July 12, 1966 A. KOVATS 3,260,311

VANE ADJUSTING DEVICE FOR PUMP IMPELLERS AND TURBINE WHEELS

Filed July 5, 1963 3 Sheets-Sheet 1

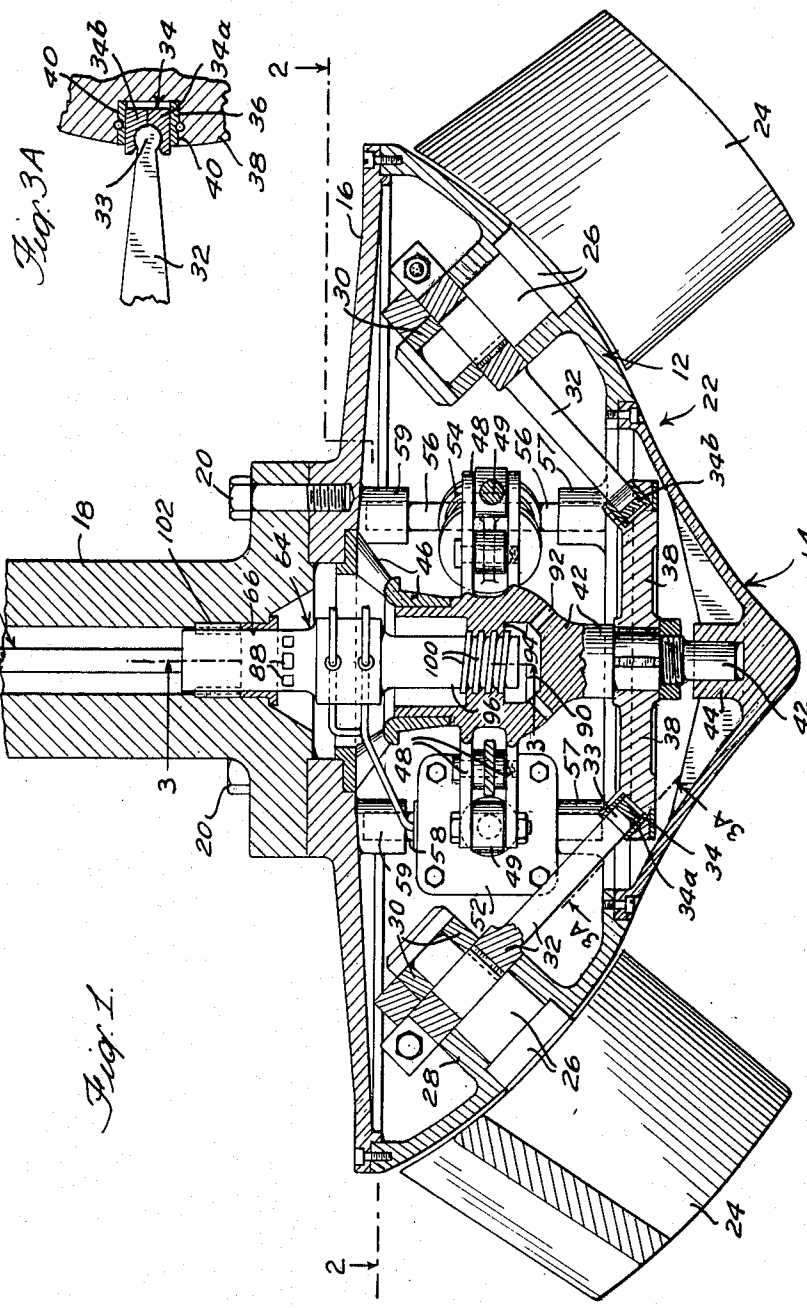

