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A. PFAU

1,901,773

PROPELLER BLADE ADJUSTING SYSTEM

Filed Aug. 22, 1931

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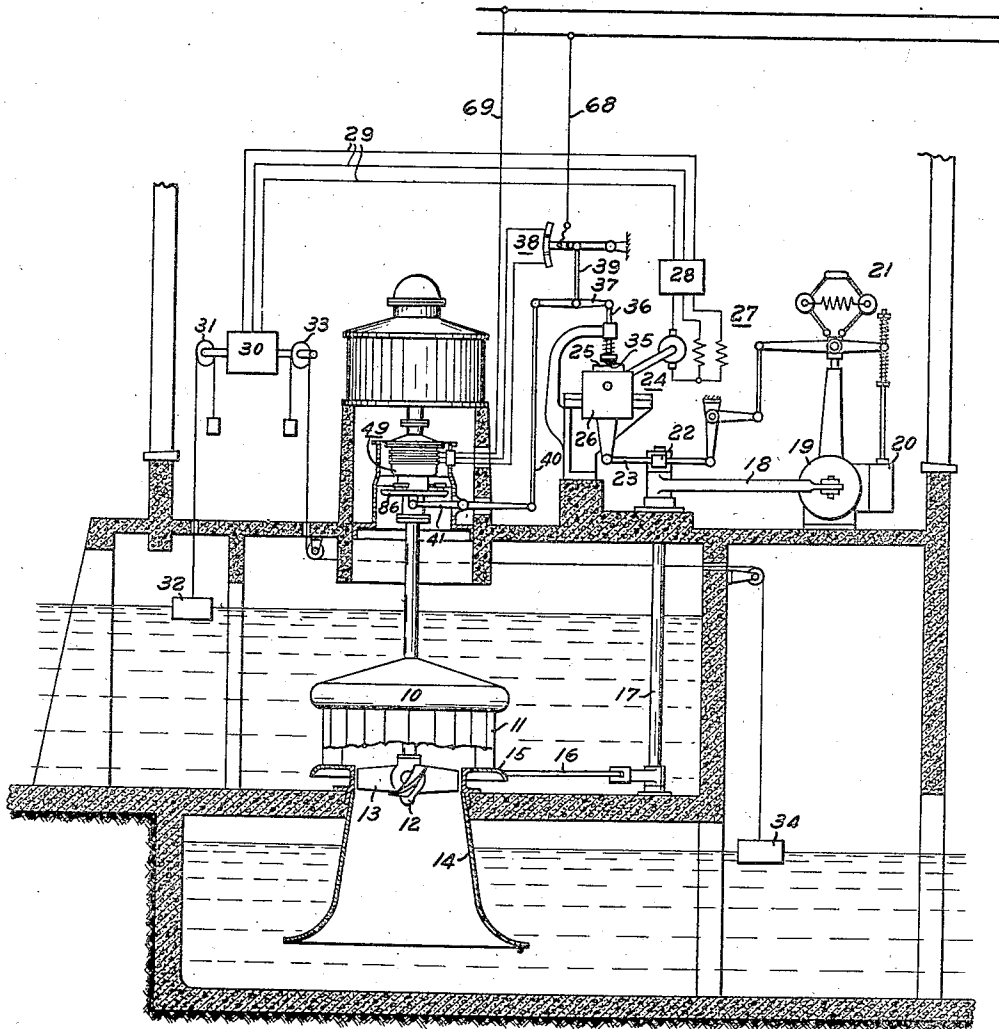


