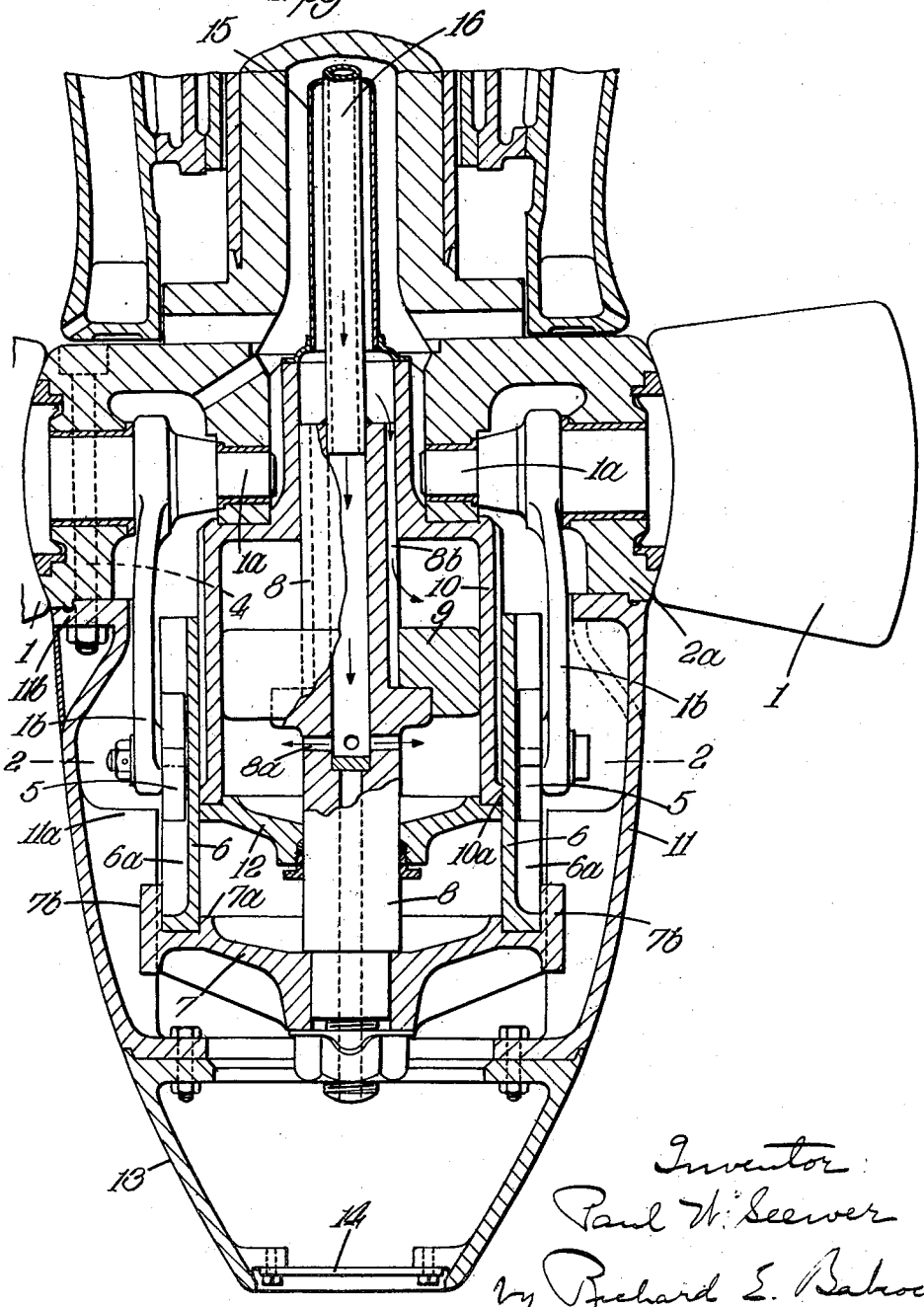
Aug. 29, 1944. P. W. SEEWER 2,357,228

HYDRAULIC TURBINE

Filed March 13, 1942 4 Sheets-Sheet 1

Fig. 1.



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HYDRAULIC TURBINE

Filed March 13, 1942 4 Sheets-Sheet 2

Fig. 2.