Fig. 1

Fig. 3A

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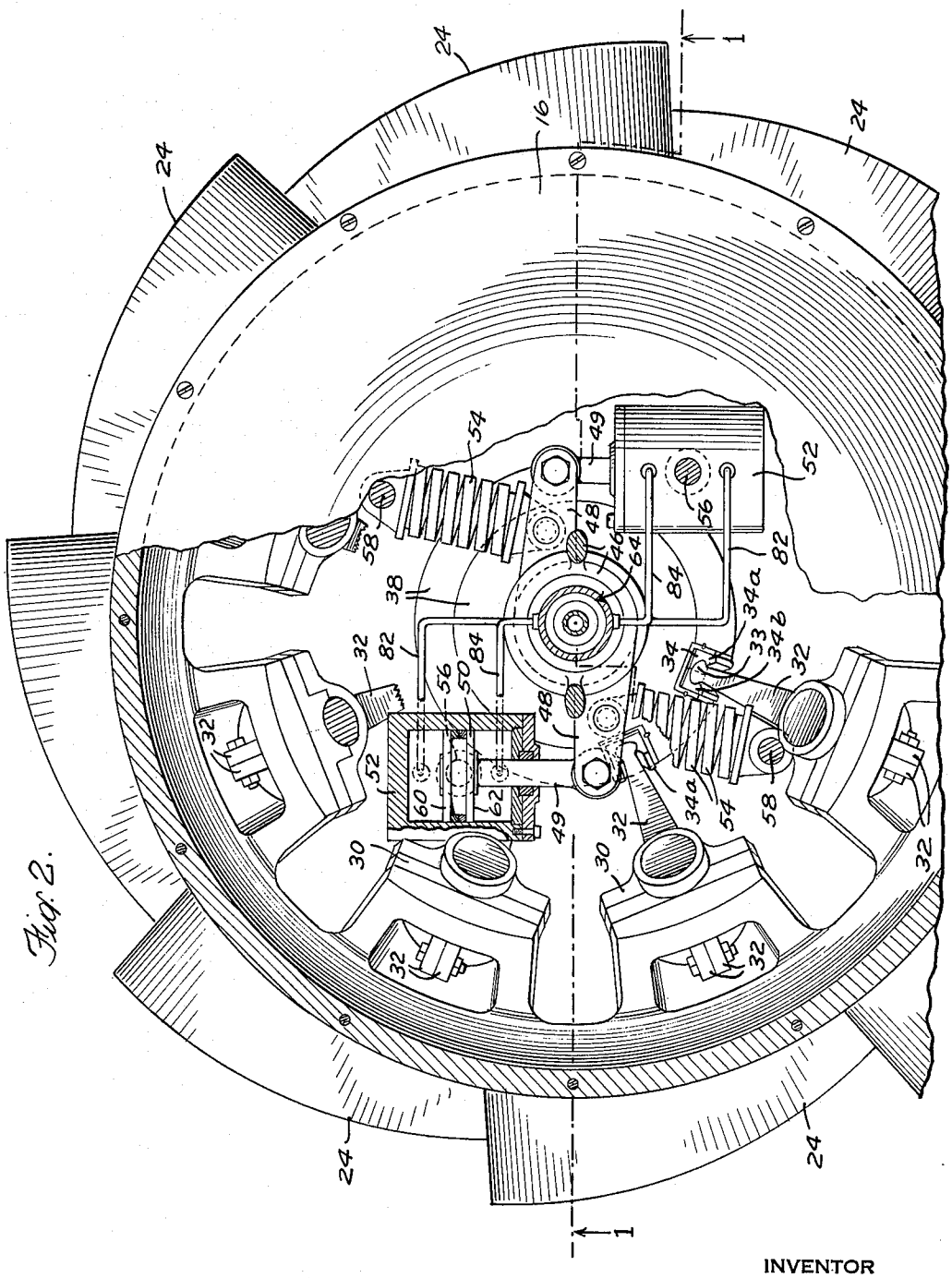

Fig. 2.

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Fig. 4.

