the pitch adjusing means, valve means connected with said source and with said pitch adjusting means for controlling the flow of pressure fluid from said source to said pitch adjusting means for adjusting the pitch position of said blades in either direction, and centrifugally responsive means rotatable with the propeller and operatively associated with said valve means for restricting the permissible rate of flow from said source through said valve means to said pitch changing means in a decrease pitch direction above a predetermined rotation of speed of said propeller.

3. In combination with a variable pitch propeller having blades mounted for rotation about their longitudinal axes to different pitch positions, fluid pressure operated means operatively connected to said blades for adjusting the pitch position thereof in either direction, a source of fluid pressure for actuating the pitch adjusting means, valve means connected with said source and with said pitch adjusting means for controlling the flow of pressure fluid from said source to said pitch adjusting means for adjusting the pitch position of said blades in either direction, said valve means including an element rotatable with the propeller and movable in response to the thrust of centrifugal force established by rotation of said propeller and a pivotally mounted assembly rotatable with the propeller and movable in response to centrifugal force including a stop pin operatively associated with said valve element for limiting movement of said valve element in one direction, the construction and arrangement being such that the rate of flow to the pitch adjusting means in the decrease pitch direction is restricted above a predetermined rotational speed of said propeller.

4. In combination with a variable pitch propeller having blades mounted for rotation about their longitudinal axes to different pitch positions, fluid pressure operated means operatively connected to the blades for adjusting the pitch position thereof in either direction, a source of fluid pressure for actuating the pitch adjusting means, valve means connected with said source and with said pitch adjusting means for controlling the flow of pressure fluid from said source to said pitch adjusting means for adjusting the pitch position of said blades in either direction, said valve means including an element rotatable with the propeller and mounted for movement in response to the thrust of centrifugal force established by propeller rotation in one direction, a lever having an intermediate fulcrum point, one end of said lever being pivotally attached to said valve element, resilient means acting on said lever about said fulcrum point so as to oppose the thrust of centrifugal force on said valve element so as to move the valve element in the opposite direction when the force of the resilient means exceeds the thrust of centrifugal force, and a stop assembly rotatable with the propeller and responsive to the thrust of centrifugal force, said stop assembly including means operatively associated with said lever for limiting movement of said valve element by said resilient means in opposition to centrifugal force, the construction and arrangement being such that the stop assembly controls the maximum permissible rate of flow to the pitch adjusting means in the decrease pitch direction so that at rotational speeds of the propeller above a predetermined angular velocity of, the flow to the pitch adjusting means from the source through the valve means is restricted in the decrease pitch direction, whereas below said predetermined angular velocity the flow from the source through the valve means to the pitch adjusting means may be virtually unrestricted.

5. In combination with a centrifugally responsive valve assembly mounted in a centrifugal field and adapted to control the rate of fluid flow from a source of fluid pressure to a servo-motor, a centrifugally responsive lever pivotally attached to said valve assembly, said valve assembly including a reciprocable element, the position of which is affected by the thrust of centrifugal force, and a two-position stop pin carried by said lever and engageable with said element for limiting movement of said element in one direction, the construction and arrangement being such that the position of said stop pin varies between said two positions dependent upon whether the thrust of centrifugal force is more or less than a predetermined value.

6. In combination with a valve assembly mounted in a centrifugal field and including a reciprocable element movable in one direction by the thrust of centrifugal force, resilient means operatively associated with said element for opposing the thrust of centrifugal force, and a two-position stop assembly pivotally connected to said valve assembly in said centrifugal field including means coacting with said valve element for limiting the movement of said valve element in one direction, the construction and arrangement being such that the position of said last recited means varies dependent upon whether the thrust of centrifugal force is more or less than a predetermined value and thereby limits movement of said valve element by said resilient means.

7. In a variable pitch propeller, the combination including, a rotatable propeller having a plurality of blades mounted for rotation about their longitudinal axes to vary the pitch position thereof in both directions, mechanism operatively connected to said blades for adjusting the pitch position thereof, and centrifugally actuated means operatively connected with the pitch adjusting mechanism for varying the maximum rate of pitch adjustment in one direction when the speed of propeller rotation is above a predetermined value from the maximum rate of pitch adjustment in said one direction when the speed of propeller rotation is below said predetermined value.

8. In a variable pitch propeller, the combination including, a rotatable propeller having a plurality of blades mounted for rotation about their longitudinal axes to vary the pitch position thereof in either direction, mechanism operatively associated with said blade for adjusting the pitch position thereof in both directions, and means rotatable with the propeller and actuated by the thrust of centrifugal force, said means having operative connection with said pitch adjusting mechanism so as to increase the maximum rate of pitch adjustment in one direction below a predetermined rotational speed of the propeller.

9. In a variable pitch propeller, a rotatable propeller having a plurality of blades mounted for rotation about their longitudinal axes to vary the pitch position thereof in either direction, fluid pressure operated mechanism for varying the pitch position of said blades including, a source of fluid pressure comprising pressure developing means associated with and operable upon rotation of the propeller and an accumulator having connection with the pressure developing means so as to be charged thereby, fluid pressure operated motor means having connection with said blades for adjusting the pitch position thereof, and valve means having connection with said source and said motor for controlling the application of fluid pressure from the source to the motor means, and centrifugally actuated means operatively connected with said valve means for limiting the rate of application of fluid pressure to said motor means by said valve means in one direction above a predetermined rotational speed of said

propeller to thereby limit the maximum rate of pitch change of said propeller blades in said one direction.

10. In a variable pitch propeller, a rotatable propeller having a plurality of blades mounted for rotation about their longitudinal axes to vary the pitch position thereof in either direction, fluid pressure operated mechanism for altering the pitch position of said blades comprising, a source of fluid pressure including pressure developing means associated with and operable during propeller rotation and an accumulator having connection with said pressure developing means so as to be charged thereby, fluid pressure operated motor means having connection with said blades for adjusting the pitch position thereof, and valve means having connection with said source and said motor for controlling the application of pressure fluid from the source to the motor, and means rotatable with the propeller and responsive to the thrust of centrifugal force, said means having operative connection with said valve means so as to increase the permissible rate of application of pressure fluid to the motor means by said valve means in one direction when the propeller is stationary and the accumulator is supplying pressure fluid.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 2,626,669 | Moore et al. | Jan. 27, 1953 |
| 2,640,555 | Cushman | June 2, 1953 |
| 2,661,806 | Nims et al. | Dec. 8, 1953 |