

DESCRIPTION

of the industrial invention bearing the title:

- 5 “Device for the continuous and discriminated positioning of each blade of hydraulic turbines at vertical axis”

Hydraulic turbines at free-flow with direct contact to streams (river or marine)
10 symbolize a valid system of water kinetic energy. The Verdant Power Ltd. turbine, installed in East River of New York on 2008, represents the first example of such technique.

The three-blade rotor of turbines at horizontal axis is a classic configuration derived from wind application which, despite being relatively simple and reliable, produces
15 somewhat modest returns in terms of fluid-dynamic efficiency.

The decision to use a turbine with blades arranged vertically can be an alternative solution both to improve the hydrodynamic efficiency and to simplify the construction of turbine of great dimensions since the one-way river stream does not require the utilization of devices for the modification of yaw rotation angle as
20 well as to interpose a fifth-wheel coupling between the fix and mobile parts as required for the turbine for wind generators. This allows the use of assemblies of modest size, easy to carry and assembly directly on installation sites.

The hydrodynamic efficiency in the solution with vertical axis turbine, with discs and support arms (similarly to Darrieus and Kobold turbines, as examples of turbine
25 with vertical axis) can be significantly improved by adopting a technological system of instant and proper orientation of the blades to allow a stream crossing free of interferences, thus overcoming the limit of the existing turbines that have a transverse crossing cross which is not quite free.

The critical points of the today used solutions can be overtaken by adopting a blades assembly system placed cantilever on the rotating barrel with different orientation grades for each blade thus allowing a continuous variation along the orbital path.

- 5 The kinetic energy of stream transverse crossing is efficiently converted into mechanical energy since the utilization of a turbine with vertical axis of large diameter allows the exploitation also of the geodetic energy that is determined by the difference in quota at the two counter posed extremes of the tilted barrel that holds the blades, condition non-obtainable in turbines with horizontal axis.

- 10 The essential condition for obtaining high hydrodynamic efficiency lies within the continuous orientation of the instantaneous angle of incidence that can be achieved through appropriate command and control of the blades position.

Computerized systems are already validly used within the substantive scope of engines with vertical axis, but the hydraulic turbines require extreme reliability and
15 total absence of maintenance. These conditions can be achieved almost exclusively or in any case more easily, through the utilization of very sturdy mechanical systems devoid of specific electronic controls. The attention is therefore focused on systems with very sturdy kinematic control at electrical control.

The device for the continuous and discriminated positioning of each blade of
20 hydraulic turbines at vertical axis, subject of this industrial invention represents a real solution to reliability and very low maintenance problems (see Fig. 1, 2, 3, 4, 5).

Fig. 1 displays the three electrical stepper motors (ref. 1, 2, 3) connected to their own gear trains and in-built on the fix disc (ref. 48).

- 25 Fig. 2 displays the electrical stepper motor (ref. 1) connected with a flange to its own worm gearbox (ref. 46) whose crown gear (ref. 62) is rigidly connected to the end of the maneuvering and connection screw (ref. 4). The assembly (electrical stepper motor ref. 1; worm gear box ref. 46; maneuvering and connection screw

ref. 4) can rotate on the pin (ref. 50) by an angle $\pm \alpha$ in respect to support (ref. 49), secured to disk (ref. 48 of Fig. 1) that is connected to the hydraulic turbine by means of pillars (ref. 47 of Fig. 1). The maneuvering and connection screw (ref. 4) is moved by the electrical stepper motor (ref. 1) receiving the rotary motion by the crown gear (ref. 62), while the other end of the maneuvering and connection screw (ref. 4) is idle on the support attached to the box (ref. 64 of Fig. 3). On the maneuvering and connection screw (ref. 4) are combined two separated female screws (ref. 6 of Fig. 1 and Fig. 2; ref. 7 of Fig. 1 and Fig. 5). For a given rotation of the electrical stepper motor (ref. 1) the female screw (ref. 6) moves for a certain distance rx . On the female screw (ref. 6) is hinged, in idle status, the roller (ref. 5) that will move for the same distance rx . The idler roller (ref. 5) is connected to the fixed part of the hydraulic turbine and makes the repositioning rx of the housing support (ref. 8) that is instead connected to the floating disk (ref. 40 of Fig. 5).

