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(54) HYDROELECTRIC POWER PLANT AND METHOD OF GENERATING POWER

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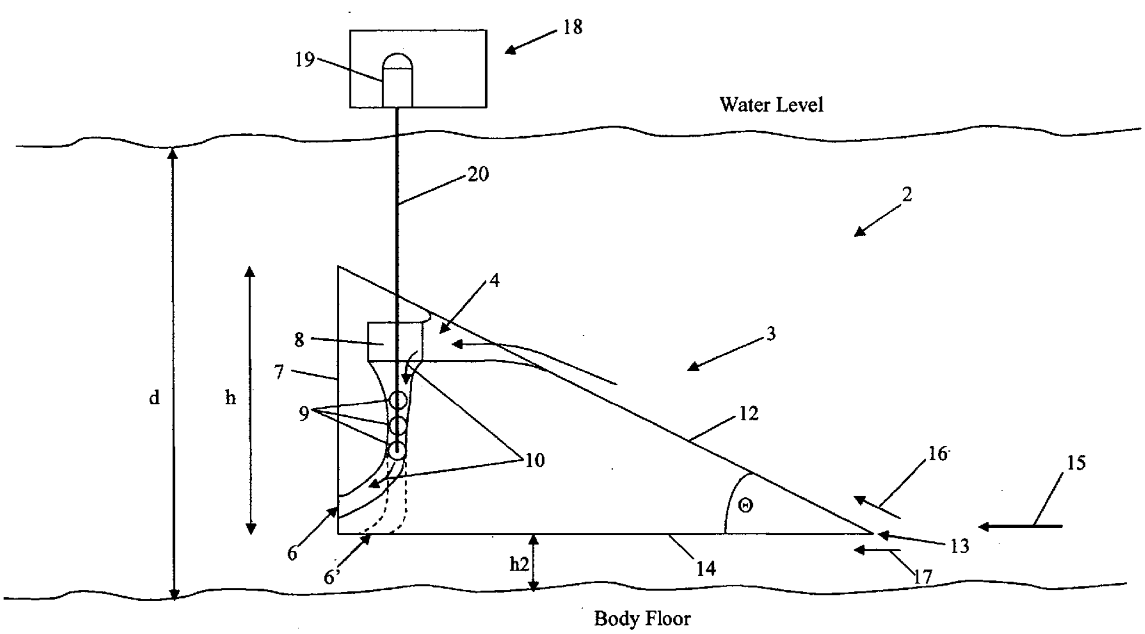
(52) **U.S. Cl.** **415/1**

(57) **ABSTRACT**

A hydroelectric power plant includes a wedge having a fluid intake, and a fluid engine located in a fluid path between the fluid intake and a fluid exhaust. The wedge may include at least upper and lower surfaces, the upper and lower surfaces angled with respect to each other by at least approximately 15°, and the wedge may be shaped to receive a fluid flow in the fluid intake.