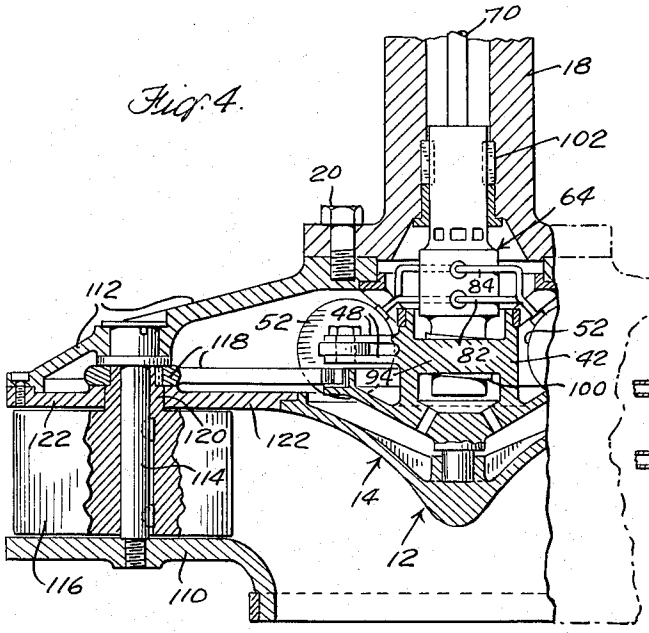
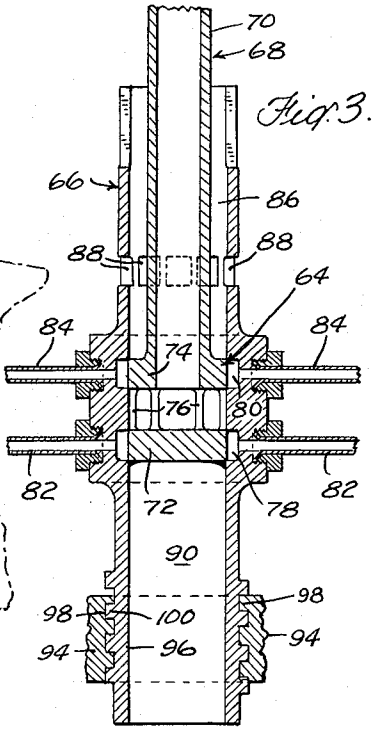


Fig. 3.



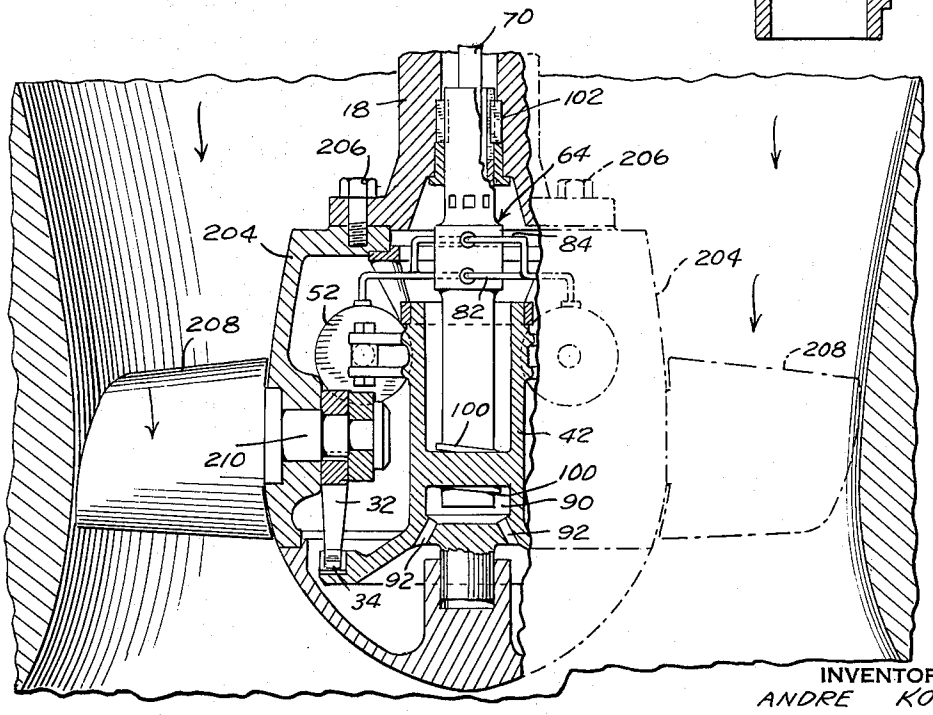


Fig. 5.

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VANE ADJUSTING DEVICE FOR PUMP IMPELLERS AND TURBINE WHEELS

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2 Claims. (Cl. 170—160.31)

This invention relates to a servomotor mechanism for feathering the vanes of hydraulic pump impellers or of turbine wheels. The invention is equally applicable to radial-flow or centrifugal, mixed-flow, and axial-flow or propeller pumps and turbines. For the purposes of this application, the term "rotor" shall be deemed to include impeller and wheel mechanisms for all of the above types of pumps or turbines.

