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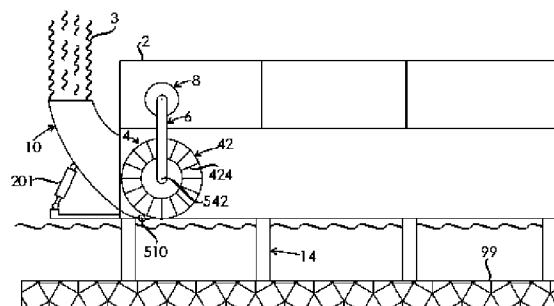
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(54)	Title	Hydroelectric power plant and method for building the same
(57)	Abstract	

A hydroelectric power plant comprising a body part (2), a hydraulic turbine system adapted to convert kinetic energy of a waterfall flow (3) into rotational energy, and a deflecting member (10) adapted to deflect direction of the waterfall flow (3). The deflecting member (10) is pivotable relative to the body part (2) around a pivoting axis (510) between an operative position adapted to deflect the waterfall flow (3) towards a runner (42) of at least one hydraulic turbine (4) of the hydraulic turbine system in a downstream flow direction, and a by-pass position adapted to allow at least most of the waterfall flow (3) to bypass the runner (42) of the at least one hydraulic turbine (4), the pivoting axis (510) being parallel to the rotation axis (542) of the runner (42).



HYDROELECTRIC POWER PLANT AND METHOD FOR BUILDING THE SAME

FIELD OF THE INVENTION

The present invention relates to a hydroelectric power plant for producing electricity from the energy of falling water in a waterfall.

5 Harnessing a waterfall for generation of electricity is difficult with hydroelectric power plants known in the art. A lot of work is required at a mountainside alongside which the waterfall is located.

BRIEF DESCRIPTION OF THE INVENTION

10 An object of the present invention is to provide a hydroelectric power plant and a method for building a hydroelectric power plant so as to solve the above problem. The objects of the invention are achieved by a hydroelectric power plant and a method for building a hydroelectric power plant which are characterized by what is stated in the independent claims. The preferred embodiments of the invention are disclosed in the dependent claims.

15 The invention is based on the idea of providing a flow guide system of a hydroelectric power plant with a pivotable deflecting member for selectively deflecting a waterfall flow towards a runner of hydraulic turbine in a downstream flow direction, or allowing the waterfall flow to bypass the runner, wherein the flow guide system comprising the pivotable deflecting member is mounted to a
20 body part of the hydroelectric power plant.

 An advantage of the hydroelectric power plant of the invention is that it is easy and fast to build. It is possible to build a power plant assembly at a distance from a waterfall, and to float the power plant assembly to a location adjacent the waterfall along a water area downstream the waterfall. The hydroelectric power
25 plant of the invention is located entirely at a bottom of a waterfall, and requires no components or construction work at a mountainside alongside which the waterfall is located. The hydroelectric power plant of the invention requires minimal permanent changes to the scenery at the waterfall.

BRIEF DESCRIPTION OF THE DRAWINGS

30 In the following the invention will be described in greater detail by means of preferred embodiments with reference to the attached drawings, in which

 Figure 1 is a schematic side view of a hydroelectric power plant according to an embodiment of the invention, wherein the hydroelectric power plant is in

an operating state in which a deflecting member thereof is in an operative position;

Figure 2 shows the hydroelectric power plant of Figure 1 in an operating state in which the deflecting member is in a by-pass position;

Figure 3 is a schematic top view cross section of the hydroelectric power plant of Figure 1 with a pontoon system; and

Figure 4 shows a portion of a supporting system which supports the hydroelectric power plant of Figure 1 to a bottom of a water area.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 is a schematic side view of a hydroelectric power plant comprising a body part 2, a hydraulic turbine system comprising a hydraulic turbine 4, a generator system comprising a generator 8, a transmission system 6, and a flow guide system comprising a deflecting member 10. A side wall of the hydroelectric power plant has been omitted in order to show the hydraulic turbine system, the generator system, and the transmission system 6.

The hydraulic turbine system is adapted to convert kinetic energy of a waterfall flow 3 into rotational energy. The hydraulic turbine system is mounted to the body part 2. Figure 1 shows that the waterfall flow 3 is a vertical downward water flow.