Fig. 1

Inventor
A. Pfau
by G. J. O'Brien
Attorney

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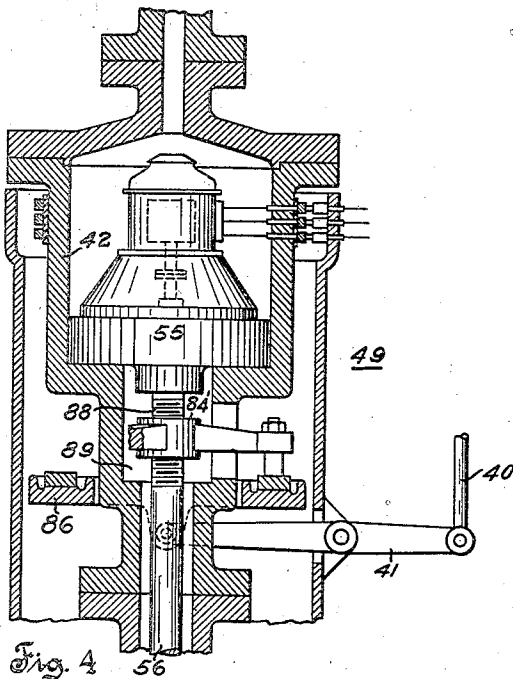
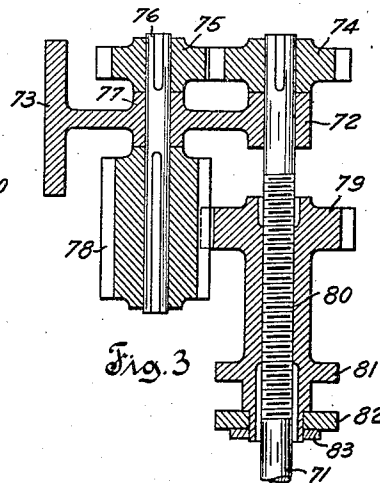
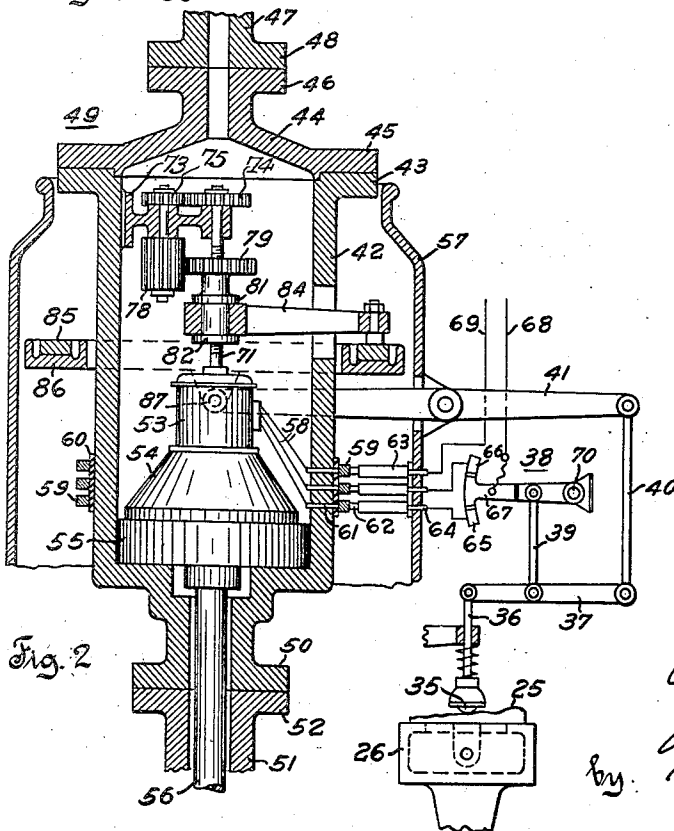
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2 Sheets-Sheet 2



Inventor
A. Pfau
by *G. P. Wein*
Attorney

UNITED STATES PATENT OFFICE

ARNOLD PFAU, OF MILWAUKEE, WISCONSIN, ASSIGNOR TO ALLIS-CHALMERS MANUFACTURING COMPANY, OF MILWAUKEE, WISCONSIN, A CORPORATION OF DELAWARE

PROPELLER BLADE ADJUSTING SYSTEM

Application filed August 22, 1931. Serial No. 552,723.

This invention relates in general to systems using electric motors for controlling the tilt of the rotor blades of propeller type hydraulic turbines, pumps, blowers, and of aircraft and marine propellers.