At the end of the support disk fixed to the frame of the hydraulic turbine (ref. 48 of Fig. 1) is fastened the box (ref. 64 of Fig. 3) that allows to the maneuvering and connection screw (ref. 4) to swing an angle $\pm \alpha$ on pin (ref. 50 of Fig. 2). The grade of the maneuvering and connection screw (ref. 4) of an angle α is required in order to balance out the moderate deviation induced by the rotation of the hydraulic turbine to the direction of the free crossing flow.

On the far side of box (ref. 64 of Fig. 3) is bolted the plate (ref. 53 of Fig. 3) which holds the pins with the idle rollers (ref. 54 of Fig. 3) that allow the travel of the maneuvering and connection screw (ref. 4).

The idle rollers (ref. 54 of Fig. 3) are high-placed on slopes (ref. 52) and low-placed on slopes (ref. 65), which are connected to the support disk (ref. 48 of Fig. 1).

The electrical stepper motor (ref. 2 of Fig. 1) is flanged on top of box (ref. 64 of Fig. 3) that through a connecting joint sets in rotation the conical pinion (ref. 55), which engages the corresponding crown gear (ref. 56 of fig. 3). On the crown gear (ref. 56) is keyed in the endless screw (ref. 57) that engages the crown gear (ref. 58) that

put in slow rotation the shaft (ref. 59), which has at its edge mounted the pinion (ref. 60) that engages the crown gear (ref. 65) secured to the support disk (ref. 48 of Fig.1).

Due to the high reduction ration of rpm, realized through shaft (ref. 55) and gear (ref. 60), the kinematic motion is irreversible ensuring the keeping of position of the maneuvering and connection screw (ref. 4) to angle α in any operating condition of the hydraulic turbine.

On the maneuvering and connection screw (ref. 4), in addition to the female screw (ref. 6 of Fig. 2), is screwed in another female screw (ref. 7 of Fig. 3), which is formed on outside by a crown gear that engages the endless screw put in rotation by the shaft of the electrical stepper motor (ref. 3 of Fig. 1 and Fig. 5).

The box containing the endless screw with outer crown gear (ref. 7) is free to swing onto the pivot of the support ring (ref. 35), which remains anchored on the fixed part of the hydraulic turbine, being interposed a bearing with rotating ring (ref. 41 of Fig. 5). Finally the upper part of the device integral to the fixed support disk (ref. 48 of Fig. 1) determines irreversibly the position of idler roller (ref. 5) and its relative support (ref. 8 of Fig. 2 and Fig. 5) and of ring (ref. 41).

The positioning comes from the preset rpm of the electrical stepper motors (ref. 1, 2, 3 of Fig.1).

Referring to the central vertical axis $z-z$ of the hydraulic turbine, the idler roller (ref. 5 of Fig. 5) sets up the eccentricity value of floating disk (ref. 40 of Fig. 5), while the ring (ref. 41 of Fig. 5) sets up the disk value (ref. 37 Fig. 5).

The two disks (ref. 40 and ref. 37 of Fig. 5) are coplanar and orthogonal to the vertical axis of hydraulic turbine and transfer their eccentricities to kinematics hosted in the rotating barrel of hydraulic turbine.

The pivot (ref. 30 Of Fig. 5) is integral to floating disk (ref. 40) and on it are inserted the levers (ref. 12 of Fig. 4 and Fig. 5) in equal number to their blade holder shafts (ref. 33).

The levers (ref. 12) are hinged in idle status on shaft (ref. 30). At the edge of each lever, there are the respective connecting rods (ref. 16 of Fig. 5) that set up the dimension λb of blade holder shafts (ref. 33) swing during the barrel rotation carrying out the blades (ref. 28) cycloidal orientation.