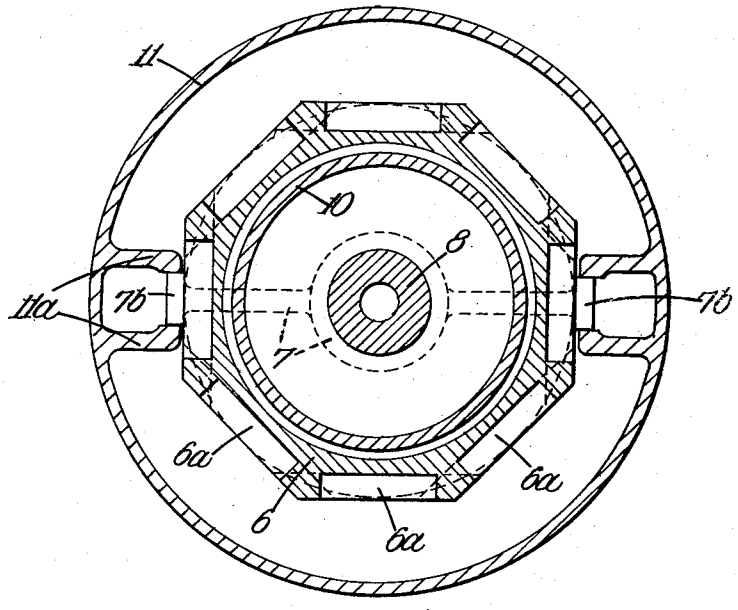
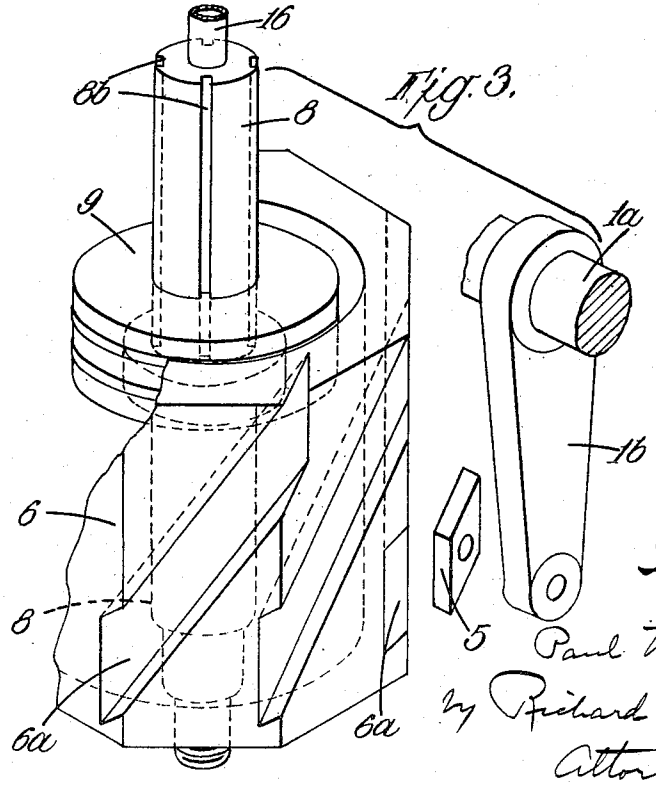


Fig. 3.