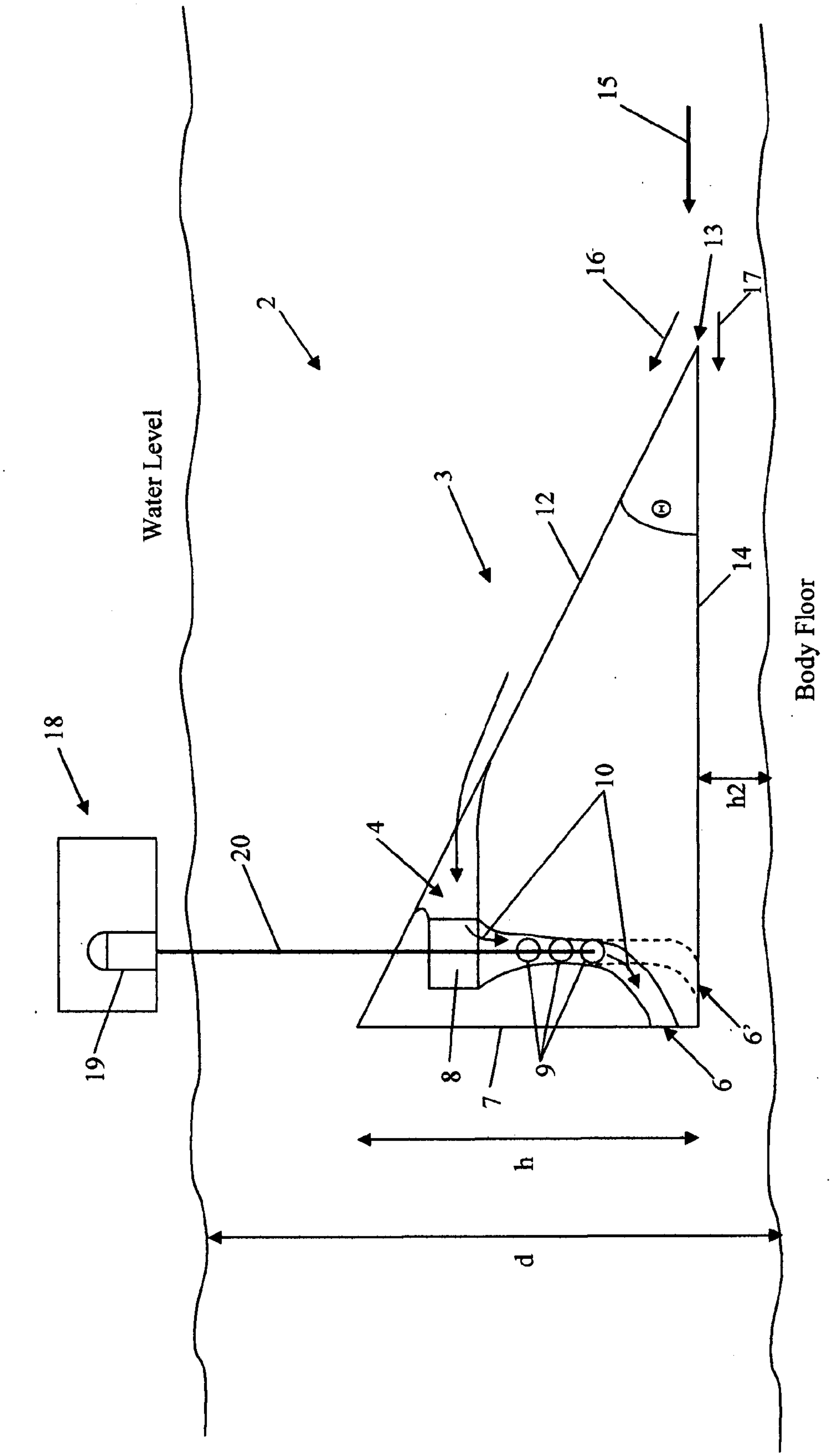

Water Level
Body Floor
2
3
4
6
6'
7
8
9
10
12
13
14
15
16
17
18
19
20
Θ
h2
h
d

Fig. 1a

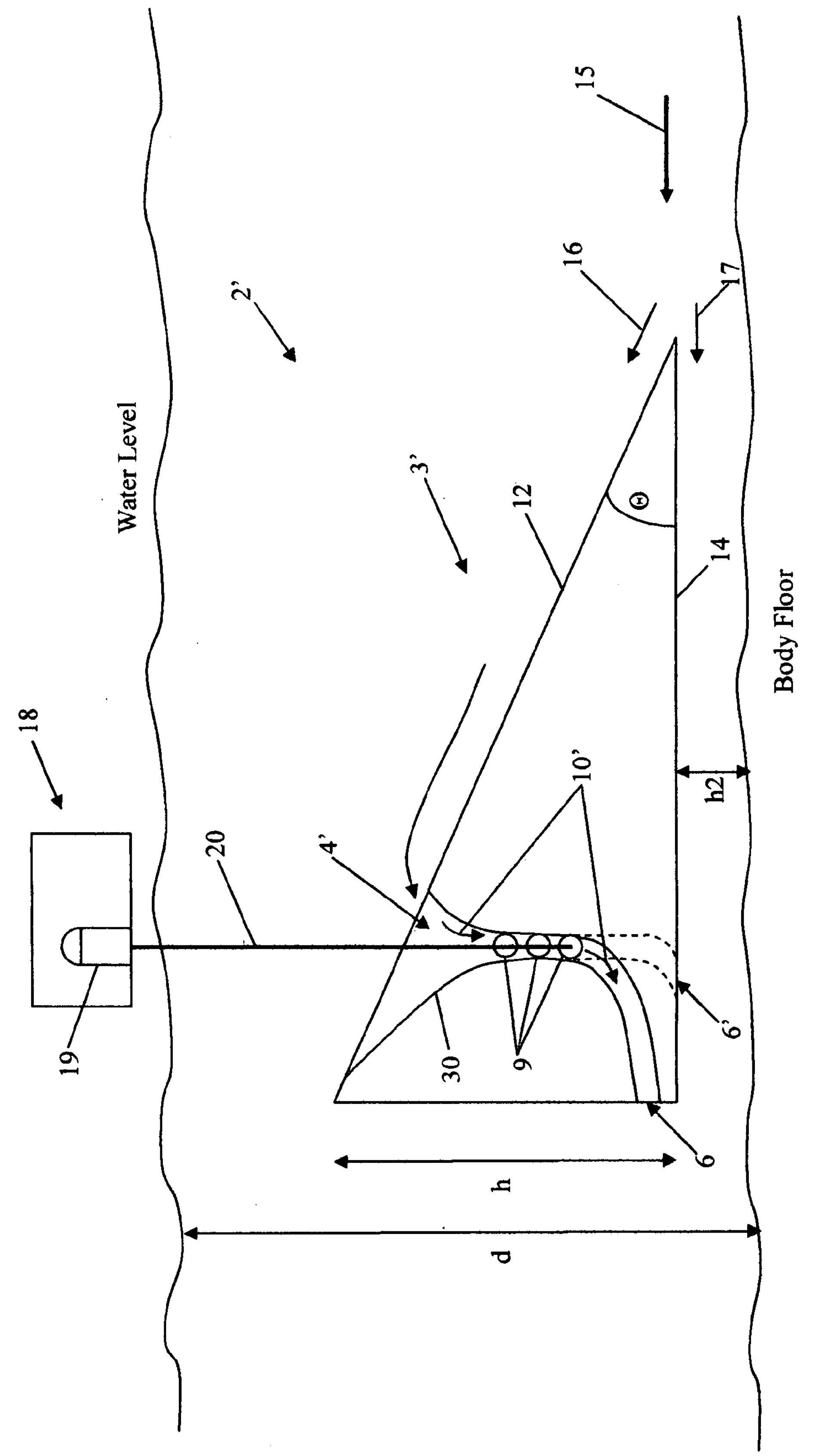

Water Level
Body Floor
2'
3'
4'
6
6'
9
10'
12
14
15
16
17
18
19
20
30
h
h2
d
Θ

Fig. 1b

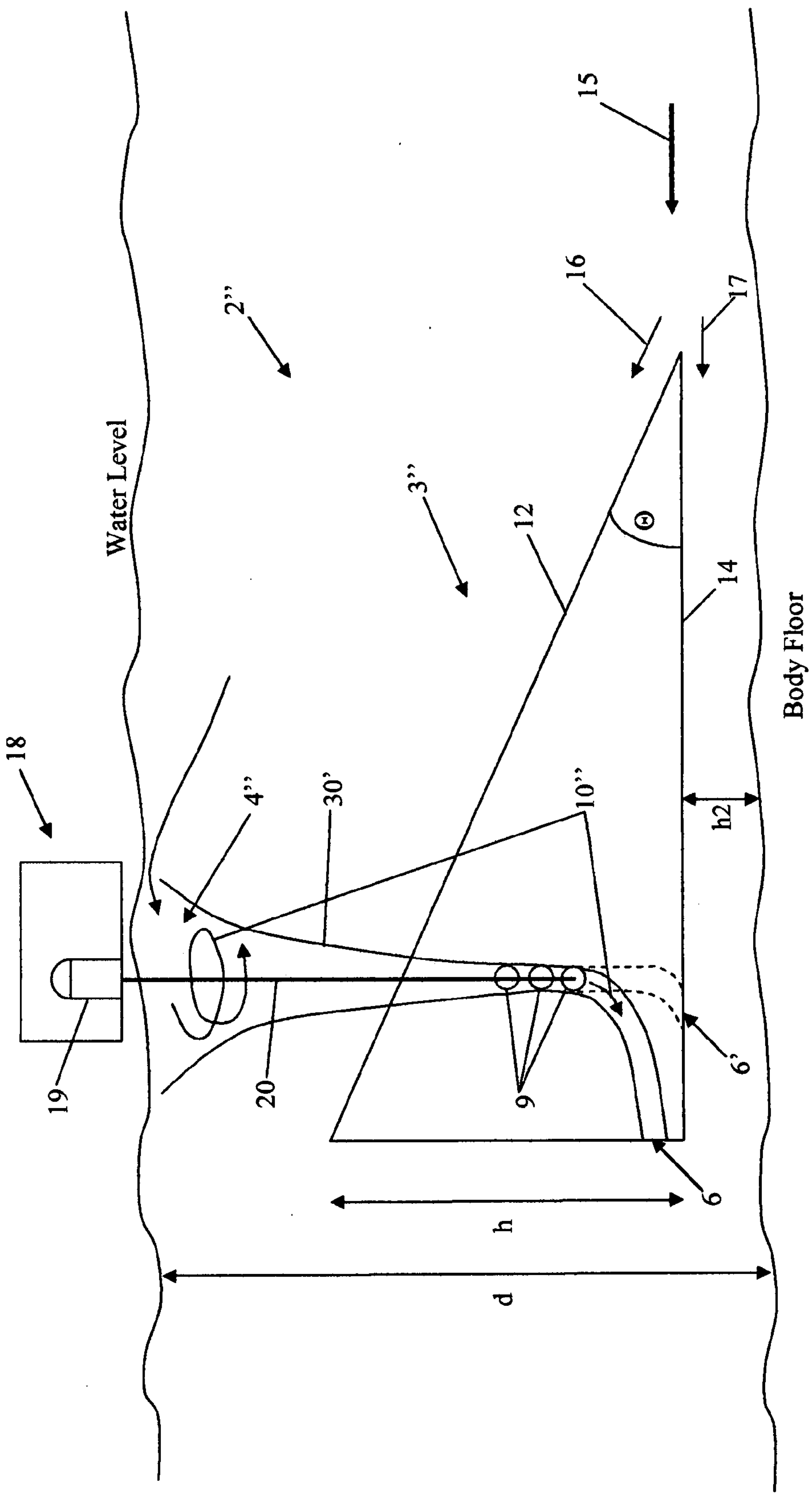

Water Level
Body Floor
2''
3''
4''
6
6'
9
10''
12
14
15
16
17
18
19
20
30'
Θ
h
h2
d

