ADJUSTABLE BLADE PROPELLER TYPE PUMPS AND PUMP TURBINES

Filed Sept. 16, 1964 4 Sheets-Sheet 1

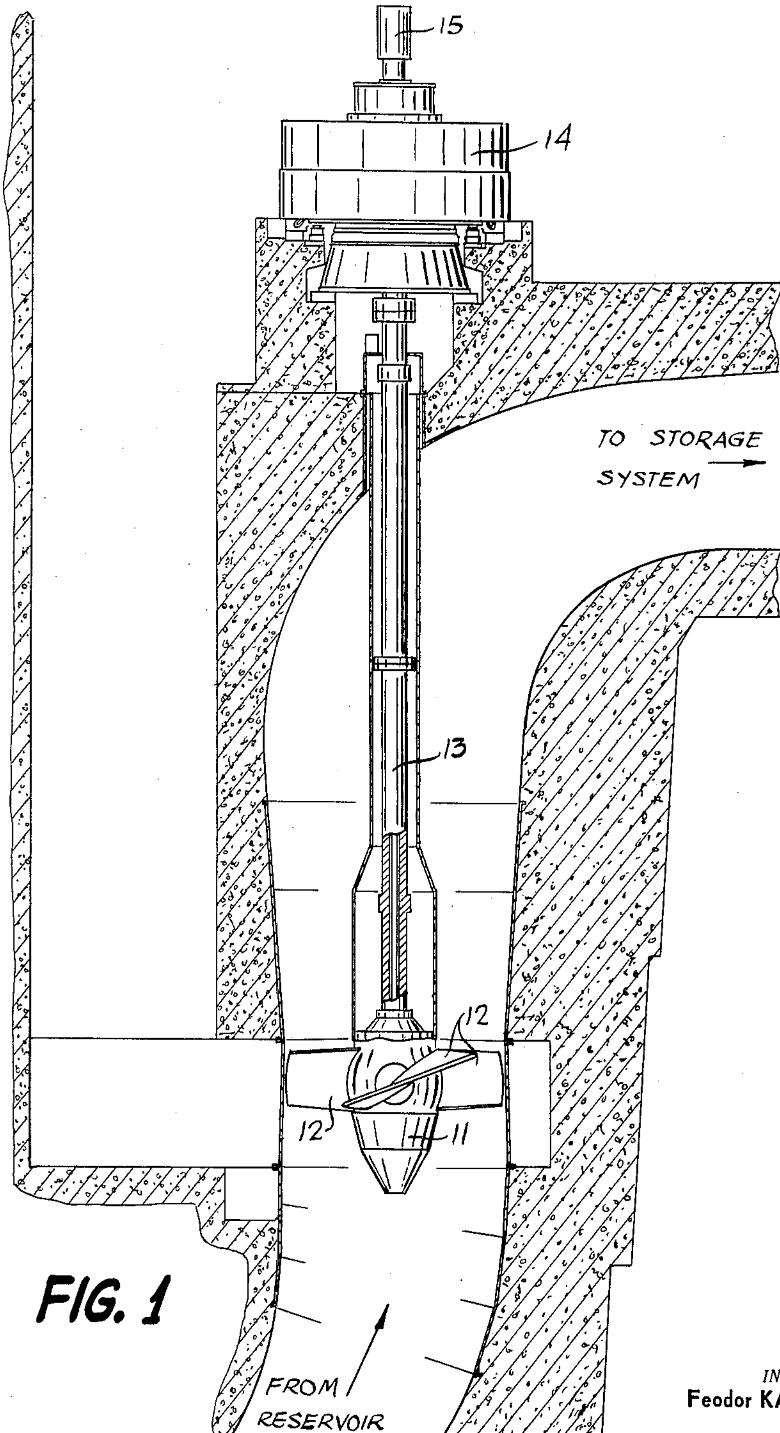

FIG. 1

INVENTOR
Feodor KANGER

Fetherstonhaugh & Co.
ATTORNEYS

ADJUSTABLE BLADE PROPELLER TYPE PUMPS AND PUMP TURBINES