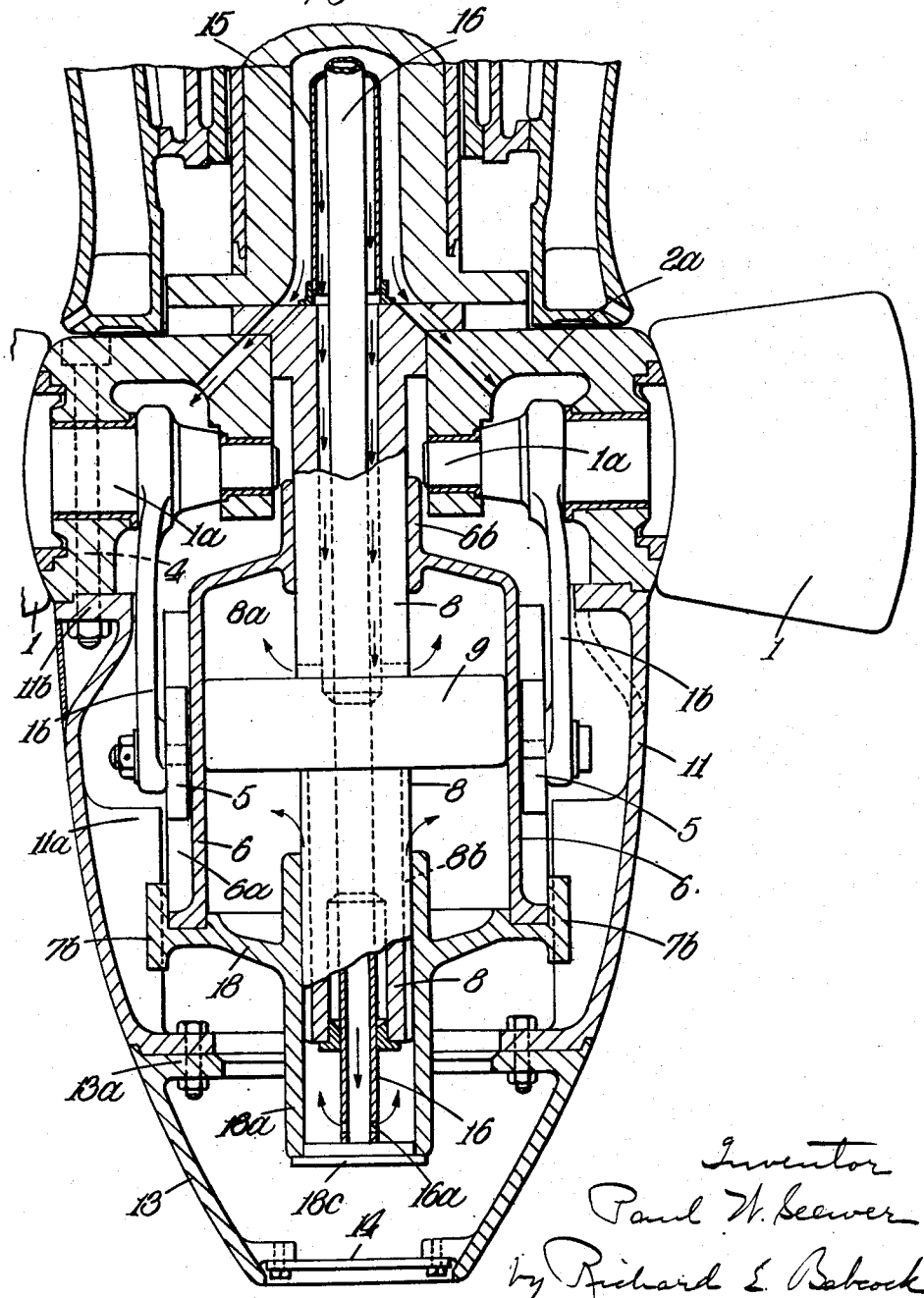
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HYDRAULIC TURBINE

Filed March 13, 1942 4 Sheets-Sheet 3

Fig. 6.



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HYDRAULIC TURBINE

Filed March 13, 1942 4 Sheets-Sheet 4

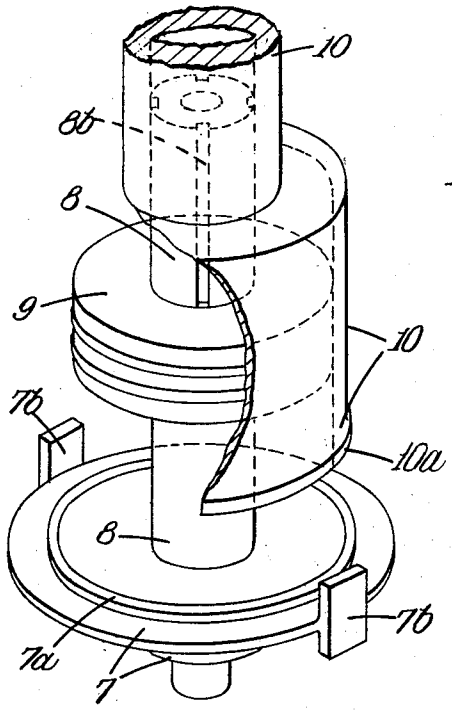


Fig. 4.