In connection with water reclamation projects, there is an increasing demand for large circulating pumps with adjustable vanes for flow regulation. It is, therefore, an object of this invention to provide improved means by which adjustability of impeller vanes, and in particular vanes for mixed-flow impellers of large circulating pumps, may be effected. It is a further object of the invention to provide a servo-motor mechanism for a rotor and vanes thereof wherein components of the mechanism are located within the rotor housing and shaft, and are fully accessible for adjustment, maintenance and repair purposes without removal of the rotor. A further object of the invention is to provide a servomotor mechanism in which adjustment of the rotor vanes is achieved in either direction without play or fluttering of the vanes. A further object of the invention is to provide an hydraulic control system in which over-speeding of the rotor is automatically prevented in the event of loss of pressure in the system.

These and other objects will become apparent from the following description with reference to the accompanying drawings, in which:

FIGURE 1 is a section view taken along line **1**—**1** of FIG. 2 with parts shown in plan view and with certain parts broken away of a rotor and servomotor mechanism in accordance with the invention;

FIGURE 2 is a section view taken along line **2**—**2** of FIG. 1 with certain parts broken away;

FIGURE 3 is an axial section view of a distributor valve and control rod assembly on a larger scale taken along line **3**—**3** of FIG. 1;

FIGURE 3A is a sectional view taken along line 3A—3A of FIG. 1;

FIGURE 4 is a sectional view in accordance with the invention of a radial-flow or centrifugal pump; and

FIGURE 5 illustrates the invention as applied to an axial-flow or propeller (Kaplan) type pump.

Referring to FIGS. 1 and 2, there is illustrated a mixed-flow pump impeller consisting of a rotor housing **12** having a cone-shaped bottom plate **14** and a cover plate **16**. The rotor is secured to a pump shaft **18** by means of bolts **20**, the cover plate **16** and bottom plate **14** making up the hub **22** of the rotor.

Attached to and pivoted on the hub are a plurality of vanes **24** mounted on trunnions **26** which are pivoted in bearings **28** and **30**, the bearing **28** being a part of the bottom plate **14**, and the bearing **30** being of the split ring type. The trunnions are turned by lever arms **32** connected to the trunnions between the bearing surfaces **28** and **30**.

Engaging the lever arms **32**, at an enlarged end portion **33** removed from the trunnions, are split slider blocks **34**, illustrated in detail in FIG. 3A. The slider blocks which are made up of split members **34***a* and **34***b* clamping on the enlarged end portions of the lever arms, are retained

in slots **36** annularly spaced around the periphery of a disc **38**, the split members being held together in clamping position by means of filler pieces **40**, but at the same time being capable of movement radially on the periphery of the disc with rotation of the disc. Exact adjustment and spacing of the lever arms circumferentially around the disc **38** is made by using filler pieces of different thicknesses to move the split members circumferentially in one direction or the other.

Supporting the disc **38** for rotational movement is a shaft **42**, to which the disc **38** is keyed. The shaft pivots in bearings **44** and **46** fixed to the bottom and top cover plates (**14**, **16**) respectively. Intermediate the upper and lower shaft bearings **44** and **46** are radially projecting lever arms **48**. In the embodiment illustrated, the two lever arms extend radially from the shaft **42** in opposite directions, the free ends of the lever arms being connected, through oppositely directed piston rods **49**, to pistons **50** sliding in hydraulic cylinders **52**. Also acting on the lever arms **48** are compression springs **54**, the hydraulic cylinders **52** and springs **54** being pivotally mounted on pinions **56** and **58** extending between and seated in opposed bearings **57** and **59** fixed to the bottom plate and cover plate. The springs are arranged to exert a force in a direction approximately opposite to the direction of force exerted by the pistons **50** on the lever arms.

With respect to the latter force, the larger surface **60** on one side of the pistons, as compared to the surface **62** on the other side reduced in area by the cross sectional area taken-up by the piston rod **49**, creates a resultant force, which in FIG. 2, effects a counter-clockwise torque on the shaft **42**, when the pressure is equal on oposite sides of the piston **50**. This resultant force is counterbalanced by the springs **54**. Since the pistons **50** and springs **54** exert forces in opposite directions, there is no play at any of the pivot points of the assembly. The slider block assembly **34** also eliminates play in the linkage between the disc **38** and the vanes, so that during and after adjustment of the rotor vanes, no play or fluttering of the vanes results.