Fig. 1c

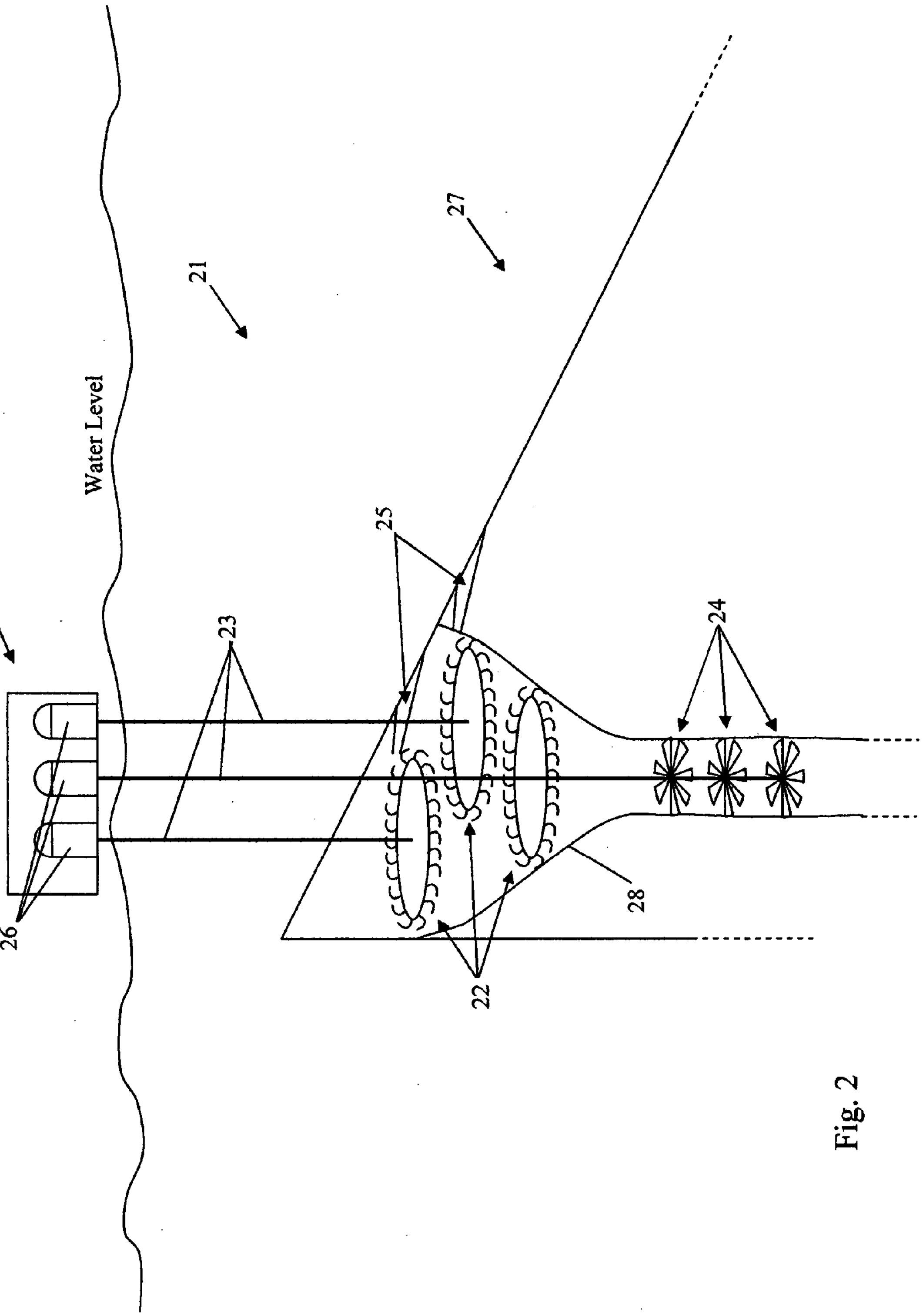


Fig. 2

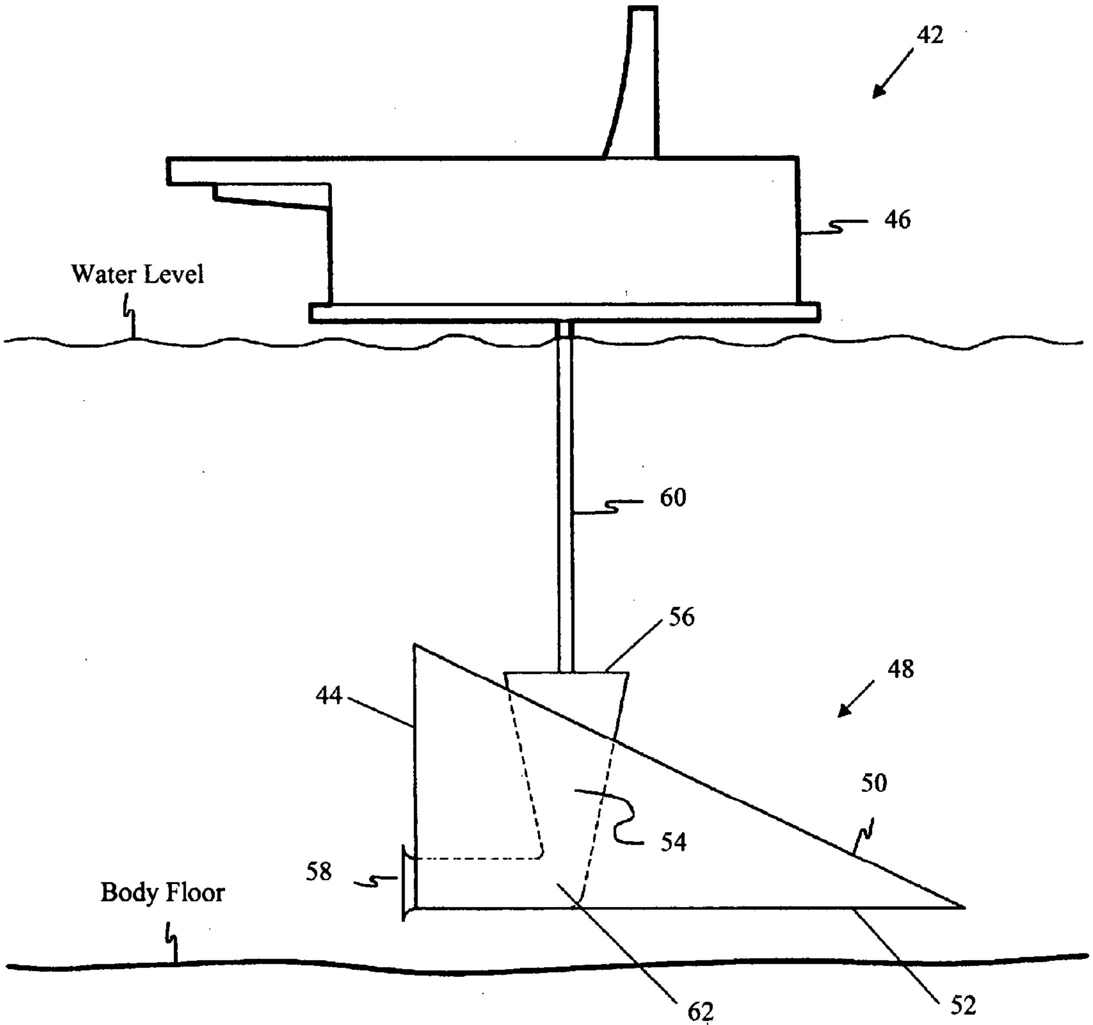


Fig. 3

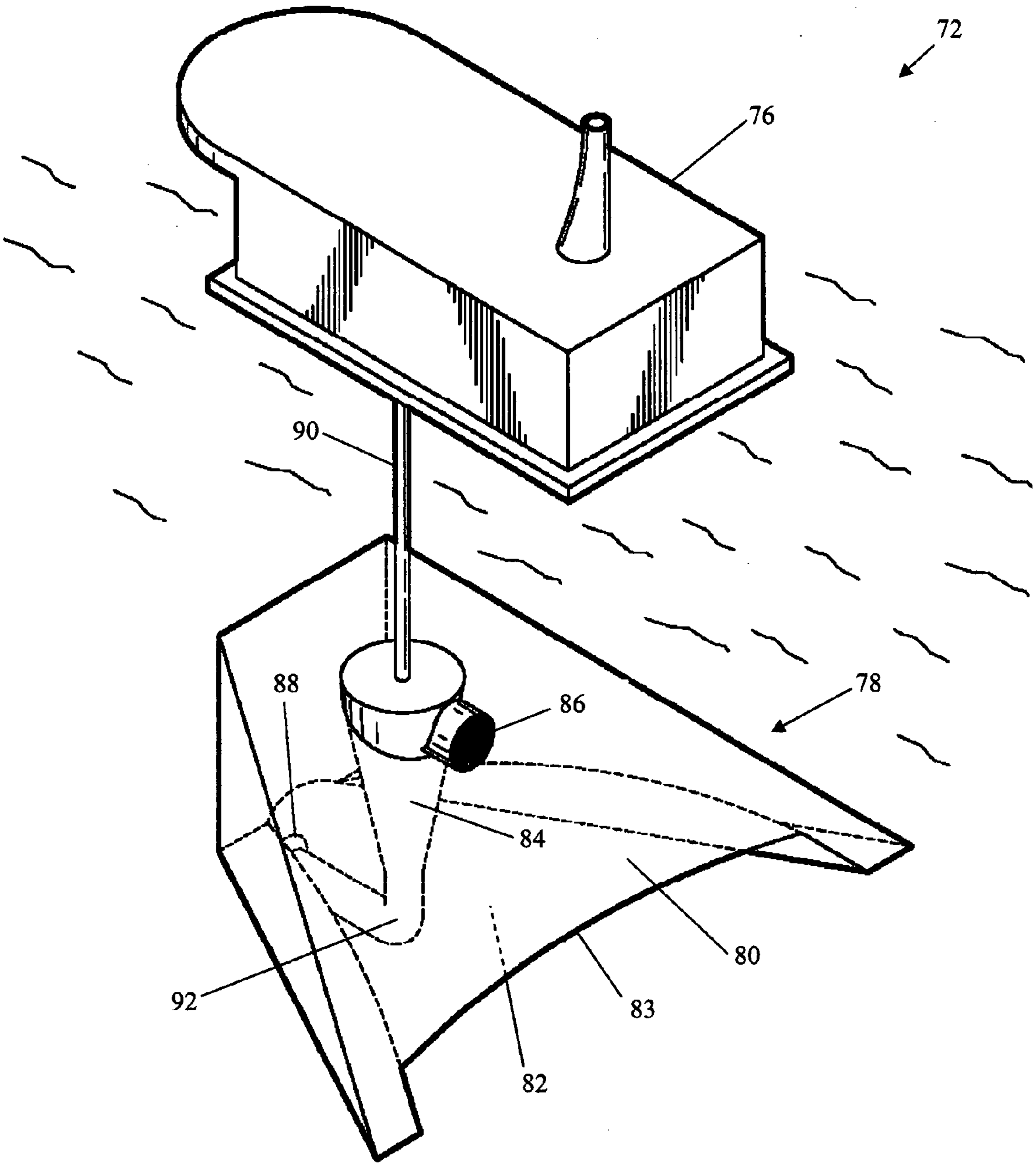


Fig. 4a

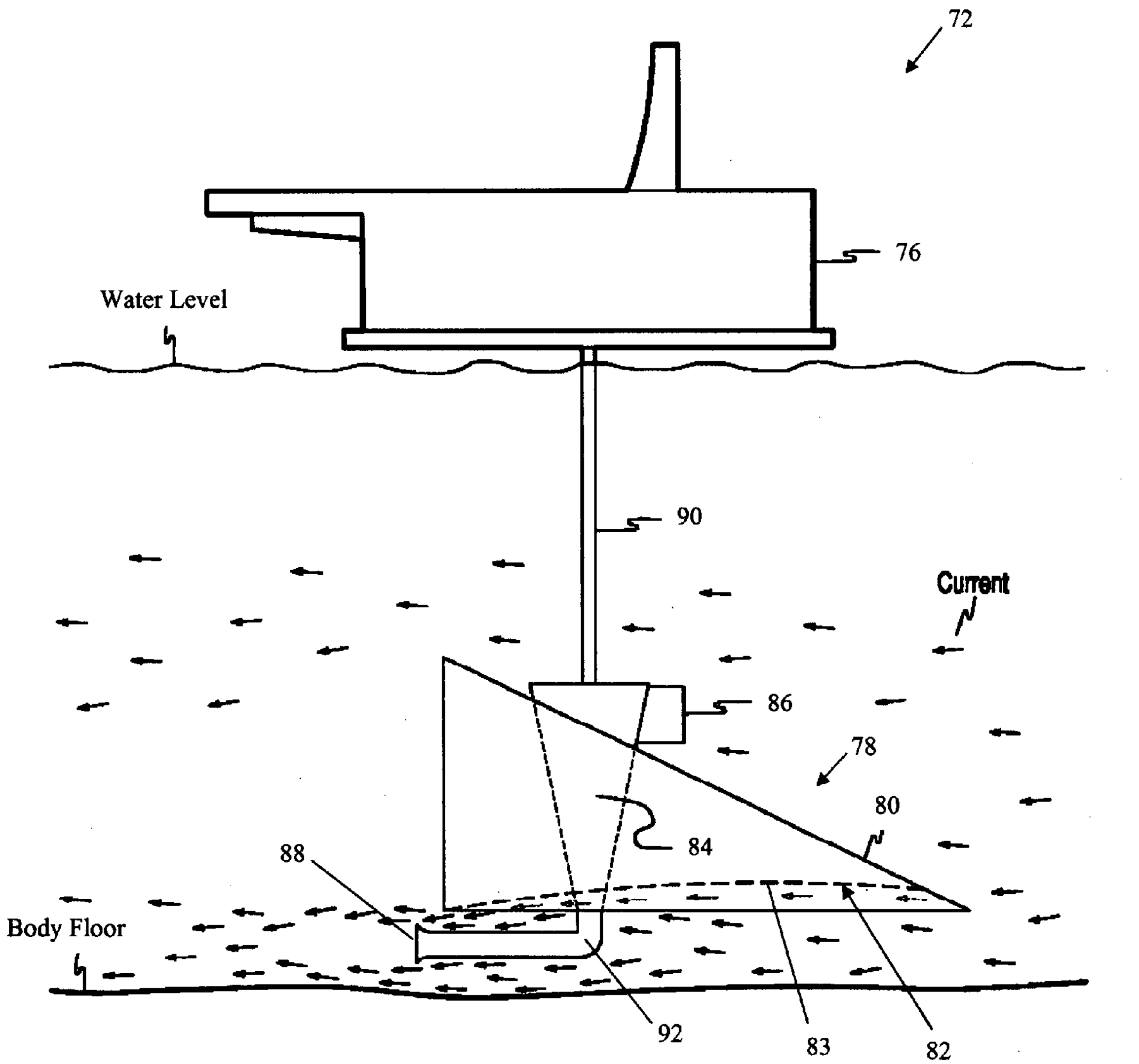


Fig. 4b

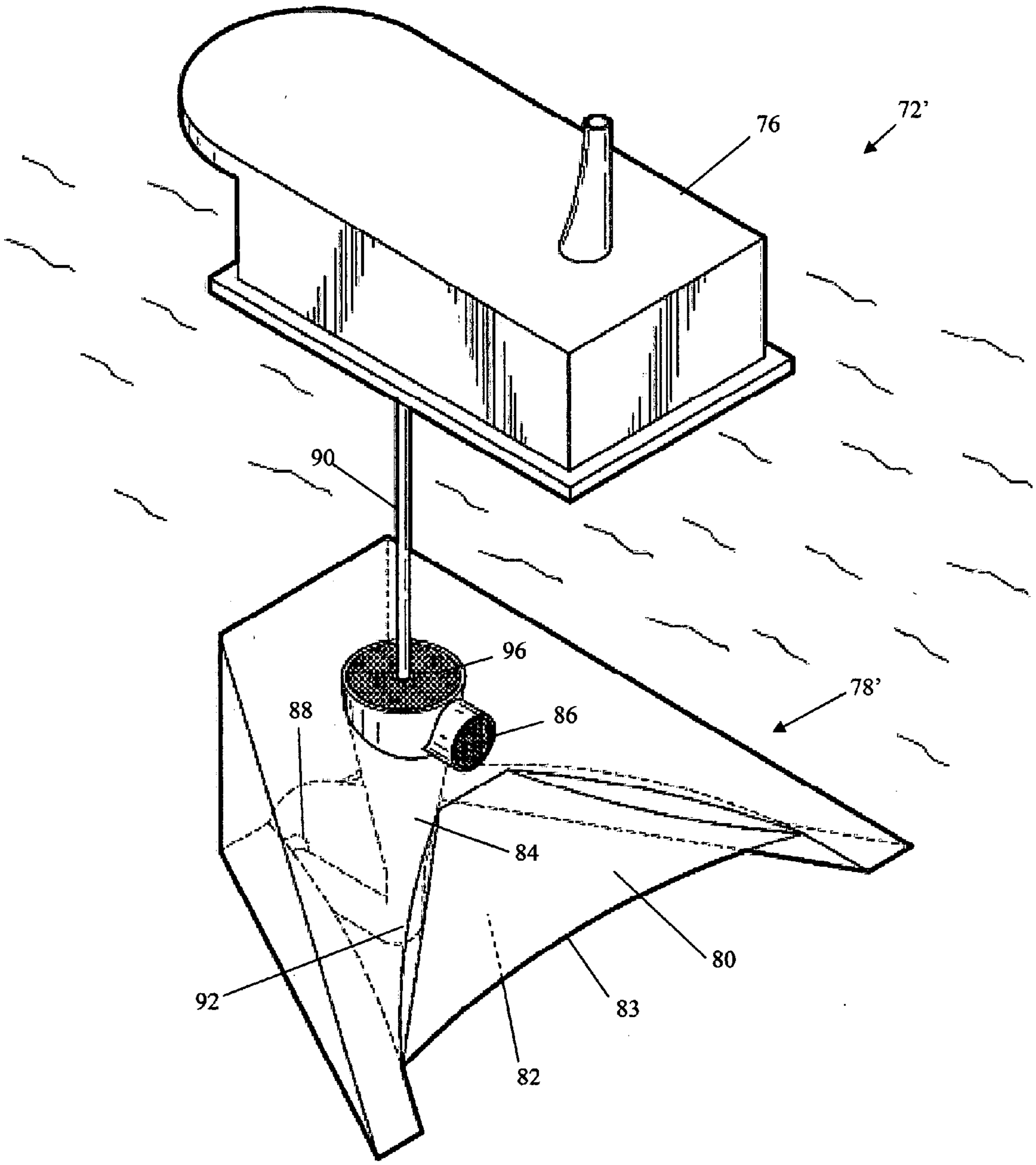


Fig. 4c

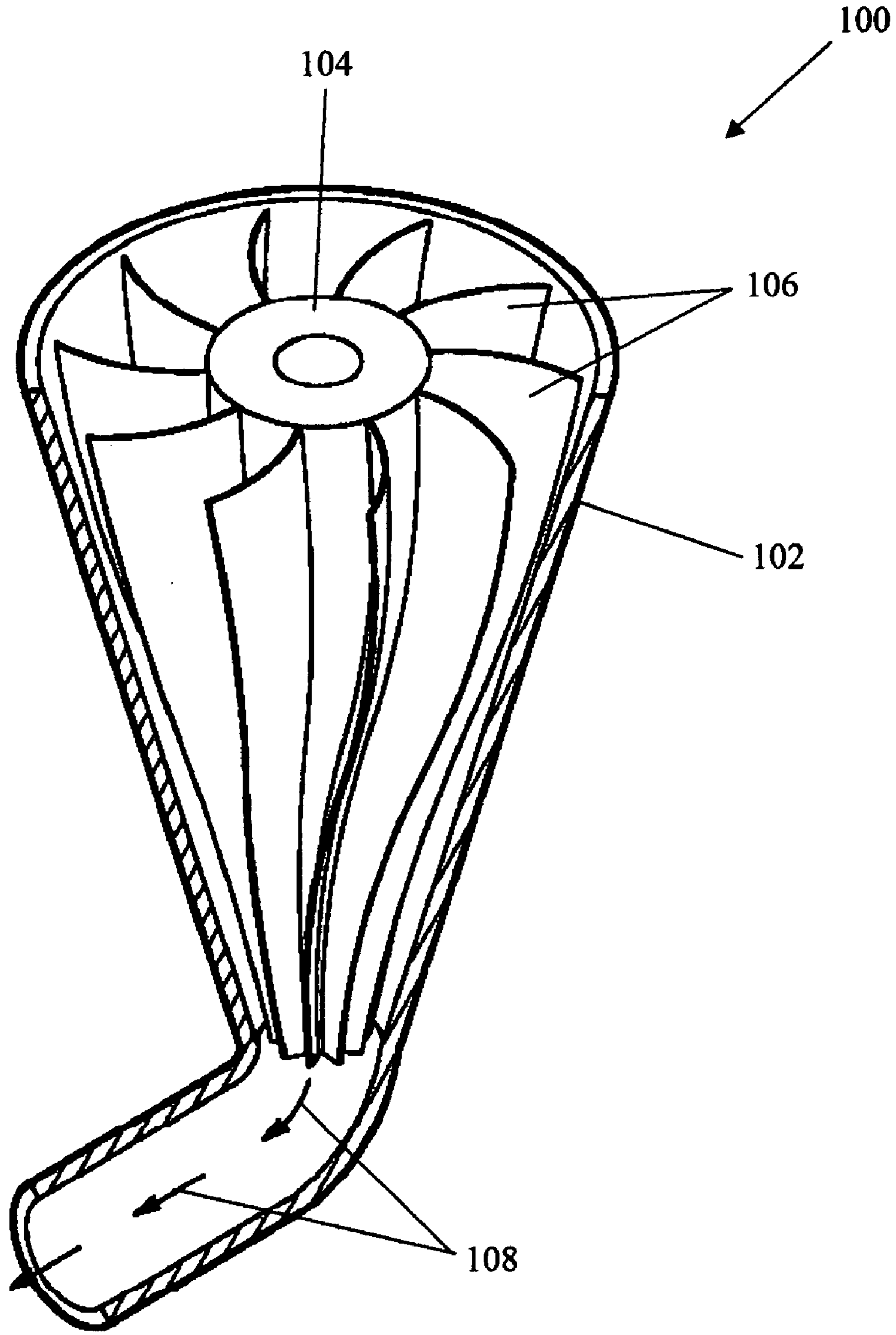


Fig. 5

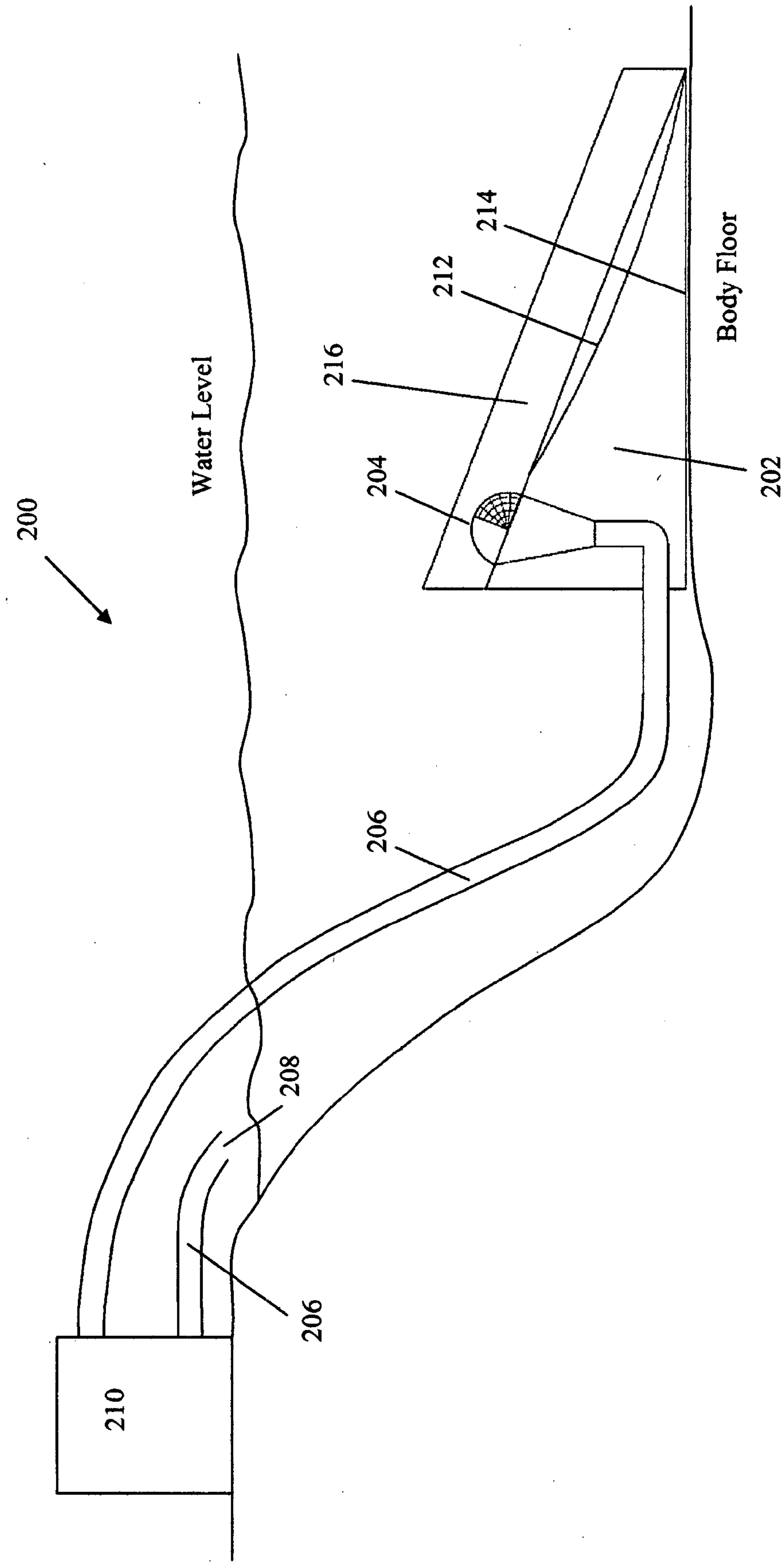


Fig. 6a

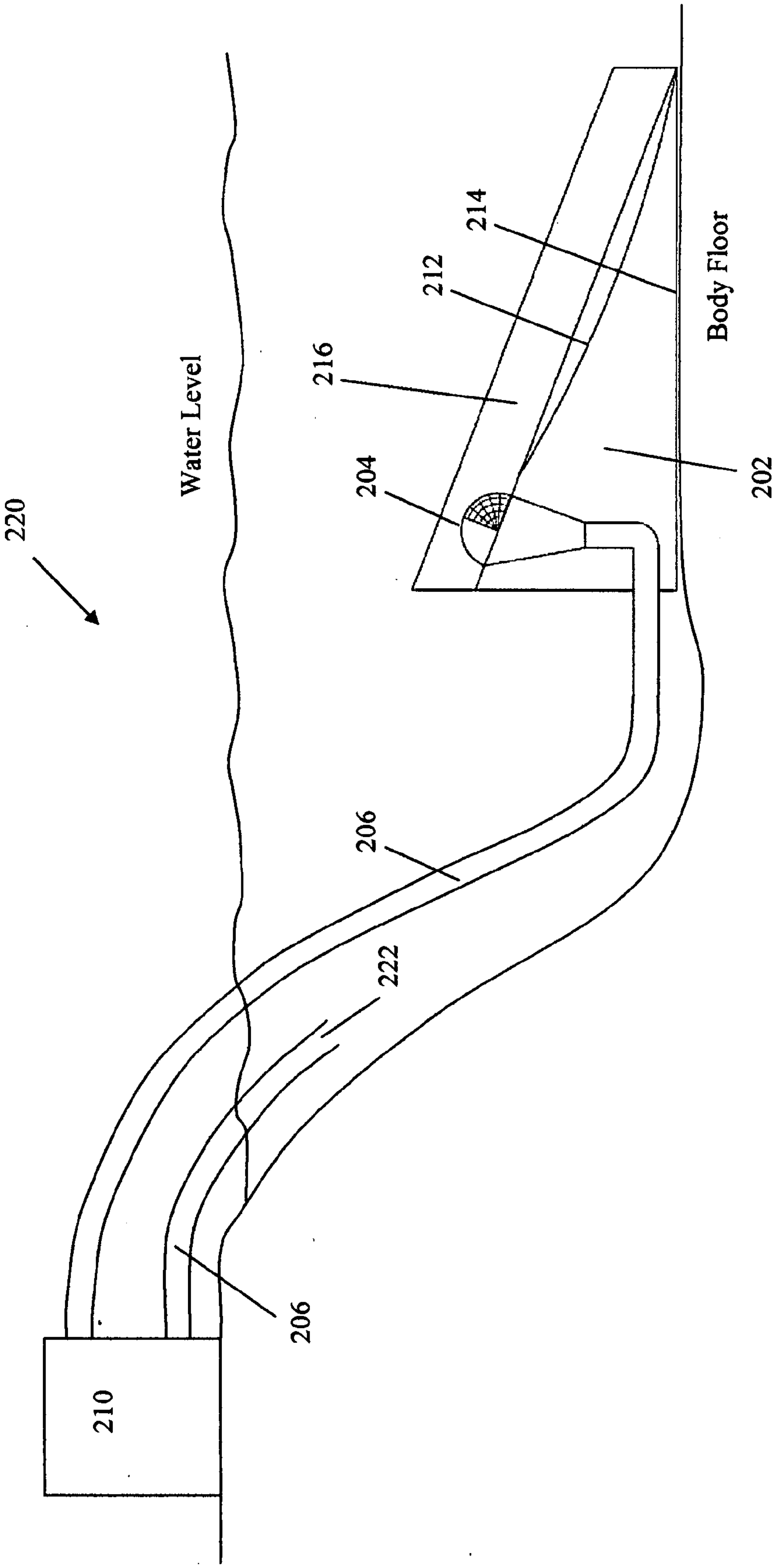


Fig. 6b

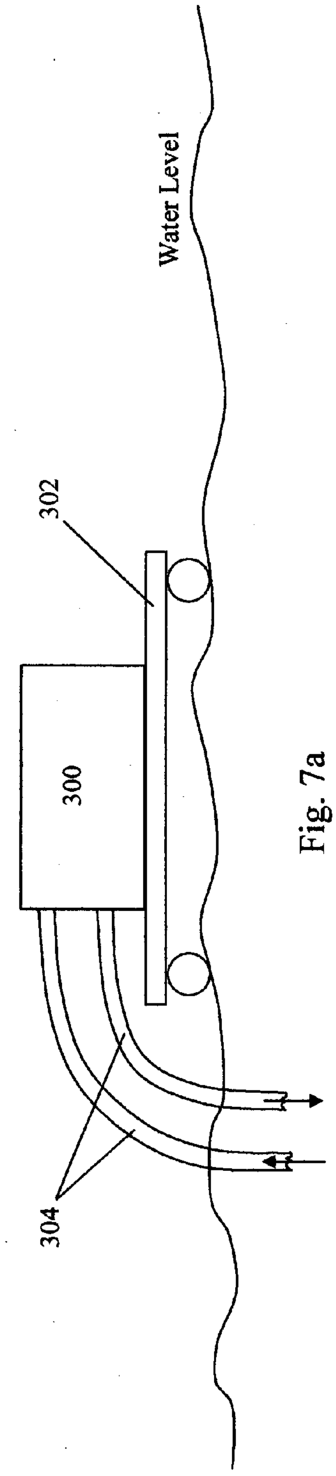

Water Level
302
300
304

Fig. 7a

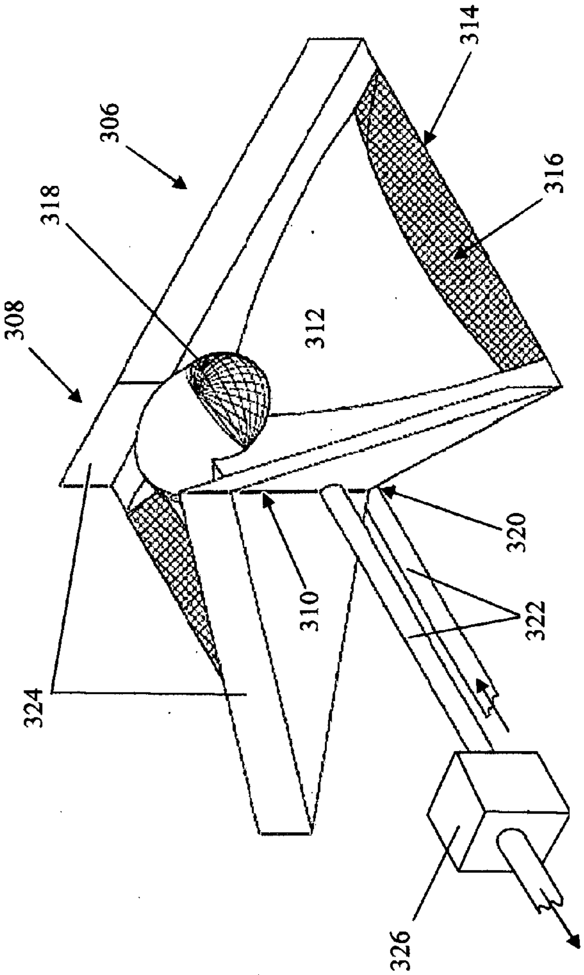

306
308
318
312
314
316
320
310
322
324
326

Fig. 7b

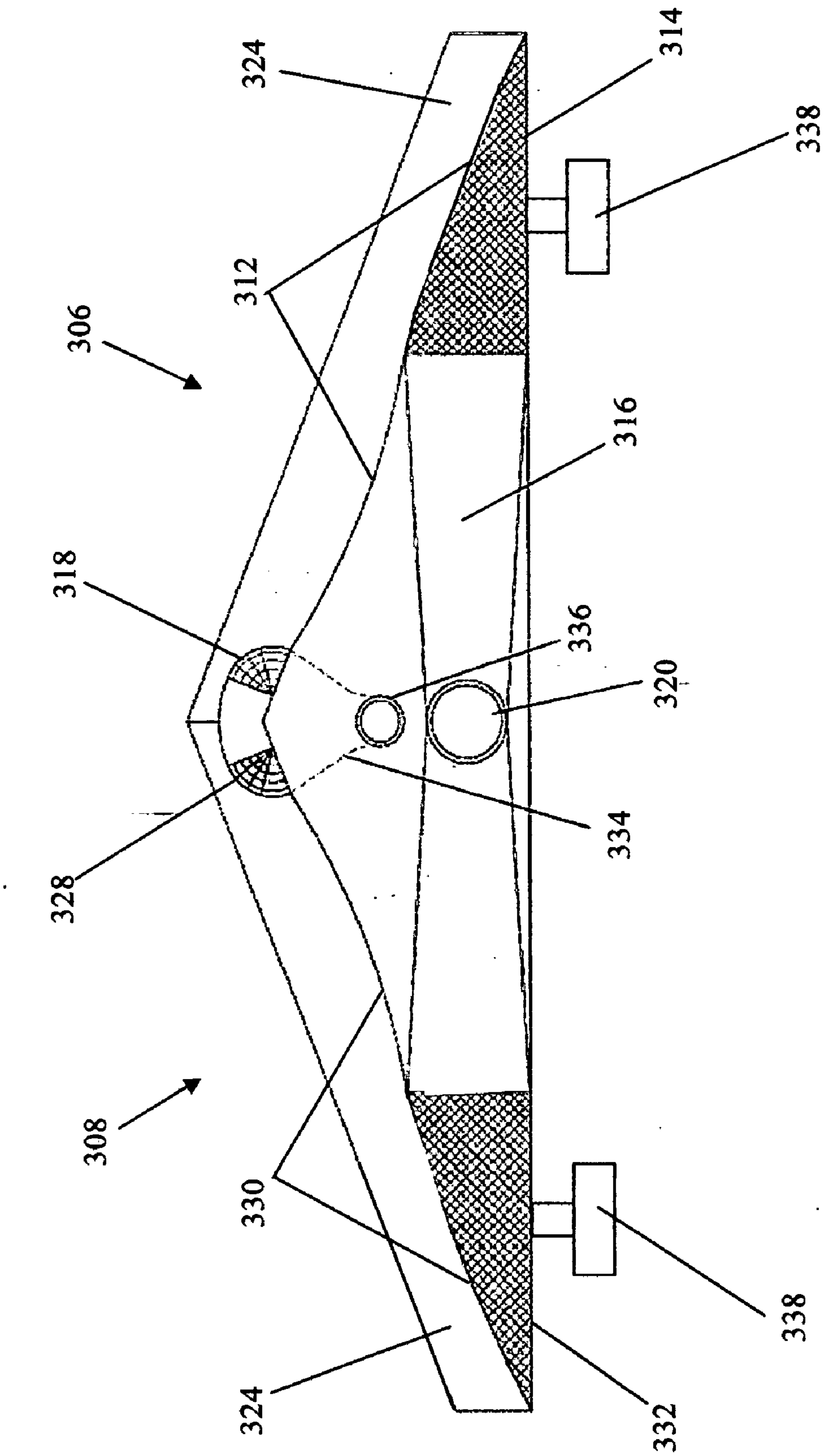


Fig. 7c

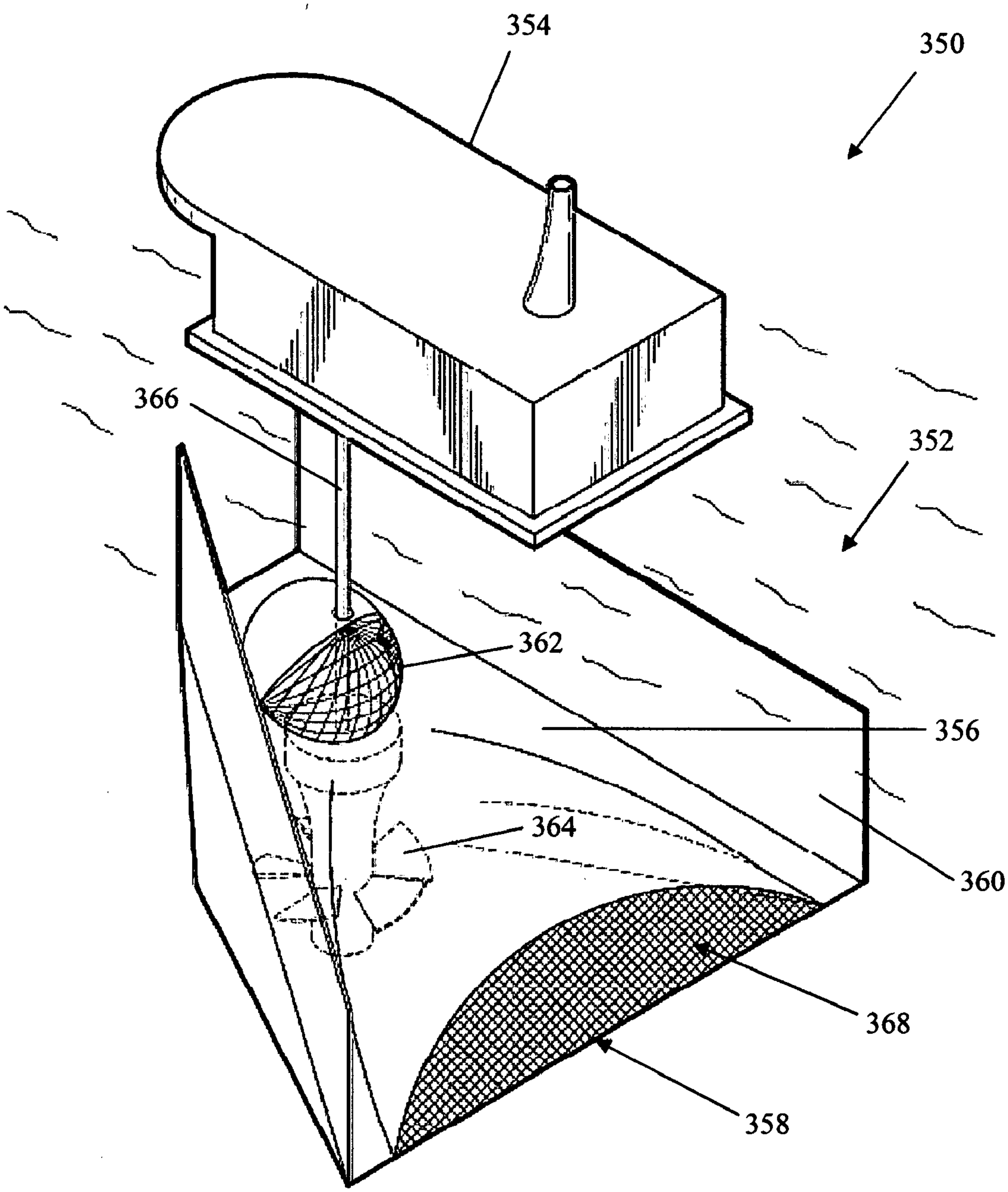


Fig. 8

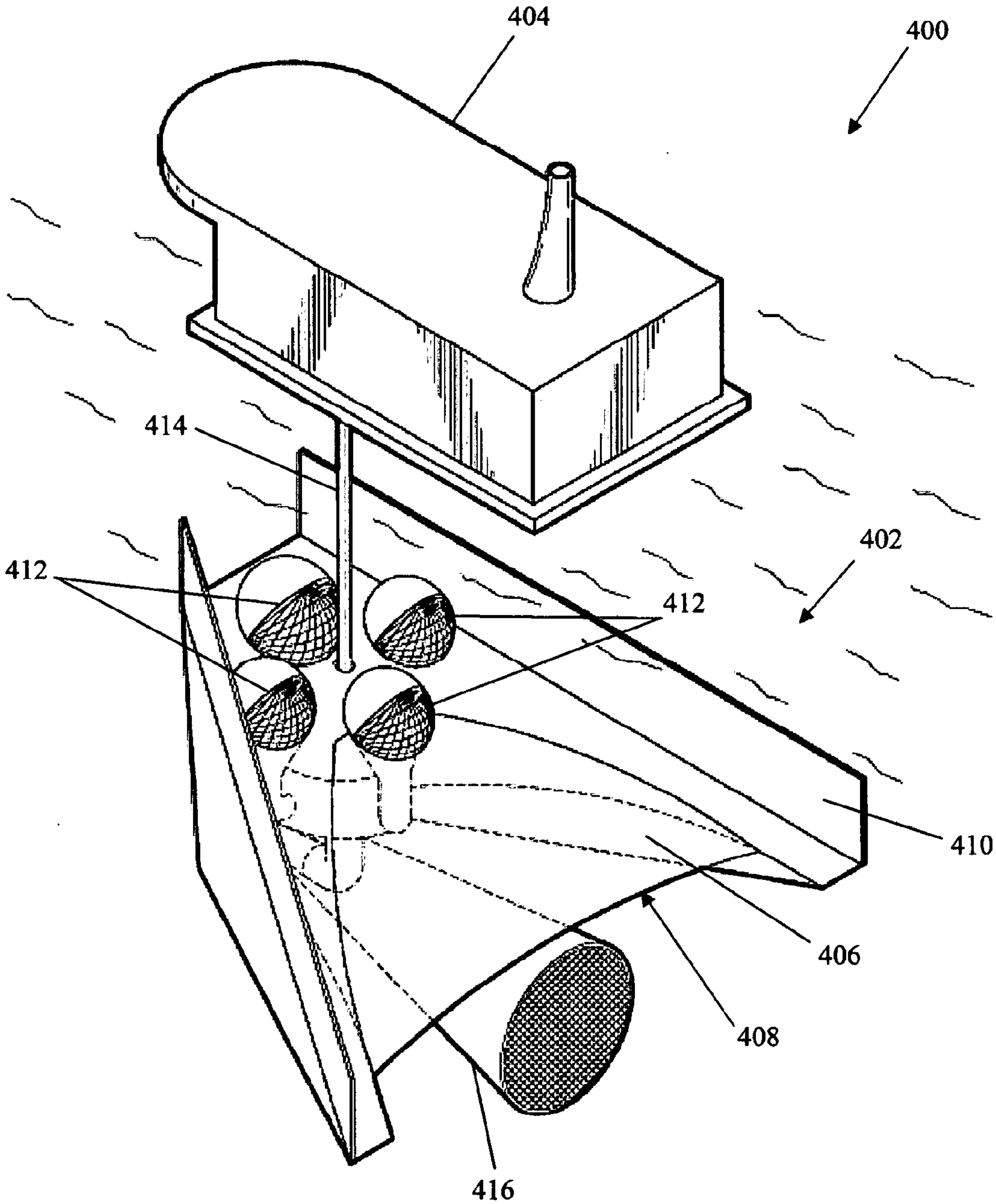


Fig. 9

HYDROELECTRIC POWER PLANT AND METHOD OF GENERATING POWER

REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a Continuation-in-Part of U.S. patent application Ser. No. 11/348,604, filed Feb. 7, 2006, entitled, "Hydroelectric Power Plant and Method of Generating Power," the disclosure of which is hereby incorporated by reference.

BACKGROUND

[0002] Power is often extracted from moving water by either damming the water (i.e., effectively stopping the water) and taking advantage of a flow of water downward from the dam, or by using a turbine within a water flow.

SUMMARY OF THE INVENTION

[0003] One problem with the former solution is that power is most efficiently extracted from moving water by not having to stop and then re-accelerate the water. One problem with the latter solution is that harsh water environments (such as silt, mud, salt, etc.) often cause fouling and regular maintenance of the turbines. The present invention aims to solve at least one of these and other problems.