It is known that the efficiency of hydraulic turbines of the propeller type can be increased when operating with low loads and low effective heads of water by adjusting the tilt of the rotor blades. The efficiency of other machines having blades adapted to rotate in a fluid medium may also be increased by controlling the tilt of the blades in accordance with the operating conditions. Various mechanisms for tilting the rotor blades of hydraulic machines by means of a rod which is rotatable within a hollow shaft which is connected to the blade carrying hub have been devised, but certain of these mechanisms can only be adjusted after the machine has been shut down, and others have proven unsatisfactory from a practical operating standpoint. It is obviously desirable that the tilt of the blade be adjustable during rotation thereof in order to obviate the inconvenience of stopping the machine every time an adjustment of the blades is to be made.

An object of this invention is to provide a propeller blade tilting servo-motor which is adapted to be mounted within a portion of the shaft which transmits power to and from the propeller blades.

Another object of this invention is to provide a rotor blade tilting system in which the blades are tilted during running by a shaft which is rotatable within the power transmitting shaft by a rotary servo-motor.

Another object of this invention is to provide a propeller blade tilting system in which a rotary electric servo-motor for tilting the blades is caused to rotate a number of revolutions proportional to the movement of a control switch.

A further object of this invention is to provide a rotary servo-motor device for tilting propeller blades which is simple and compact in construction, efficient and dependable in operation, and inexpensive to manufacture.

These and other objects and advantages are attained by this invention, various novel features of which will be apparent from the description and drawings herein, and will be more particularly pointed out in the claims.

Various illustrative examples of the application of this invention are shown in the accompanying drawings, in which;

Figure 1 shows a system for controlling the tilt of the runner blades of a hydraulic turbine;

Fig. 2 is a vertical section of an electric servo-motor embodying features of the present invention;

Fig. 3 is an enlarged vertical section of the limit switch operating reduction gearing shown in Fig. 2;

Fig. 4 is a vertical section of a modified form of electric servo-motor embodying features of the present invention.

With the above objects in view, as well as other objects which will appear as the specification proceeds, the invention comprises a construction, arrangement, and combination of parts now to be fully described and hereinafter claimed. It being understood that the disclosure herein described is merely illustrative of the invention and is not to be taken in a limiting sense, change in detail of construction and arrangement of parts being permissible so long as within the spirit of the invention and the scope of the claims which follow.

Referring now to Figure 1, 10 is a hydraulic turbine having adjustable guide vanes 11, and a rotor hub member 12 to which tiltable blades 13 are connected. Any suitable mechanism within hub 12 for tilting blades 13 may be used, noting the patent to J. J. Ring, U. S. 1,656,017, and the patent to J. F. Roberts, U. S. 1,656,018, both issued on January 10, 1928, for typical showings of such mechanism. Movement of guide vanes 11 is effected by a servo-motor 19 which is operatively connected to the guide vanes 11 by means of crank 18, a shaft 17, rod 16, and a guide vane adjusting ring 15. Valve 20 of servo-motor 19 is controlled by governor 21 in any known manner. The runner blades

are tilted by a servo-motor 49 which is controlled by a reversing switch 38 which in turn is actuated in accordance with the altitude of the topographic cam 25, through the medium of link 39, floating lever 37, cam actuated control rod 36, and cam follower member 35. The topographic cam device 24 is provided with a cam element 25 which is transversely moved by electric motor 27 in accordance with the effective head of water. To be more specific, cam 25 is traversed back and forth by motor 27 which is caused to rotate in a forward or reverse direction by the control mechanism of follow-up device 28, which in turn is controlled by the differential transmitter device 30 having pulleys 31 and 33 which are rotated in accordance with the height of float 32 in the head water and the height of the float 34 in the tail water, respectively. The motion of guide vanes 11 is relayed to topographic cam 25 by means of linkage which comprises guide vane adjusting ring 15, rod 16, shaft 17, crank 22, link 23, and cam carriage 26. Cam member 25 is thus longitudinally movable in response to the position of the guide vanes.

No claim is broadly made herein to the above described hydraulic turbine controlled system comprising governor controlled guide vanes, a servo-motor for tilting the runner blades, a topographic cam device for controlling the blade tilting servo-motor in accordance with both the effective head of water and the position of the guide vanes, because this system constitutes the subject of a co-pending application, Serial No. 552,639, filed by this same inventor on July 23, 1931.