The hydraulic turbine 4 of the hydraulic turbine system has a runner 42 with a plurality of blades 424. A rotation axis 542 of the runner 42 extends in a first horizontal direction, which in Figure 1 is perpendicular to the image plane. The runner 42 is located at a distance from the waterfall flow 3 in a downstream flow direction perpendicular to the first horizontal direction. In Figure 1 the downstream flow direction is a horizontal rightwards direction. The runner 42 is located slightly above a water-level of a water area downstream the waterfall.

The generator system is adapted to convert the rotational energy of the hydraulic turbine system into electrical power. The generator system is mounted to the body part 2.

The generator 8 is located above the hydraulic turbine 4. A rotation axis of the generator 8 is parallel to the rotation axis 542 of the runner 42.

The transmission system 6 connects the hydraulic turbine system to the generator system. The transmission system 6 comprises a power transmission shaft whose rotation axis extends in a vertical direction.

The flow guide system is adapted to guide the waterfall flow 3 to the

runner 42 of the hydraulic turbine 4. The deflecting member 10 is adapted to selectively deflect direction of the waterfall flow 3 towards a lower portion of the runner 42 of the hydraulic turbine 4.

5 The deflecting member 10 is pivotable relative to the body part 2 around a pivoting axis 510 between an operative position and a by-pass position. The pivoting axis 510 is parallel to the rotation axis 542 of the runner 42, and is located lower than the rotation axis 542 of the runner 42. The pivoting axis 510 is located approximately at the same level in the vertical direction as the lowest point of the runner 42.

10 In Figure 1 the deflecting member 10 is in the operative position, and in Figure 2 the deflecting member 10 is in the by-pass position. The deflecting member 10 is adapted to be transferred between the operative position and the by-pass position by means of a hydraulic cylinder 201. One end of the hydraulic cylinder 201 is connected to the body part 2, and the other end of the hydraulic cylinder 201
15 is connected to the deflecting member 10.

The operative position of the deflecting member 10 is adapted to deflect the waterfall flow 3 towards the runner 42 of the hydraulic turbine 4 in the downstream flow direction. The deflecting member 10 deflects the waterfall flow 3 such that the waterfall flow contacts the runner below the rotation axis 542 of the runner 42. The change in the direction of the waterfall flow is provided by a contact
20 between the waterfall flow and the deflecting member 10.

The deflecting member 10 is adapted in the operative position thereof to deflect a portion of the waterfall flow 3 into a maximum deflection direction which is in a maximum deflection angle relative to the vertical direction. In the embodiment of Figure 1, the maximum deflection angle is close to 90°. This means that
25 a portion of the waterfall flow 3 moves almost horizontally when it contacts a lower portion of the runner 42 of the hydraulic turbine 4. In alternative embodiments, the maximum deflection angle is in the range of 45° - 90°.

The by-pass position of the deflecting member 10 is adapted to allow at
30 least most of the waterfall flow 3 to bypass the runner 42 of the hydraulic turbine 4. The by-pass position of the deflecting member 10 is adapted for example for building phase of the hydroelectric power plant, and for maintenance of the hydroelectric power plant.

The deflecting member 10 is a flow channel having an inlet and an outlet. A cross-section of the inlet is smaller than a cross-section of the outlet such that
35 the deflecting member 10 does not increase pressure of the waterfall flow 3 but

only deflects direction thereof.

In the operative position of the deflecting member 10, the inlet of deflecting member 10 is adapted to receive an operative inlet flow. In the by-pass position of the deflecting member 10, the inlet of deflecting member 10 is adapted to receive a by-pass inlet flow. Ratio between the operative inlet flow and the by-pass inlet flow is more than one hundred to one. In practice, the by-pass inlet flow consists of small splashes from the waterfall flow 3.

Figure 3 is a schematic top view cross section of the hydroelectric power plant of Figure 1 with a pontoon system 12, which is omitted from Figures 1 and 2. The cross section is taken along a horizontal plane. Figure 3 shows that the hydraulic turbine system comprises two hydraulic turbines 4 which are located side by side such that their rotation axes coincide. The generator system is located above the hydraulic turbine system so that runners 42 of the adjacent hydraulic turbines 4 can be close to each other in first horizontal direction.