[0004] In one embodiment, a hydroelectric power plant comprises: a wedge comprising a fluid intake; and a fluid engine located in a fluid path between the fluid intake and a fluid exhaust, wherein the wedge comprises at least upper and lower surfaces, the upper and lower surfaces angled with respect to each other by at least approximately 15°, and wherein the wedge is shaped to receive a fluid flow in the fluid intake.

[0005] In one aspect, the fluid engine is located external to the wedge. In one aspect, at least a portion of the fluid path inside the wedge is approximately vertical. In one aspect, the upper and lower surfaces are angled with respect to each other by approximately 30° to 60°.

[0006] The plant may further comprise a second wedge comprising a back connected to a corresponding back of the wedge, wherein the second wedge comprises a second fluid intake, and wherein the second wedge comprises at least second upper and lower surfaces, the second upper and lower surfaces angled with respect to each other by at least approximately 15°.

[0007] In one aspect, the wedge further comprises a flow constriction device configured to increase a velocity of the fluid flow. The flow constriction device may comprise at least two sides connected to the upper surface and extending above the upper surface, and the at least two sides may taper toward each other in a direction approaching the fluid intake. The at least two sides may be configured to be raised and lowered.

[0008] The plant may further comprise a fluid accelerating device located adjacent to the fluid exhaust and configured to accelerate fluid past the fluid exhaust. The fluid accelerating device may be approximately shaped as a portion of a cone. The plant may further comprise a pump located in the fluid path and configured to increase a velocity of fluid traveling to the fluid engine. The plant may comprise: a plurality of wedges, each wedge comprising a fluid intake; and a plurality of fluid engines, each fluid engine located in a fluid path between a fluid intake and a fluid exhaust.

[0009] In one embodiment, a hydroelectric power plant comprises: a wedge comprising a fluid intake; and a fluid engine located external to the wedge and located in a fluid path between the fluid intake and a fluid exhaust, wherein the wedge comprises at least upper and lower surfaces, the upper and lower surfaces angled with respect to each other by at least approximately 15°, wherein the wedge is shaped to receive a fluid flow in the fluid intake, wherein the wedge further comprises at least two sides connected to the upper surface and extending above the upper surface, and wherein at least a portion of the fluid path inside the wedge is approximately vertical.