Referring now to Fig. 2, the power transmitting shaft between the turbine and the generator is constructed in two sections, 47 and 51, having flange members 48 and 52, respectively, which engage corresponding flange members 46 and 50 of a rotatable casing member 42, having cover member 44. A stationary housing member 57 surrounds the casing member 42 and is supported from any suitable stationary structure such as the generator foundation as shown in Figure 1, or the upper part of the turbine casing 10. Within the lower section of the power transmitting shaft is located a rotor blade tilting rod which is rotatable with respect to this shaft to actuate the mechanism in hub member 12. The blade tilting rod 56 is rotated at slow speeds by an electric motor 53 by means of speed reduction gearing 55 of any suitable form. The motor 53 is mounted to casing 42 by any suitable means such as base member 54. Current is supplied to motor 53 by means of conductors 58, slip rings 59, brushes 62, brush holders 63, reversing switch 38 and conductors 68-69. It is to be noted that brush holders 63 are fastened to the stationary casing 57 and are insulated therefrom by insulating members 64, and that slip rings

59 are insulated from the rotatable casing 42 by means of insulation 60 and 61.

Reversing switch 38 comprises stationary contacts 65 and 66 and movable contact 67 which is suitably insulated from the contact pivot 70. Reversing switch 38 is normally held in the neutral position shown in Fig. 2 by means of a link 39 which connects contact 67 with floating lever 37. One end of floating lever 37 is actuated by control rod 36 and cam follower member 35 in accordance with the altitude of cam 25. The other end of floating lever 37 is actuated in accordance with the position of the runner blades by means of mechanism which is responsive to the position of a gear member 79 threaded on the shaft of 71 as will be more fully described.

Referring more particularly to Fig. 3, a threaded shaft 71 is rotated in stationary guide bearings 72 by motor 53. A traveling gear 79 having a bore provided with screw threads 80 is threaded on shaft 71. A pinion 74, which is fixed to shaft 71, drives a gear 75 which is fixed to counter-shaft 76. Counter-shaft 76 is suitably supported in bracket member 73 as by bearing 77. Bracket member 73, which carries bearings 72 and 77, is attached to the inner wall of casing 42. A pinion 78 is also fixed on counter-shaft 76 and is sufficiently long to remain in engagement with the teeth of gear 79 as this gear travels on threaded shaft 71. The gears and pinions are of such a ratio that gear 79 is driven by pinions 78 in the same direction of rotation as shaft 71, but preferably at slightly less speed. It is thus seen that gear 79 will be caused to move transversely at a speed proportional to the difference of the rotative speeds of the shaft 71 and the gear 79. Gear 79 is provided with a fixed collar 81 and a removable collar 82 which is held in place by means of nut 83.

Referring again to Fig. 2, a spider member 84 is carried by collars 81 and 82 and is provided with arms which project through suitable slots in casing member 42. The ends of these arms are provided with shoe members 85 which rest upon an annular thrust ring 86 which is attached to relay lever 41 by means of a pivot connection 87. It is desirable in some instances to construct spider member 84 (and 84' in Fig. 4) in two parts to expedite the assembling of the servo-motor. It will thus be seen that the right hand end of floating lever 37 is actuated by link 40 and relay lever 41 in accordance with the number of revolutions of motor 53 from any given position.

Referring now to Fig. 4, the servo-motor shown in this figure is substantially the same as that shown in Figs. 2 and 3, except that the annular thrust ring 86 is actuated by a spider member 84' which is threaded directly onto the blade tilting rod 56 instead of being actuated by a spider member which

is driven by auxiliary differential gearing. In this modification the pitch of the threads 88 on shaft 56 are so chosen that for a full range movement of the rotor blades the spider member 84' will be moved from one end of chamber 89 to the other end thereof.