In alternative embodiments the hydraulic turbine system comprises one or more hydraulic turbines. In an embodiment, a number of parallel hydraulic turbines is selected such that a width of the hydraulic turbine system covers at least majority of a useful width of the waterfall.

In Figures 1 to 3 the hydraulic turbines 4 are depicted as simplified water-wheels. A hydraulic turbine system of a hydroelectric power plant according to the invention comprises one or more known hydraulic turbines such as Pelton wheels.

The pontoon system 12 comprises two pontoons 121 located at opposite sides of the body part 2 in the first horizontal direction. The hydraulic turbine system is located between the two pontoons 121 in the first horizontal direction. Each of the pontoons 121 is connected to the body part 2.

A method for building a hydroelectric power plant of Figure 1 comprises providing the body part 2, the hydraulic turbine system, the generator system, the flow guide system and the pontoon system 12, and forming a power plant assembly by mounting the hydraulic turbine system, the generator system, the flow guide system and the pontoon system 12 to the body part 2. The power plant assembly is formed at a distance from the waterfall.

The power plant assembly is floated to a location adjacent the waterfall along a water area downstream the waterfall, wherein during the floating operation the pontoon system 12 provides the required buoyancy for the power plant

assembly. The power plant assembly is towed along the water area by four tug-boats, for example.

In a supporting operation, the power plant assembly is supported to a bottom of the water area by a supporting system. During the supporting operation the deflecting member 10 is in the by-pass position. After the supporting operation, the deflecting member 10 is pivoted to the operative position in order to enable generation of electricity with the hydroelectric power plant.

The supporting operation comprises lowering the power plant assembly towards the bottom of the water area. In other words, during the floating operation the power plant assembly is located higher relative to a water-level of the water area than during use of the hydroelectric power plant for generation of electricity. In an embodiment the supporting operation comprises increasing mass of the pontoon system 12 by supplying water to the pontoon system 12.

After the supporting operation, the pontoon system 12 is disconnected from the body part 2. It is possible to use the same pontoon system for building of several hydroelectric power plants in several locations.

Figure 4 shows a portion of a supporting system which supports the hydroelectric power plant of Figure 1 to the bottom of the water area. The supporting system comprises a plurality of frame support members 24, a plurality of support pillars 14, and a plurality of bottom support members 64. Each of the frame support members 24 is fixed to body part 2, and comprises a lower recess 242. Each of the bottom support members 64 has an upper recess 648, and is fixed to a bedrock 99 at the bottom of the water area by four anchor members 77. Each of the support pillars 14 has a tapered upper end 142 adapted to be received in a lower recess 242 of a frame support member 24, and a tapered lower end 148 adapted to be received in an upper recess 648 of a bottom support member 64.

The tapered lower end 148 of a support pillar 14 facilitates connecting the support pillar 14 to a corresponding bottom support member 64. The tapered upper end 142 of a support pillar 14 facilitates connecting the support pillar 14 to a corresponding frame support member 24. An angle of taper of the tapered upper end 142 and the tapered lower end 148 is 10°.

Cross-section of each of the bottom support members 64 is circular, and has a diameter of one meter. Each of the bottom support members 64 is partially embedded in the bedrock 99 such that the bottom support member 64 extend 30 cm into the bedrock 99. Each of the anchor members 77 extend 30 cm from a bottom surface of corresponding bottom support member 64 into the bedrock 99.

The support pillars 14 are made of stainless steel. Cross-section of each of the support pillars 14 is circular, and has a diameter of 0.5 m. A length of each of the support pillars 14 is selected based on depth of the water area, and a profile of the bottom of the water area.

5 In an embodiment at least one of the support pillars is an adjustable support pillar whose length can be adjusted. In an alternative embodiment a method for building a hydroelectric power plant comprises placing at least one adjustment piece between a support pillar and a corresponding frame support member in order to provide a horizontal position for the body part of the hydroelectric
10 power plant.

Bottom support members 64 are fixed to the bedrock 99 before the power plant assembly is floated to the location. The support pillars 14 are connected to the bottom support members 64 before the power plant assembly is lowered to the use position thereof in the vertical direction.