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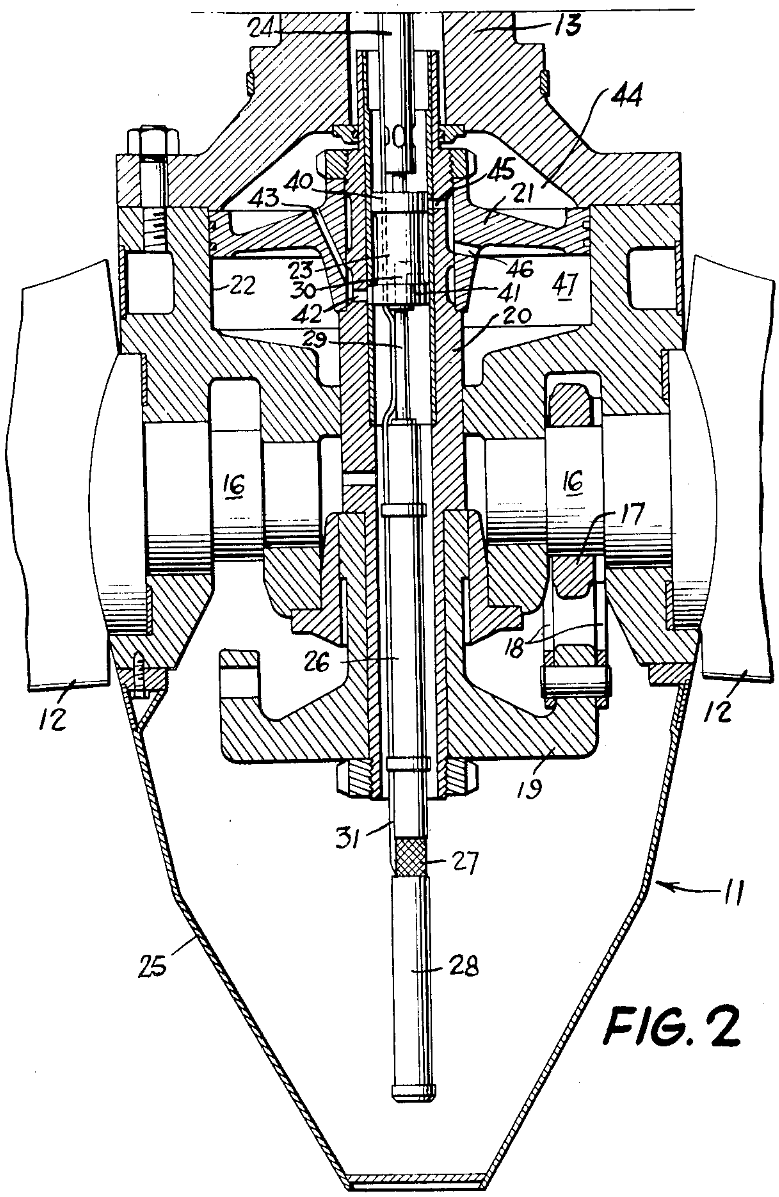

FIG. 2

INVENTOR
Feodor KANGER

Fetherstonhaugh & Co.
ATTORNEYS

ADJUSTABLE BLADE PROPELLER TYPE PUMPS AND PUMP TURBINES

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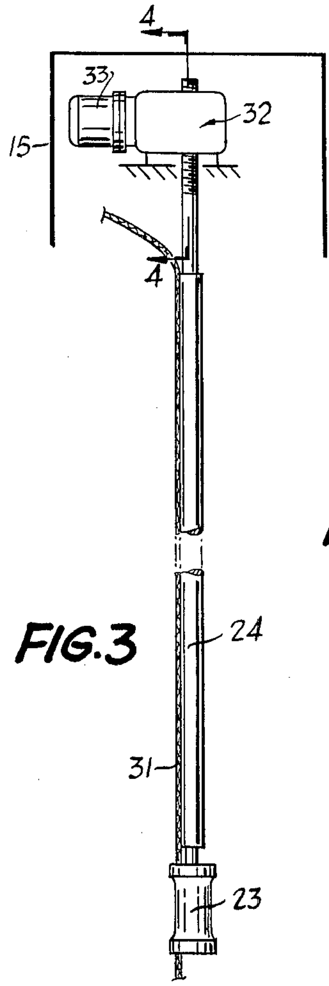