The operation of the propeller blade adjusting system is as follows:

Upon movement of topographic cam member 25 in response either to a change in guide vane opening or a change in effective head of water, cam follower 35 will raise or lower contact 67 a predetermined amount thereby establishing a circuit for motor 53 from supply conductors 68—69 through either contact 66 or 65 depending on the direction of motion of cam follower 35. Motor 53 in rotating drives rotor blade tilting shaft 56 through reduction gears 55 and also moves spider member 84 (or 84' as in Fig. 4), in such a direction as to restore movable contact 67 to its initial off position after the motor has rotated a number of revolutions proportional to the amount of movement of switch contact 67. The rotation of rod 56 relative to power transmitting shaft 51 changes the tilt of the propeller blades 13 by means of the mechanism in hub 12. When switch contact 67 is returned to its off position the motor 53 is deenergized and rotor blades 13 remain in their newly adjusted position until the operating conditions again change.

While the embodiment of the invention herein described relates more in particular to hydraulic turbines, the invention is obviously applicable to impeller type pumps, blowers, and to aircraft and marine propellers and it is therefore desired that the term "propeller" be considered descriptive of such mechanism. It is to be noted that if the ratios of gears 74, 75, 78, and 79 are such that gear 79 is rotated faster than shaft 71, spider member 84 can be made to operate in a direction opposite to what it would rotate if the gear ratios were such that gear 79 rotated slower than shaft 71.

It is to be understood that the disclosure herein described is merely illustrative of the invention and is not to be taken in a limiting sense, changes in details of construction and arrangement of parts being permissible so long as within the spirit of the invention and the scope of the claims which follow.

It is claimed and desired to secure by Letters Patent:

1. In combination, a propeller shaft, tiltable propeller blades carried by said shaft, a rod for tilting said propeller blades, means including an electric motor for operating said blade tilting rod, a control switch movable from a neutral position to control the energization and direction of rotation of said motor, and means including a traveling nut member on said motor shaft for restoring said switch to said neutral position.

2. In a servo-motor for controlling the tilt of propeller blades, the combination of a rotatable shaft, a housing attached to said shaft, an operating rod extending longitudinally of said shaft, an electric motor within said housing, a speed reduction gearing connected between said electric motor and said operating rod, means including slip-rings and a reversing switch for conducting current to said motor, means for moving said reversing switch a predetermined amount to cause said motor to rotate, and means including speed reduction gearing driven by said motor for stopping said motor after said motor has rotated an amount proportional to the said predetermined movement of said reversing switch.

3. In a servo-motor for controlling the tilt of propeller blades, the combination of a rotatable shaft, a housing attached to said shaft, a blade tilting rod extending co-axially of said shaft, an electric motor within said housing, a reversing switch for controlling the direction of rotation of said motor, a threaded shaft driven by said motor, a pinion fixed to said threaded shaft, a counter-shaft driven by said pinion, an elongated pinion fastened to said counter-shaft, a gear having an internally threaded bore and mounted on said threaded shaft whereby said gear is driven by said elongated pinion in the same direction as said threaded shaft, and means for moving said reversing switch in response to the axial movement of said gear.

4. In a servo-motor for positioning a movable element, the combination of an electric motor, a normally open switch for controlling the energization of said motor, means for moving said switch a predetermined amount to start said motor, a threaded shaft driven by said motor, a member having an internally threaded bore engaging said threaded shaft, means for rotating said member in the same direction as the rotation of said motor but at a different speed, to cause said member to move axially of said threaded shaft, and means for causing said switch to move toward its open position in response to the axial movement of said member whereby said motor is operative to rotate a number of revolutions proportional to the amount of said predetermined movement of said switch.

5. In a servo-motor for positioning a movable element, the combination of an electric motor, a switch for controlling the energization of said motor and having an off position, means for moving said switch from said off position a predetermined amount to operate said motor, a threaded shaft driven by said motor, a gear having an internally threaded bore rotatably carried by said threaded shaft, means including a pinion and a counter-shaft for rotating said gear at a speed proportional to the speed of the motor but not equal thereto to axially move said

gear, and means responsive to the motion of said gear for returning said switch to its off position to stop said motor.

6. In a servo-motor control system, the combination of an electric motor, a switch for starting and stopping said motor, a gear having an internally threaded bore, a threaded shaft extending through said bore and driven by said motor, a pinion on said threaded shaft, a counter-shaft driven by said pinion, a pinion on said counter-shaft for driving said gear, whereby said gear is moved axially proportionally to the algebraic sum of the speed of said threaded shaft and the speed of said gear and means for moving said switch proportionally to the axial movement of said gear.