15 It will be obvious to a person skilled in the art that the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

CLAIMS

1. A hydroelectric power plant comprising:
 - a body part (2);
 - a hydraulic turbine system adapted to convert kinetic energy of a waterfall flow (3) into rotational energy, and comprising at least one hydraulic turbine (4) having a runner (42) with a plurality of blades (424), a rotation axis (542) of the runner (42) extending in a first horizontal direction, and the hydraulic turbine system being mounted to the body part (2);
 - a generator system connected to the hydraulic turbine system by means of a transmission system (6), and adapted to convert the rotational energy of the hydraulic turbine system into electrical power, the generator system comprising at least one generator (8), and the generator system being mounted to the body part (2);
 - a flow guide system for guiding the waterfall flow (3) to the runner (42) of the at least one hydraulic turbine (4), and comprising a deflecting member (10) adapted to deflect direction of the waterfall flow (3) towards a lower portion of the runner (42) of the at least one hydraulic turbine (4) in a downstream flow direction perpendicular to the first horizontal direction,

characterized in that the deflecting member (10) is pivotable relative to the body part (2) around a pivoting axis (510) between an operative position adapted to deflect the waterfall flow (3) towards the runner (42) of the at least one hydraulic turbine (4) in the downstream flow direction, and a by-pass position adapted to allow at least most of the waterfall flow (3) to bypass the runner (42) of the at least one hydraulic turbine (4), the pivoting axis (510) being parallel to the rotation axis (542) of the runner (42).
2. A hydroelectric power plant according to claim 1, **characterized** in that the deflecting member (10) is adapted in the operative position thereof to deflect a portion of the waterfall flow (3) into a maximum deflection direction which is in a maximum deflection angle relative to the vertical direction, the maximum deflection angle being in the range of 45° - 90°.
3. A hydroelectric power plant according to claim 1 or 2, **characterized** in that the pivoting axis (510) of the deflecting member (10) is located lower than the rotation axis (542) of the runner (42).
4. A hydroelectric power plant according to any one of the preceding claims, **characterized** in that the at least one generator (8) is located above the at least one hydraulic turbine (4).

5. A method for building a hydroelectric power plant according to any one of claims 1 to 4, the method comprising:

providing the body part (2), the hydraulic turbine system, the generator system, and the flow guide system;

5 providing a pontoon system (12);

forming a power plant assembly by mounting the hydraulic turbine system, the generator system, the flow guide system and the pontoon system (12) to the body part (2),

10 floating the power plant assembly to a location adjacent a waterfall along a water area downstream the waterfall, wherein during the floating operation the pontoon system (12) provides the required buoyancy for the power plant assembly;

supporting the power plant assembly to a bottom of the water area by a supporting system, wherein during the supporting operation the deflecting member (10) is in the by-pass position; and

15 pivoting the deflecting member (10) to the operative position after the supporting operation.

6. A method according to claim 5, wherein the supporting operation comprises increasing mass of the pontoon system (12).

20 7. A method according to claim 6, wherein said increasing mass of the pontoon system (12) comprises supplying water to the pontoon system (12).

8. A method according to any one of claims 5 to 7, wherein the supporting operation comprises lowering the power plant assembly towards the bottom of the water area.

25 9. A method according to any one of claims 5 to 8, wherein the supporting system comprises a plurality of anchor members (77) anchored to a bedrock (99) at the bottom of the water area.