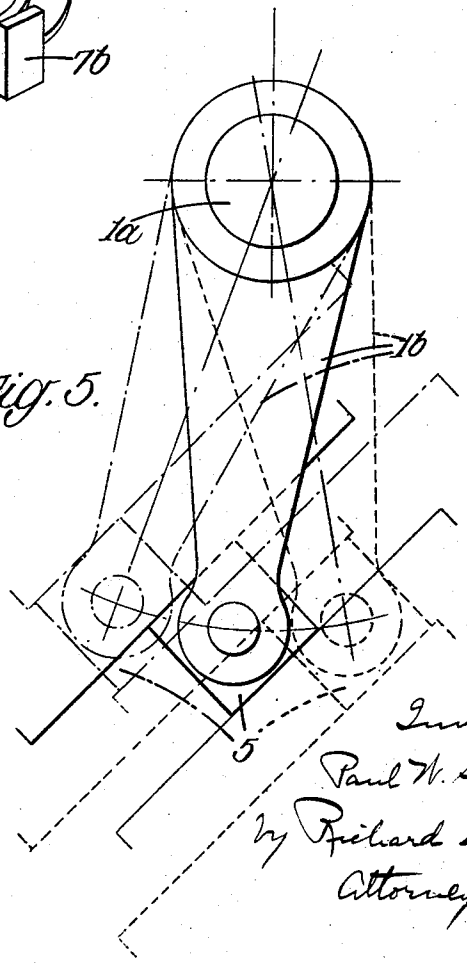


Fig. 5.

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UNITED STATES PATENT OFFICE

2,357,228

HYDRAULIC TURBINE

Paul Werner Seewer, Rugby, England, assignor to The English Electric Company Limited, London, England, a British company

Application March 13, 1942, Serial No. 434,628
In Great Britain March 7, 1941

4 Claims. (Cl. 253—148)

This invention relates to water turbine and pump rotors and to marine and aeroplane propellers of the swivelling blade type, and since it has for its object blade swivelling gear which can overcome forces of considerable magnitude acting on each blade the invention will be described as applied to a hydraulic turbine.

The invention uses inside the rotor an axially reciprocating hydraulic servo-motor, a crank substantially rigid with each swivelling blade and operative connections directly between each crank and the servo-motor. In order that the servo-motor acts on each crank with considerable leverage and in order to accommodate in the rotor operating gear for six or eight blades the present invention provides that each crank extends, in one of its working positions, parallel to the rotor axis, while the operative connections are disposed to transmit to the cranks a blade-swivelling force in a direction at a considerable angle to the axis of the rotor. According to a further feature of the invention, each crank extends at the side of and outside the servo-motor and the operative connections are similarly located so that when the cover or hood is removed from the hub the servo-motor, cranks and operative connections are all exposed. According to another feature of the invention using an axially reciprocating servo-motor, a member reciprocable with the servo-motor has therein a plurality of flat-sided channels (one per crank) inclined at an angle to the axis of the rotor and the cranks which extend substantially axially from the blades inside the rotor each carry a flat-sided slider block mounted on the end of the crank, said slider blocks being each a sliding fit within the said flat-sided grooves.

The invention is illustrated by the accompanying drawings of which Fig. 1 is a vertical cross section through the rotor axis of one form of hydraulic turbine according to the invention, Fig. 2 is a sectional plan transverse to Fig. 1, Fig. 3 is a partly diagrammatic view showing the servo-motor piston, a prismatic grooved member reciprocating therewith, the slider block and the crank which actuates one of the swivelling blades, Fig. 4 is a partly diagrammatic view showing the servo-motor cylinder partly cut away to expose the piston therein and showing also the cross-head member secured to the lower end of the piston rod but with the prismatic grooved member removed, Fig. 5 is a diagrammatic side view of a crank with its slider block in the groove in the prismatic member, while Fig. 6 is a cross-section—corresponding to Fig. 1—through a modified form of turbine according to the invention.

As shown in Fig. 1, each swivelling turbine blade 1 is cast in one piece with its spindle 1*a* and with an operating crank 1*b* depending therefrom or is fabricated by welding the crank to the spindle or is otherwise formed integrally with the spindle and crank. The spherical hub 2*a* of the rotor incorporates bearings for the spindles 1*a*. Each spindle is provided with an inner and an outer bearing, each crank being located between the two bearings. The servo-motor cylinder to be described later is attached to the hub in the space between the inner bearings.

The bearings or at least the outer bearings are split on a horizontal plane through the axes of the spindles 1*a* so that the single piece blades and cranks can be put in place and the bearings placed over them, the parts being spigoted into each other and held together by through-going bolts, screws or studs 4 with nuts and locking washers. The horizontal surfaces where the bearings are split are scraped together and securely joined by a tightening solution or other tightening agent and thereby sealed both against the ingress of water and the egress of lubricating oil. The rotor is completed by the hood 11*a* secured to the hub 2*a* and which may terminate in a separate nose 13 and is closed by the manhole cover 14.