- 5 In the center line of levers (ref. 12 of Fig. 4 and Fig. 5) is hinged on the shaft (ref. 32) connecting the hinge (Ref. 13). The hinge (ref. 23) is articulately connected to the skid pins (ref. 18).

- The connecting and transmission rod (ref. 24 of Fig. 4 and Fig. 5) receiving the transmission input from disk (ref. 15), moves the skid (ref. 18) through the pins (ref. 44) tied to it. The connecting and transmission rod (ref. 24 of Fig. 4 and Fig. 5) swing on pivot (ref. 43 of Fig. 4). The disk (ref. 15) set up the range of differential displacements of the position of the control main ring (ref. 41). The disk (ref. 15) and the control main ring (ref. 41) are connected by means of vertical pillars Ref. 42 of Fig. 5). Therefore, the change of position of ring (ref. 41) determines the
- 10 corrective differentiation of size of λb swinging of each lever (ref. 12) connected to blade holder shafts (ref. 33) by means of respective connecting rods (ref. 16 of Fig. 5).

- The bottom ring (ref. 27 of Fig. 5) has on both its parallel sides the slide guides that are orthogonal between them, respectively connected to disk (ref. 15) and rails (ref. 25). The rails are fastened to bottom of barrel (ref. 26).
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The system of mutually orthogonal slides allows the transmission of rotary motion Ω_r from bottom of barrel (ref. 26) to disk (ref. 15), even in case there is pertaining offset from the central axis $z-z$.

- All the hinged levers are enclosed between the disk of upper and lower ends (ref. 36 and ref. 26 of Fig. 5, respectively) and the external cylindrical layer (ref. 31).
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The rotating barrel is therefore formed by the layer (ref. 31) and disks (ref. 36 and ref. 26, respectively) on which are mounted the supports (ref. 29) of blade holder shafts.

Barrel and blades represent the rotating part of the hydraulic turbine that draws energy from the slowing down of river streams or from marine streams that pass through the turbine.

The device subject of this industrial invention allows creating the blades cycloidal
5 differentiated path, allowing them to get the maximum power uptake from the flow of crossing stream for whatever speed, slope and swirl it may has.

The various paths allowed to blades using the device subject of this industrial invention have been simulated using numerous CFD (Computational Fluids Dynamics) that highlighted the excellent performance of the hydraulic vertical
10 turbine in wide ranges of the parametric value of work.

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CLAIMS

- 1) We claim a device for the continuous and discriminated positioning of each blade of hydraulic turbines at vertical axis characterized by the arrangement of three electrical stepper motors on a single maneuvering screw for handling rotary-transfer (contemporary rotation and translation) and swinging movement (fluctuating movement) of blades and by the utilization of two separated coplanar floating disks placed on a rotating barrel layer, having:
- The electrical stepper motor (ref. 1 of Fig. 2) connected with a flange to its own worm gearbox (ref. 46 of Fig. 2) whose crown gear (ref. 62 of Fig. 2) is rigidly connected to the end of the maneuvering and connection screw (ref. 4 of Fig. 2);
 - The assembly (electrical stepper motor Fig. 2 ref. 1; worm gear box Fig. 2 ref. 46; maneuvering and connection screw Fig. 2 ref. 4) that can rotate on the pin (ref. 50) by an angle $\pm \alpha$ in respect to support (ref. 49), secured to disk (ref. 48 of Fig. 1) that is connected to the hydraulic turbine by means of pillars (ref. 47 of Fig. 1);
 - The maneuvering and connection screw (ref. 4) that is moved by the electrical stepper motor (ref. 1) receiving the rotary motion by the crown gear (ref. 62), while the other end of the maneuvering and connection screw (ref. 4) is idle on the support attached to the box (ref. 64 of Fig. 3);
 - On the maneuvering and connection screw (ref. 4) are combined two separated female screws (ref. 6 of Fig. 1 and Fig. 2; ref. 7 of Fig. 1 and Fig. 5). For a given rotation of the electrical stepper motor (ref. 1) the female screw (ref. 6) moves for a certain distance rx