FIG.3

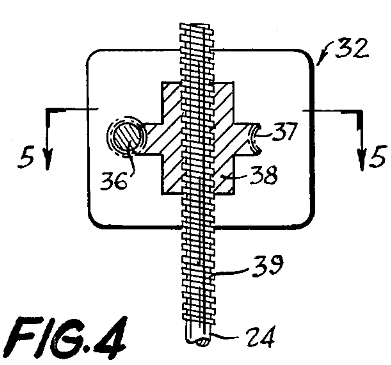

FIG.4

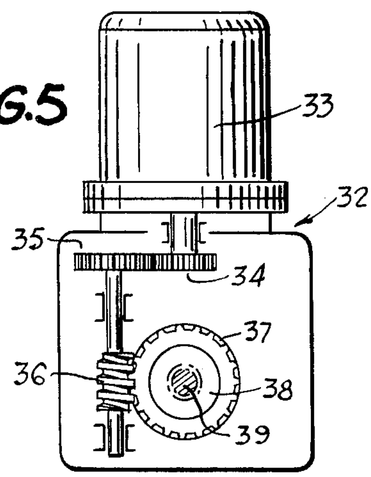

FIG.5

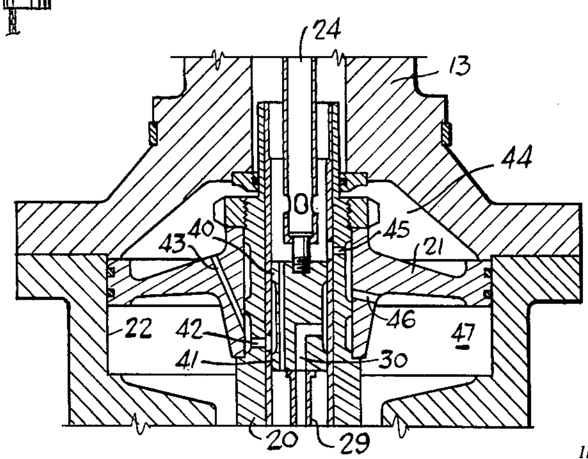

FIG.6

INVENTOR
Feodor KANGER

Fetherstonhaugh & Co.
ATTORNEYS

Dec. 28, 1965 F. KANGER 3,226,084

ADJUSTABLE BLADE PROPELLER TYPE PUMPS AND PUMP TURBINES

Filed Sept. 16, 1964 4 Sheets-Sheet 4

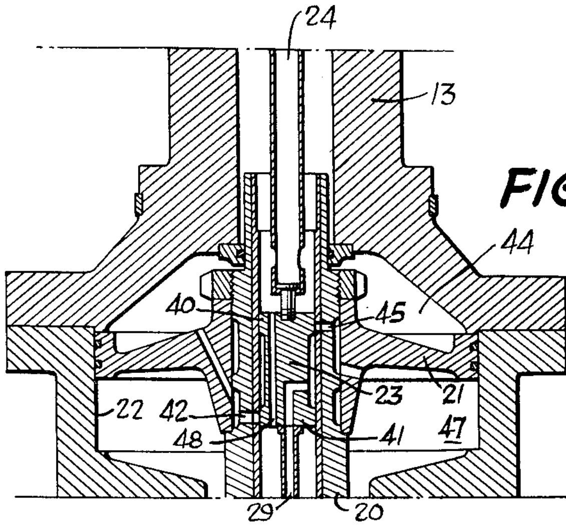

FIG. 7

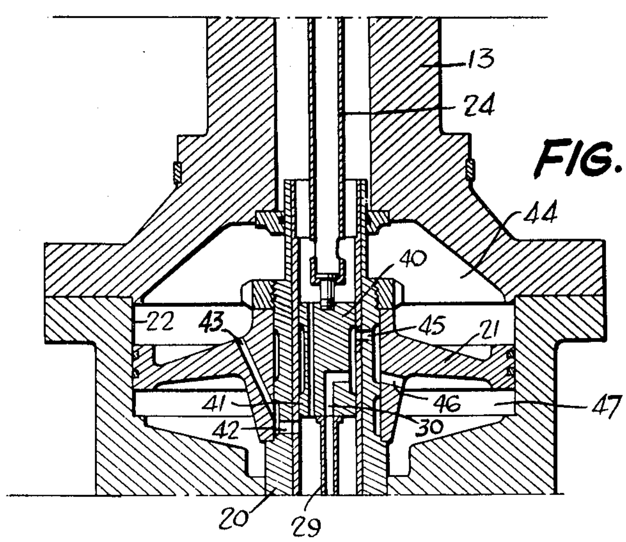

FIG. 8

INVENTOR
Feodor KANGER

Fetherstonhaugh & Co.
ATTORNEYS

United States Patent Office 3,226,084
Patented Dec. 28, 1965

3,226,084

ADJUSTABLE BLADE PROPELLER TYPE PUMPS AND PUMP TURBINES

Feodor Kanger, Cote St. Luc, Quebec, Canada, assignor to Dominion Engineering Works Limited, Montreal, Quebec, Canada

Filed Sept. 16, 1964, Ser. No. 396,974
1 Claim. (Cl. 253—31)

This invention relates generally to hydraulic pumps and pump turbines and particularly to a blade adjusting mechanism for constant speed adjustable blade propeller type pumps or pump turbines which are sensitive to power output or input demands, such as those used in the generation of hydro-electric power, or in water distribution systems.

In the following specification, this invention is described as embodied in a vertical axial flow propeller type machine, but it will be understood that it is in no way limited to this embodiment and that the features of this invention may be applied to other propeller type hydraulic machines, such as diagonal flow propeller type machines, and also to machines in other configurations, such as horizontal axial flow machines.

In U.S. Patent Serial No. 3,130,955 there is shown a mechanism for adjusting the angles of the blades of a Kaplan turbine in predetermined synchronism with wicket gate movement, this mechanism being almost entirely enclosed in the turbine hub. In more detail, U.S. Patent 3,130,955 discloses an arrangement in which axial movement of a valve spool situated within the hub of a Kaplan turbine, in response to movement of the turbine wicket gates, produces movement of a piston in a hydraulic cylinder, also situated within said hub, resulting in angular movement of the turbine blades. Thus, in machines of this type, wicket gates form an essential part of the blade adjustment mechanism.