[0010] In one embodiment, a method of generating electricity comprises: providing a hydroelectric power plant, the plant comprising: a wedge comprising a fluid intake; and a fluid engine located external to the wedge and located in a fluid path between the fluid intake and a fluid exhaust, wherein the wedge comprises at least upper and lower surfaces, the upper and lower surfaces angled with respect to each other by at least approximately 15°, and wherein the wedge is shaped to receive a fluid flow in the fluid intake; and inserting the wedge into a body of water.

[0011] The method may further comprise placing the lower surface of the wedge approximately flush to a bottom surface of the body of water. The method may further comprise placing the fluid exhaust above a water level of the body of water. The method may further comprise placing the fluid exhaust in a body of water remotely from the wedge. The method may further comprise placing the fluid engine on land. The method may further comprise providing a platform above the body of water and placing the fluid engine on the platform.

[0012] In one aspect, the wedge further comprises at least two sides connected to the upper surface and extending above the upper surface. In one aspect, at least a portion of the fluid path inside the wedge is approximately vertical.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. **1***a* shows a side view of a power plant according to an embodiment.

[0014] FIG. **1***b* shows a side view of a power plant according to another embodiment.

[0015] FIG. **1***c* shows a side view of a power plant according to another embodiment.

[0016] FIG. **2** shows a side view of a power plant according to another embodiment.