Also making up part of the servomotor mechanism is a distributor valve **64** (FIGS. 1 and 3), coaxial with and partly contained by the pump rotor shaft **18**, comprising a cylindrical valve stem **66** and a control rod **68** capable of axial movement within the valve stem. The control rod, which may be actuated from the top of the rotor shaft by a governor or perhaps manual control means, consists of a hollow, tubular pipe **70**, arranged to deliver oil under pressure to the servomotor mechanism, and lower and upper spaced pistons **72** and **74** secured to the lower end of the pipe and connected by ribs **76**. The pistons are arranged to coincide with annular chambers **78** and **80**, spaced longitudinally along the valve stem **66**, and to cover the chambers when appropriately positioned. Connected to the chambers are flexible lines **82** and **84** leading to opposite sides of the pistons **50** within the hydraulic cylinders **52**, whereby on movement of the control rod, upwardly or downwardly, oil under pressure is fed from the control rod pipe **70** into one or the other of the annular chambers **78**, **80** and to the hydraulic cylinders on one side of the pistons **50**.

The distributor valve **64** also comprises an annular channel **86** leading upwardly within the valve stem **66** between the stem and the inner control rod **68**, spaced openings **88** leading from the inside of the rotor hub to the channel **86**, and a lower channel **90** extending below the control rod pistons **72** and **74**. Openings **92** in the disc shaft **42** provide a passageway for the flow of oil from the lower channel **90** to the inside of the rotor hub.

In operation of the servomotor mechanism, when it is desired to change the vane positioning, the control rod **68**

is moved upwardly or downwardly so that oil flows through the control rod pipe **70** into either annular channel **78** or **80** to one side of the other of pistons **50**. The oil pressure moves the pistons **50**, which, in turn, move the lever arms **48**, shaft **42**, and disc **38**, adjusting the positioning of the vanes through lever arms **32**. If the control rod is moved downwardly, the lower annular chamber **78** is exposed so that oil flows into the lower flexible line **82** and to the larger area side **60** of the hydraulic pistons **50** moving the piston so as to force the lever arms in a counterclockwise direction (FIG. 2) against the force of the springs **54**. At the same time, the upper chamber **80** is exposed permitting oil to flow from the smaller area side **62** of the pistons into the annular channel **86** and upwardly in the valve stem. As the springs compress, the force exerted by the springs is increased, but the arrangement is such that the torque exercised on the trunnions **26** resulting from the flow around the vanes **24** is also increasing. The variation in this torque depends upon the position of the vane pivot axis relative to the width of the vanes in the direction of flow. In accordance with the invention, the axis or pivot point for the vanes is selected such that the increase in torque coincides with the increase in spring force whereby the variation in pressure required on opposite sides of the piston **50** for movement of the vanes is reduced to a minimum.

When the control rod is moved upwardly, the oil from the inside of the control rod flows into the upper chamber **80** through the flexible line **84** and to the smaller face of the pistons **50**. This forces the pistons and lever arms **48** in a clockwise direction. Oil flows outwardly through the flexible line **82**, into the lower annular chamber **78** which is exposed, and downwardly through the lower channel **90**. From the lower channel the oil flows outwardly through openings **92** into the rotor hub **22**, and from there to openings **88** and into the annular channel **86** within the valve stem. Thus, the rotor hub serves as an oil reservoir.

As a feature of the invention, the shaft **42** is provided with a threaded cylindrical member **94** which encompasses the lower end **96** of the distributor valve **64**. The cylindrical member and lower end of the distributor valve are each provided with engaging threads **98** and **100** by which, as the lever arms **48** rotate, along with shaft **42**, and disc **38**, the distributor valve is caused to be raised or lowered. The valve is guided by means of keys **102** in the pump rotor shaft **18** for longitudinal or axial movement only. Accordingly, the distributor valve **64** follows the positioning of the control rod **68**, such that after the vanes are turned to a predetermined position by movement of the control rod, the annular chambers **72** and **74** are blocked off locking the servomotor pistons **50**, and thus vanes, in the selected position. Accordingly, for each position of the control rod **68**, there is also a specific position for the vanes **24**.