This invention relates to propeller type hydraulic pumps and pump turbines which include blade adjusting mechanisms situated in the hubs thereof, similar to the blade adjusting mechanism disclosed in U.S. Patent 3,130,955, but which do not embody wicket gates.

In many conventional adjustable blade propeller type hydraulic pumps and pump turbines the hydraulically actuated rotor blade adjusting mechanisms are located in the rotating hub assemblies. However, in these conventional machines, hydraulic fluid is supplied to the adjusting mechanisms from station external sources by means of external piping, thus necessitating the inclusion of rotary seals for fluid tight connections to the rotating shafts and hub assemblies.

These conventional arrangements have many inherent disadvantages, some of which are as follows:

(a) The risk that hydraulic fluid may spill onto the motor/generators.

(b) The unsightly appearance of the piping and rotary seals and,

(c) The cost of maintaining the piping and seals in fluid tight condition.

In a pump or pump turbine, according to this invention, the rotating assembly includes a hub casing which also serves as a hydraulic fluid reservoir and houses the components of the rotor blade positioning mechanism, an axially movable control valve spool and an oil pump. Thus there is no requirement for the provision of hydraulic fluid from an external source to operate the blade position changing mechanism and it is only necessary to provide a simple mechanical connection for axial movement of the control valve.

In pump and pump turbine installations there may be considerable variation in hydraulic conditions and, for each different combination of head or discharge pressure

and quantity, there is an optimum blade angle which provides maximum operational efficiency. This data is determined in laboratory tests on scale models of specific pump installations and by tests on the full size machines.

In accordance with the basic concept of this invention the valve spool is moved mechanically to obtain any desired angular position of the blades.

In the preferred execution of this invention an electrically driven screw-jack, or gear motor, is positioned on top of the machine for mechanically raising and lowering the spool valve, and an operator, provided with the necessary predetermined data and current operating conditions, can manually operate the gear motor to select optimum blade angles which provide the required maximum operational efficiency.