[0017] FIG. **3** shows a side view of a power plant according to another embodiment.

[0018] FIG. **4***a* shows a perspective view of a power plant according to another embodiment.

[0019] FIG. **4***b* shows a side view of the power plant shown in FIG. **4***a*.

[0020] FIG. **4***c* shows a perspective view of a power plant according to another embodiment.

[0021] FIG. **5** shows a fluid engine according to an embodiment.

[0022] FIG. 6*a* shows a side view of a power plant according to another embodiment.

[0023] FIG. 6*b* shows a side view of a power plant according to another embodiment.

[0024] FIG. 7*a* shows a side view of a portion of a power plant according to an embodiment.

[0025] FIG. 7*b* shows a perspective view of a portion of a power plant according to an embodiment.

[0026] FIG. 7*c* shows a side view of the portion shown in FIG. 7*b*.

[0027] FIG. 8 shows a perspective view of a power plant according to another embodiment.

[0028] FIG. 9 shows a perspective view of a power plant according to another embodiment.

DETAILED DESCRIPTION

[0029] In the following description, the use of "a,""an," or "the" can refer to the plural. All examples given are for clarification only, and are not intended to limit the scope of the invention.

[0030] Referring now to FIG. **1***a*, a power plant **2** comprises a wedge **3** connected to a generating station **18** via a shaft **20**. The generating station **18** includes at least one electrical generator **19**, such as a generator that converts