If, for any reason, for instance, a change in torque on the vanes **24**, or leakage in the servomotor mechanism, the position of the vanes should change, this will also cause the distributor valve **64** to change in position relative to the control rod, admitting oil pressure to the servomotor pistons to restore the proper positioning of the vanes.

As a further safety feature, should all pressure be lost by virtue of leakage, or for any other reason, the springs turn the vanes to an extreme position, which may be a wide-open or closed position depending upon whether the unit is a turbine or pump, to prevent over-speeding of the unit. In the embodiment illustrated, for a mixed-flow pump, if all pressure is lost, the springs **54** will turn the vanes to a wide-open position or maximum torque position preventing over-speeding of the pump. The reverse situation could be achieved simply by interchanging the spring and hydraulic cylinder positions, or by other obvious suitable means.

It should be apparent from the above description that the entire servomotor mechanism, including the distributor valve, is accessible from the bottom of the rotor housing, the mechanism, being located within the rotor hub. For maintenance, or adjustment, it is a simple matter to remove the bottom plate **14**.

In the embodiment illustrated in FIG. 4, the pump is adapted for radial or centrifugal flow. The operation of components is exactly the same as in FIGS. 1–3A, except that the rotor is provided with a suction-side shroud **110** connected to top cover plate **112** by means of rods **114**. The vanes **116** pivot around the rods **114** being fixed to lever arms **118**. This is accomplished by providing the vanes with extensions **120**, extending through the bottom plate **122** of the rotor, to which the lever arms are fixed.

In the embodiment of FIG. 5, for a rotor of the propeller type, again, the components are substantially the same as those of FIGS. 1–3A except that the hub **204** is attached directly to the rotor shaft **18** by means of bolts **206**. No cover plate is required. The vanes **208** are provided with trunnions **210** which extend at an axis perpendicular to the axis of the rotor shaft **18**.

Although the invention has been described with respect to specific embodiments, many variations within the scope and spirit of the invention as defined in the following claims will be apparent to those skilled in the art.

What is claimed is:

1. A runner assembly comprising:

a runner shaft;

a runner housing on said shaft having a cover plate and a removable bottom plate affixed to the cover plate;

vane means supported from said housing bottom plate;

linkage means in said housing for rotating said vane means comprising a second shaft coaxial with said runner shaft, a rotatable disc supported on said second shaft, lever arms extending between said disc and vane means;

a motor mechanism also in said housing for rotating said second shaft comprising reversible hydraulic cylinder means having a normally resultant force acting in one direction on said second shaft, spring means arranged to act on said second shaft exerting a force in a direction opposite to that of said cylinder means, said spring means and vane means being dimensioned whereby an increase or decrease in torque on said vane means effects a corresponding and substantially equal increase or decrease in the force exerted by said spring means such that only a small change in the resultant force exerted by said cylinder means is required to rotate said vane means;

means for transmitting a hydraulic pressure to said cylinder means;

and a valve positioner means comprising a cylindrical valve casing coaxial with said runner and second shafts, a control rod means movable within and relative to said valve casing means and operatively associated with the valve casing means for regulating said pressure transmitted to the hydraulic cylinder means, and means operatively engaging said valve casing with said second shaft for longitudinal movement of the valve casing to an equilibrium position following a change in position of said vane means, whereby for each position of the control rod there is also a position for the said second shaft and the vane means;

said above-mentioned means being accessible by removal of said bottom plate.

2. A runner assembly comprising

a shaft;

a runner housing on said shaft;

vane means supported from said housing;

linkage means in the housing comprising a first arm attached to said vane means, and a second arm pivotable about the axis of said housing connected to said first arm;

hydraulic cylinder means including piston means connected to the second arm at a point removed from the housing axis, the piston means being reversible to urge the linkage means in opposite directions;

control means adapted to transmit a hydraulic pressure to opposite sides of said piston means, said piston means having unequal surface areas on opposite sides thereof to provide a resultant force in one of said directions when the pressure is equal on opposite sides thereof;

spring means connected to said second arm at a point between the point of connection of the piston means and the housing axis exerting a continuous compressive biasing force on the linkage means in the other of said directions;

said spring means and vane means being dimensioned whereby an increase or decrease in torque on said vane means achieves a corresponding and substantially equal increase or decrease in the force exerted by said spring means;

said linkage means, spring means and cylinder means being situated in said runner housing.

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