The operator may be stationed relatively close to the gear motor and make manual adjustments thereon in response to local observations, or he may be stationed in a remote location and signal adjustments to be made according to relayed data of local conditions.

Alternatively the signal for operation of the blade adjusting means may be provided by an automatic control system sensitive to one or more varying operating conditions.

It is, therefore, the main object of this invention to provide a rotor blade adjusting mechanism, including a hydraulic servo-system, for a constant speed adjustable blade pump or pump turbine, in which the adjusting mechanism is enclosed within the rotor hub and in which the hydraulic fluid for actuating the servo-system is also contained within the rotor hub.

Another object of this invention is to provide an adjustable blade pump or pump turbine in which no external piping is required for the supply of operating hydraulic fluid to the rotor hub enclosed blade adjusting mechanism.

A further object of this invention is to provide a rotor blade adjusting mechanism and control spool valve enclosed in the rotor hub of an adjustable blade pump or pump turbine, and including a control valve positioning means for axially moving the control valve, and thereby moving the blades to selected angular positions, in accordance with predetermined data and current hydraulic conditions.

These and other objects and advantages of this invention will be further apparent by referring to the following detailed specification and figures, in which:

FIG. 1 is an elevational view, partly in section, showing an adjustable blade propeller type pump turbine which embodies the features set forth in this invention

FIG. 2 is a sectional view, to an enlarged scale, showing the details of the rotor hub and blade adjusting mechanism shown in FIG. 1.

FIG. 3 is an elevational view of the control valve, control rod, and control valve positioning mechanism.

FIG. 4 is an enlarged section on 4—4 in FIG. 3.

FIG. 5 is an enlarged section on 5—5 in FIG. 4.

FIG. 6 is a sectional view of the blade adjusting mechanism, showing the control valve in position to move the servo-piston downwardly.

FIG. 7 is a sectional view of the blade adjusting mechanism, showing the control valve and piston in equilibrium.

FIG. 8 is a sectional view of the blade adjusting mechanism, showing the control valve in position to move the servo-piston upwardly.

Referring now to the figures, wherein like numbers represent like parts throughout the several views, and with particular reference to FIG. 1, rotor hub **11**, having rotor blades **12** radially journalled therein, is rigidly secured to the lower end of hollow shaft **13**. Motor/generator **14** is attached to the upper end of hollow shaft **13** and suitably mounted on bearings to support the entire weight of the pump turbine assembly. The control valve positioning means is located in the control head assembly 15.

In one mode of operation, motor-generator 14 acts as a motor to rotate shaft 13 and rotor hub 11, with rotor blades 12 angularly adjusted for the machine to operate as a pump. In this mode water will be pumped and raised in level from, for example, a low level reservoir to a high level storage system. The high level storage system would then be used to operate other power installations, such as turbines, etc.

However, hydraulic conditions may be such that water will flow from the storage system down to the lower level reservoir. When this condition occurs, rotor blades 12 will be angularly adjusted for the machine to operate as a turbine and, in turn, motor/generator 14 will act as a generator and produce power.

FIG. 2 shows an enlarged sectional view of the rotor hub 11 and details of the blade angle adjusting mechanism.

Each rotor blade 12 is provided with a trunnion 16 at the inner end thereof. Trunnions 16 are rotatably journalled in suitable bearings in rotor hub 11. A conventional type of crank arm 17 is rigidly connected to each trunnion 16 and is operably connected by links 18 to cross-head 19, such that axial movement of cross-head 19 will produce simultaneous rotation of rotor blades 12. Cross head 19 is connected by hollow piston shaft 20 to servo-piston 21 in servo-cylinder 22.

Thus it can be seen that movement of servo-piston 21 will produce simultaneous rotation of rotor blades 12.

Spool shaped control valve 23 is slidably positioned within hollow piston shaft 20 and is located axially by control rod 24.