Pivotally mounted on the lower end of each crank 1*b* is a block 5 with flat edges slidably fitting in a flat-edged groove 6*a* in one face of a hollow prismatic member 6 disposed around the axis of the hub. The crank 1*b* and the swivelling slider block 5 are shown separated from each other and from the prismatic member 6 in Fig. 3. For an eight-bladed rotor the prismatic member 6 is octagonal as shown in Fig. 3 and in plan in Fig. 2. The flat-edged groove 6*a* is inclined to the axis of the hub, as in Figs. 3 and 5; a similar groove is cut in each face of the prismatic member 6, as indicated in Figs. 2 and 3.

As shown in Fig. 1, the lower end of the prismatic member 6 is supported by a cross member 7 which, as shown also in Fig. 4, is rigidly connected to the lower end of a hollow axial servo-motor piston rod 8 carrying a piston 9 which can reciprocate in the cylinder 10 secured to the hub member 2*a* and co-axial therewith. The periphery of the member 7 is provided with a diametrically opposite pair of projections 7*b* which engage and can slide axially between channelled guide members 11*a* projecting inwardly from the wall of the hood 11. The prismatic member 6

fits over the locating spigot 7a on the member 7 and between the guide projections 7b. The spigot 7a and projections 7b—before the member 6 is put in place—are shown in Fig. 4 which also shows the rim 10a provided on the fixed cylinder 10 and over which the member 6 can slide. The lower portion of the piston rod 8 slides through a packed gland in the cylinder cover 12.

A stationary pipe 15 can supply fluid under pressure from the control valve through the hollow interior of the upper part of the cylinder 10 and the grooves 8b in the piston rod 8 to the cylinder above the piston 9. The inner pipe 16—which is secured to and reciprocates with the piston rod 8 so that its upper end can be used to indicate the position of the piston and of the blades—also supplies fluid through the interior of piston rod 8 and through discharge openings 8a to the cylinder space below the piston 9. The space between the outer pipe 15 and the bore of the turbine shaft 17 is used for the supply of lubricating oil to the interior of the hub and the hood; the level of the lubricating oil accordingly alters with up and down movement of the servo-motor, surplus oil going back to the source of supply.

It will be appreciated that downward withdrawal of the hood 11 and nose 13 from the hub without any further dismantling of the rotor exposes and gives access to the cross member 7, to the prismatic member 6 lying outside and around the servo-motor, to the cranks 1b and blocks 5 (since these lie outside the servo-motor) and to the blade bearings. Downward withdrawal of the cross member 7 and of the cylinder cover 12 then give access to the piston 9. It will be further understood that the described construction reduces the number of operating parts substantially to a minimum. By reducing also the number of parts which have to be crowded into the diameter of the hub, the space available for the bearings is considerably increased and bearings of ample size can be provided.

In operation the axial reciprocating movement of the piston 9, the cross member 7 and the prismatic member 6 imparts a swivelling movement to the cranks 1b (and hence to the blades 1) through the slider 5 and the groove 6a, different positions of the crank and slider for different axial positions of the member 6 being shown in Fig. 5. The line of action of the force acting on the end of each crank 1b is perpendicular to the side face of the groove 6a and is accordingly inclined at an angle to both the horizontal and the vertical. The effective leverage is accordingly the perpendicular distance from this line to the blade axis and this distance again is inclined at a considerable angle to the horizontal. It will be appreciated that accordingly for a given diameter of the hub and hood and a given number of blades the effective leverage can be considerably greater than in arrangements in which this distance is horizontal. The centre line of the crank when the latter is in its mid position could be vertical but is preferably inclined to the vertical as in Fig. 5. If this centre line in the mid position were parallel to the sides of the grooves 6b the sliding movement relatively to these grooves would be reduced to a minimum and the leverage would remain substantially constant. If space conditions make this impossible, then as a compromise the crank may be arranged to swing about a mid position which lies between the vertical and a direction parallel to the sides of the grooves 6b. The force to be applied to the crank for overcoming a certain load on the blades is considerably less than hitherto and there is moreover a choice of this force over a limited range by varying, within limits imposed by space conditions, the length of the crank and the angle of inclination of the grooves. The direct pull required to be exerted by the piston 9 is accordingly considerably reduced as compared with other known arrangements; the diameter of the piston can be accordingly considerably reduced (which allows the servo-motor to be accommodated, as described, within the hood) the stroke of the piston being, however, correspondingly increased. It will be understood that the total work done on each blade and all the blades for any given operating condition including the extreme conditions hereinbefore mentioned remains unaltered and hence the maximum work to be done by the servo-motor remains as before; the work is done, however, by employing a smaller force acting through a longer stroke. The force applied to the lever is transmitted directly to the blade since the lever is integral with the latter and the risk of backlash developing in operation is eliminated.