- On the female screw (ref. 6) is hinged, in idle status (in other words is not engaged), the roller (ref. 5) that will move for the same distance rx . The idler roller (ref. 5) is connected to the fixed part of the hydraulic turbine and makes the repositioning rx of the housing support (ref. 8) that is instead connected to the floating disk (ref. 40 of Fig. 5);
 - The electrical stepper motor (ref. 2 of Fig. 1) is flanged on top of box (ref. 64 of Fig. 3) that through a connecting joint sets in rotation the conical pinion (ref. 55), which engages the corresponding crown gear (ref. 56 of fig. 3).
 - On the crown gear (ref. 56) is keyed in the endless screw (ref. 57) that engages the crown gear (ref. 58) that put in slow rotation the shaft (ref. 59), which has at its edge mounted the pinion (ref. 60) that engages the crown gear (ref. 65) secured to the support disk (ref. 48 of Fig. 1).
- 2) We claim a device as claimed in **claim 1** characterized by the motion irreversibility of each of the three electrical stepper motors, connected to their own gear trains, condition required to maintain the position even in case of electrical power failure supply to the electrical stepper motors.
- 3) We claim a device as claimed in **claim 1** characterized by the fastening of maneuvering system (electrical stepper motors – gear trains – screw) to a single support disk linked to the external frame supporting the hydraulic turbine.
- 4) We claim a device as claimed in **claim 1** characterized by the utilization of two separated coplanar floating disks (ref. 37 and 40 of Fig. 5), one inside the other one and both placed on the rotating barrel layer (ref. 31 of Fig. 5)
- 5) We claim a device as claimed in **claim 4** characterized by the coaxial fastening of the internal floating disk (ref. 40 of Fig. 5) to the joint pivot (ref. 30 of Fig. 5) with levers in idle status (in other words non engaged) (ref. 12 of Fig. 4 and 5)

- 6) We claim a device as claimed in **claim 5**, characterized by the stacked and sequential arrangement on a central joint pivot (ref. 30 of Fig. 5) holding the levers in idle status.
- 7) We claim a device as claimed in **claim 4** characterized by the utilization of two articulated rods, for each blade holder shaft, of which one is hinged on joint pivot and the second one hinged between the center line of the first and one guide skid pin.
- 8) We claim a device as claimed in **claim 7** characterized by the utilization of a linear guide slopes (ref. 52 and 54 of Fig. 3) whose support is linked to the bottom of the rotating housing (ref. 8 of Fig. 2) which bears the hinged pivot of the second rod, and at the end has a guide loop for motion control pivot sliding
- 9) We claim a device as claimed in **claim 4** characterized by the utilization of a lever hinged to a pivot linked to the bottom of the rotating housing (ref. 8 of Fig. 2), at one end there is a pivot inside the skid guide loop, while at the other end there is a guide loop for motion control pivot sliding (ref. 18 and 44 of Fig. 4)
- 10) We claim a device as claimed in **claim 4** characterized by the utilization of a floating disk with spokes (ref. 40 of Fig. 5), the disk itself has pivots for levers motion control and the spokes are connected to external floating disk (ref. 37 of Fig.5) by means of pillars
- 11) We claim a device as claimed in **claim 7** characterized by the utilization of orthogonal guide skids with an interposed halfway support disk, one skid is linked to rotating barrel bottom, while the other one is linked to the floating disk with spokes (ref. 40 of Fig. 5)
- 12) We claim a device as claimed in **claim 7** characterized by the utilization of connecting rods between levers (ref. 12 of Fig. 4) hinged to joint pivot and the blade holder shafts

13) We claim a device as claimed in **claim 7** characterized by the utilization of screw locking keying on the blades holder shafts connected to the rods

14) We claim a device as claimed in **claim 7** characterized by the assembly of the blades holder shafts on two end bearings, one linked to the bottom and the other one to the cover of the rotating housing (ref. 8 of Fig. 2)

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