Rotor hub casing 25 acts as a hydraulic fluid reservoir. Axial flow pump 26 is mounted to the under side of control valve 23, the pump inlet 27 and electrically driven pump motor 28 being immersed in the hydraulic fluid. The outlet from pump 26 discharges through hydraulic pressure pipe 29 into duct 30 in control valve 23. Control valve 23, pump 26, and motor 28 are axially aligned.

Electric cable 31 extends through hollow shaft 13, and exits at control head assembly 15, to provide electrical energy for driving motor 28.

FIG. 3 is an elevation of the control valve 23 and control rod 24, and shows control rod 24 connected to the control valve positioning mechanism 32, situated in control head assembly 15.

Control rod 24 is suitably mounted in control head assembly 15 to reciprocate but not to rotate.

FIGS. 4 and 5 show details of the control valve positioning mechanism 32 which, in the preferred execution of this invention, comprises an electrically driven screw-jack type gear motor, such as a Limitorque Control as manufactured by Philadelphia Gear Corporation, Pennsylvania, U.S.A. Provision is also made for this mechanism to be hand operated.

It will, of course, be understood that many other forms of control valve positioning means could equally well be used, such as pneumatic cylinder and piston means, etc.

In FIGS. 4 and 5 control valve positioning means 32 comprises an electric motor 33 which drives, through gears 34 and 35, worm 36. Worm 36 rotates worm-wheel 37, which is formed at the outer periphery of screw-nut 38. Screw-thread 39 is formed on the upper end of control rod 24 and is operably engaged in a corresponding internal thread in screw-nut 38. Screw-nut 38 is suitably journalled for rotation but is restrained from vertical movement.

Thus it will be seen that operation of electric motor 33 will produce, through worm 36, rotation of screw-nut 38, which, in turn, produces axial movement of control rod 34, depending upon the direction of rotation of electric motor 33.

The operation of this invention is as follows:

As previously stated, hub casing 25 acts as reservoir for hydraulic fluid, and the level of the fluid in the rotating assembly may be at any desired level within hollow shaft 13. Convenient filling of the hub assembly may take place through hollow shaft 13.

When the operator wishes to adjust the angular positions of blades 12, to obtain maximum operational efficiency when local hydraulic conditions change, or when it is necessary to alter the mode of the machinery from, for example, pump operation to turbine operation, the operator will operate electric motor 33 which will, according to the direction of rotation selected, raise or lower a predetermined amount the control rod 24 and control valve 23 which is attached thereto.

FIG. 6 shows details of the blade adjusting mechanism in which servo-piston 21 is at the top of its stroke and control valve 23 is in a lowered position, wherein servo-piston 21 will be moved downwardly and produce simultaneous angular movement of rotor blades 12.

Control valve 23 is spool shaped and comprises upper land portion 40, lower land portion 41, and having an annular reduced diameter central portion therebetween.

In the lowered position of control valve 23, lower land 41 has uncovered port 42 in piston shaft 20, and hydraulic pressure pipe 29 is directly connected through duct 30, port 42 and duct 43 in servo-piston 21. Similarly, upper land 40 has uncovered port 45 which is conected through duct 46 in servo-piston 21, to the space 47 below servo-piston 21.

Thus, with the components in this position, hydraulic fluid will be pumped from reservoir 25 to space 44, servo-piston 21 will be forced downwardly and the fluid in space 47 will be forced through duct 46, port 45, and return duct 48 in control valve 23 (see FIG. 7), and return to the reservoir.

Servo-piston 21, piston shaft 20, and cross-head 19 will move downwardly until lands 40 and 41 again cover ports 45 and 42, respectively, whereupon further movement of servo-piston 21 will cease and the adjusting mechanism will be in a position of equilibrium.

Thus, downward movement of control valve 23 will result in the downward movement of cross-head 19 and consequent simultaneous rotation of blades 12, for example, in the opening direction, until the desired angular position is attained.

FIG. 7 shows details of the blade adjusting mechanism in which servo-piston 21 is at the top of its stroke and control valve 23 is in a position of equilibrium, with lands 40 and 41 covering ports 45 and 42, respectively. In this position there is no connecting passageway to either space 44, or space 47, and thus servo-piston 21 cannot be moved upwardly or downwardly and will remain in this adjusted position.