Fig. 1

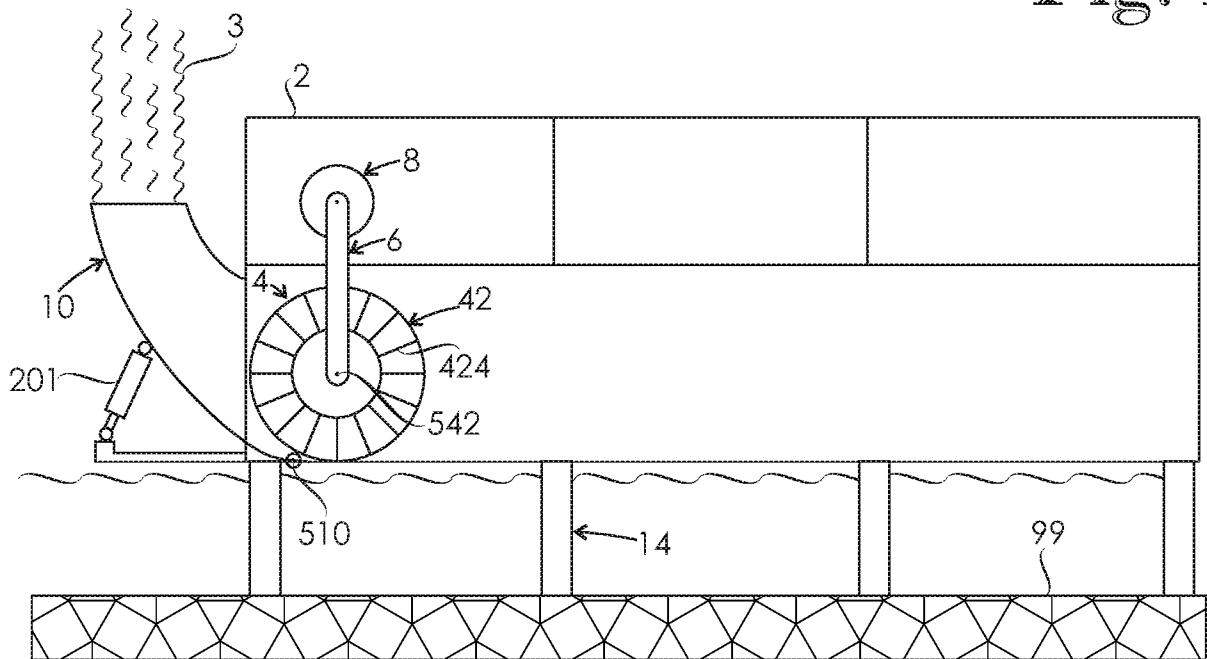


Fig. 2

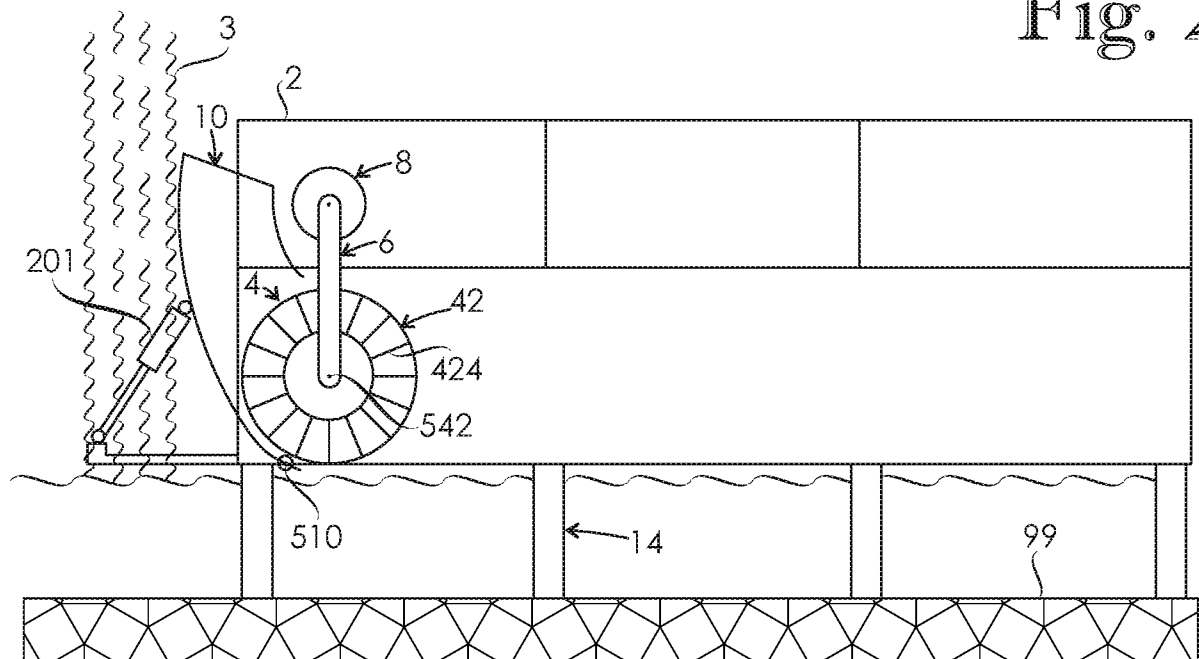


Fig. 3