7. In a servo-motor control system, the combination of an electric motor, a rotatable casing for supporting said motor, a switch for starting and stopping said motor, a traveling nut member having arms projecting through said casing and rotating therewith, a threaded shaft for axially traversing said nut member proportionally to the speed of said motor, a non-rotatable ring-member movable axially in accordance with the axial movement of said arms, and means for moving said switch in accordance with the movement of said ring-member.

8. In combination, a power transmitting shaft, tiltable propeller blades carried by said shaft, a housing member attached to said shaft intermediate its ends, speed reduction gearing and an electric motor within said housing, means including a rod co-axial of said shaft for causing said motor to rotate said rod through said gearing to tilt said blades, a switch for controlling said motor, and a traveling nut member on said rod for controlling said switch.

9. In a system for controlling the tilt of the propeller blades of a hydraulic turbine, the combination of a rotatable propeller shaft, an electric motor and gearing carried by said propeller blade tilting rod operatively connected to said motor through said gearing, a reversing switch for controlling the direction and amount of rotation of said motor, said switch having a neutral position, means for actuating said reversing switch from said neutral position in response to an operating condition of said turbine, and means actuated in accordance with the movement of said blade tilting rod for returning said reversing switch to said neutral position, said last mentioned means comprising a spider member rotatable with said propeller shaft and a non-rotatable ring member slidably engaging said spider member.

10. In a system for controlling the tilt of propeller blades, the combination of a rotatable propeller shaft, a hollow casing attached to said propeller shaft, an electric motor mounted within said hollow casing, a propeller

blade tilting rod coaxial of said propeller shaft, gearing arranged between said electric motor and said blade tilting rod for rotating said rod relative to said propeller shaft, a spider member rotatable with said hollow chamber, means for moving said spider member axially of said rod in accordance with the rotation of said rod by said motor, shoe members carried by said spider member, a ring member slidably engaging said shoe members, a lever member for holding said ring member in engagement with said shoe members, a stationary pivot for said lever member, a reversing switch for controlling the direction of rotation of said motor, and means for automatically actuating said reversing switch including a relay connection between said lever and said reversing switch.

11. In a system for automatically controlling the tilt of the propeller blades of a hydraulic turbine, the combination of a rotatable propeller shaft, a hollow casing attached to said shaft, an electric motor and speed reduction gearing mounted within said hollow casing, a propeller blade tilting rod operatively connected to said motor through said gearing, a reversing switch for controlling the direction and duration of rotation of said motor, means for actuating said reversing switch in response to operating conditions of said turbine, said means comprising a topographic cam member movable in accordance with said conditions, and means for relaying the movement of said blade tilting rod to said reversing switch.

12. In a system for automatically controlling the tilt of the propeller blades of a hydraulic turbine, the combination of a rotatable propeller shaft, a hollow casing attached to said shaft, an electric motor and speed reduction gearing mounted within said hollow casing, a propeller blade tilting rod operatively connected to said motor through said gearing, a reversing switch for controlling the direction and duration of rotation of said motor, a floating lever operatively connected intermediate its ends to said reversing switch, means for actuating one end of said floating lever in response to an operating condition of said turbine, and means for actuating the other end of said floating lever in accordance with the movement of said blade tilting rod.

13. In a system for automatically controlling the tilt of the propeller blades of a hydraulic turbine, the combination of a rotatable propeller shaft, an electric motor and gearing carried by said rotatable shaft, a propeller blade tilting rod operatively connected to said motor through said gearing, a reversing switch for controlling the direction and duration of rotation of said motor, said switch having stationary contacts and a movable contact member operable from a neutral position to selectively engage said stationary

contacts, a floating lever operatively connect-
ed at a point intermediate the ends thereof to
said movable member, means for actuating
one end of said floating lever in response to
5 an operating condition of said turbine, and
means for actuating the other end of said
floating lever in accordance with the move-
ment of said blade tilting rod so as to move
said contact member toward said neutral po-
10 sition.

In testimony whereof, the signature of the
inventor is affixed hereto.

ARNOLD PFAU.

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