FIG. 8 shows details of the blade adjusting mechanism in which servo-piston 21 is positioned mid-way in servo-cylinder 22 and control valve 23 is in a raised position, due to appropriate operation of electric motor 33, wherein servo-piston 21 will be moved upwardly and produce simultaneous movement of rotor blades 12.

In this raised position of control valve 23, upper land 40 has uncovered port 45 in piston shaft 20 and hydraulic pressure pipe 29 is directly connected through duct 30, port 45, and duct 46, to space 47 below servo-piston 21. Similarly, lower land 41 has uncovered port 42, which is directly connected through duct 43 to space 44, above servo-piston 21.

Thus, with the components in this position, hydraulic fluid will be pumped from reservoir 25 to space 47, servo-piston 21 will be forced upwardly and the fluid in space 44 will be forced through duct 43 and port 42, and return to reservoir 25.

Servo-piston 21, piston shaft 20, and cross-head 19 will move upwardly until lands 40 and 41 again cover ports 45 and 42, respectively, whereupon further movement of servo-piston 21 will cease and the adjusting mechanism will again be in a position of equilibrium.

Thus, upward movement of control valve 23 will result in the upward movement of cross-head 19 and consequent simultaneous rotation of blades 12, for example, in the closing direction, until the desired angular position is attained.

It will be seen that this invention provides a means for angularly adjusting the positions of the rotor blades in direct response to the initiation of a control valve positioning mechanism, which may be an electrically driven gear motor, or other means, positioned directly above the motor generator and having a direct mechanical connection, through the hollow turbine shaft, to the control valve. The initiation of the gear motor may be made by an operator positioned relatively close to the machine in response to observation of local hydraulic conditions, or by an operator positioned remote from the machine and having the necessary information on local hydraulic conditions, or by a suitable automatic control system.

In the preferred execution of this invention control valve 23, pump 26 and pump motor 28, are shown axially aligned and dimensioned such that they may be withdrawn, as a sub-assembly, upwardly through the bore of hollow shaft 13. This will facilitate convenient maintenance on these components, without the need for major disassembly of the pump turbine and the many accompanying disadvantages.

It will be understood that many modifications and variations of this invention are possible in the light of the above teachings. For example, the specific positioning of the piston, pump and pump motor, may be readily varied to suit specific operational requirements. The pump shown in the figures is an electrically driven centrifugal pump of a type well known for use in oil wells. It will be readily understood however that any other type of pump, such as a pneumatically operated or piston type pump, etc., could equally well be used.

From the foregoing it is thus seen that this invention provides a new and improved blade adjusting mechanism for adjustable blade propeller type pumps and pump turbines, accomplishing all of the objects and advantages as set forth herein.

What I claim is:

A hydro-electric power generation installation including an adjustable blade propeller type pump or pump turbine and a motor generator wherein no wicket gates are provided and wherein the blade angle of the pump turbine is set in accordance with hydraulic conditions comprising, a rotating assembly including a hollow shaft, a hub casing rigidly secured to one end of said shaft and comprising a fluid reservoir, rotor blades journalled in said hub casing for rotation about axes radial to said casing, a servo-motor disposed within said casing, said servo-motor including a piston operatively connected to said blades to control and adjust the angular positions thereof, a pump disposed within said casing, means for driving said pump, an axially movable control valve disposed within said casing, the inlet of said pump communicating with fluid in said fluid reservoir and the outlet thereof communicating with said control valve, said control valve adapted to direct said fluid under pressure from said pump to one side of said piston to rotate said blades in one direction and to the other side of said piston to rotate said blades in the opposite direction, a control rod extending through said hollow shaft and connected to said control valve, said pump together with said drive means for said pump and said control valve being axially aligned, and control valve positioning means located at the other end of said hollow shaft and above the motor generator and operatively connected to said control rod, said control valve positioning means functioning in response to a command to move said control valve and to thereby rotate said blades to a selected angular position, said control valve positioning means comprising a screw jack, the control rod having screw threads thereon and adapted to be moved vertically to move the control valve in accordance with predetermined data of hydraulic characteristics and operating conditions.

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MARK NEWMAN, *Primary Examiner.*

JULIUS E. WEST, *Examiner.*