The modification shown in Fig. 6 differs from the arrangement shown in Fig. 1 in that the servo-motor piston is stationary while the hollow prismatic member 6 serves also as the servo-motor cylinder.

The piston rod 8, which is hollow and carries the piston 9 as previously described, is secured by its upper flange 8c to the hub 2 coaxially therewith. The combined prismatic member and cylinder 6 has its upper boss 6b bored to fit on the upper part of the piston rod 8. The lower end of the cylinder 6 is closed by a cover 18 having a boss 18a also bored to fit on the lower portion of the piston rod 8 and also carrying the diametrically opposite pair of projections 18b which engage and can slide axially between the channel guide members 11a. The lower end of the boss 18a is closed by the cap 18c which is securely fixed thereto and which also closes up the lower end of the pipe 16 which is fixed to the cap and so moves up and down with the cylinder 6.

The stationary pipe 15 can supply fluid through the hollow interior of the piston rod 8 and the discharge openings 8a to the cylinder space above the piston 9. The inner pipe 16 can supply fluid through the discharge openings 16a and the grooves 8b in the lower part of the piston rod 8 to the cylinder below the piston 9.

In the application of the invention to marine and aeroplane propellers the rotor axis will be horizontal instead of vertical and directions referred to in the description as horizontal will remain transverse to the propeller axis and will therefore be vertical.

What I claim as my invention and desire to secure by Letters Patent is:

1. A vertical hydraulic turbine rotor comprising a hub incorporating a plurality of horizontal bearings, a plurality of swivelling propeller blades mounted in said bearings and projecting from said hub, a reciprocating hydraulic servo-motor inside said rotor below the blade bearings and reciprocable axially of the rotor, a crank substantially rigid with and extending downwardly from each swivelling blade and located inside the rotor but at the side of and outside of said servo-motor, an operative connection between the servo-motor and the lower

end of each said crank for transmitting to said end a blade-swivelling force in a direction at a considerable angle to the axis of the rotor, and a hood removable from said hub to expose said servo-motor, cranks and operative connections.

2. A swivelling-propeller-bladed rotor comprising a hub, bearings incorporated therein, a plurality of swivelling propeller blades mounted in said bearings and projecting radially from said hub, a reciprocating hydraulic servo-motor inside said rotor and reciprocable axially of the rotor, a crank inside the rotor substantially rigid with each swivelling blade and extending therefrom in one of its working positions parallel to the rotor axis, a slider block pivotally mounted on the end of each of the said cranks, said servo-motor having an axially reciprocable member formed with a plurality of channels respectively slidably receiving the said respective blocks and inclined at an angle to the axis of the rotor receiving said blocks, each of the latter having sides shaped to correspond to the sides of the corresponding channel in which the said block is a sliding fit.

3. A swivelling-propeller-bladed rotor comprising a hub, bearings incorporated therein, a plurality of swivelling propeller blades mounted in said bearings and projecting radially from said hub, a reciprocating hydraulic servo-motor inside said rotor and reciprocable axially of the rotor, a crank inside the rotor substantially rigid with each swivelling blade and extending therefrom parallel to the rotor axis in one of the working positions of said blade, a flat sided block pivotally mounted on the end of each of the said cranks and a hollow prismatic member disposed around, and axially reciprocable as part of, the said servo-motor, said prismatic member having a number of side faces equal to the number of swivelling blades and in each face a flat sided channel inclined at an angle to the axis of the rotor, each of said blocks being a sliding fit within one of said flat sided channels.

4. A vertical hydraulic turbine rotor comprising a hub incorporating a plurality of horizontal bearings, a plurality of swivelling propeller blades mounted in said bearings and projecting from said hub, a reciprocating hydraulic servo-motor inside said rotor below the blade bearings and reciprocable axially of the rotor, a hollow member around said servo-motor, axially reciprocable as part thereof and having in its outer surface a plurality of channels steeply inclined to the horizontal, rigid guides in said rotor for said channeled member, a plurality of cranks respectively substantially rigid with and extending downwardly from the respective swivelling blades and inside of the rotor at the side of the channelled member, a plurality of slider blocks respectively pivotally mounted on the ends of the respective cranks, said blocks respectively having sides shaped to correspond to the sides of the corresponding channel of the respective channels in which the respective blocks make a sliding fit, and a hood removable from said hub to expose the said servo-motor, channelled member, cranks and slider blocks.

PAUL WERNER SEEWER.