rotational energy to electricity, as known in the art. The wedge **3** is located within a body of water having a Body Floor and a Water Level, and comprises an upper surface **12** and a lower surface **14**, the surfaces **12**, **14** angled with respect to each other by angle Θ. The body of water has a current having a fluid flow **15**. The angle Θ may be at least approximately 15°, preferably ranges from approximately 30 to 60°, and more preferably ranges from approximately 40 to 50°. The upper surface **12** may be adjustable with respect to the lower surface **14** so that the angle Θ can be changed, such as from 40° to 50° upon a slowing of the speed of fluid flow **15**. One of ordinary skill in the art will understand how to make surfaces **12**, **14** adjustable with respect to each other. For example, wedge point **13** could be hinged and a hydraulically acting piston connecting opposing ends of the upper and lower surfaces **12**, **14** could raise or lower one with respect to the other.

[0031] The wedge **3** further comprises a fluid intake **4** and a fluid exhaust **6**, and at least one engine **8**, **9** located between the fluid intake **4** and the fluid exhaust **6** in a fluid path **10** inside the wedge **3**. The wedge **3** is shaped to divide the fluid flow **15** of the body of water into at least a first flow portion **16** and a second flow portion **17**, and to receive at least a portion of the first flow portion **16** in the fluid intake **4**.

[0032] The wedge **3** is located in the body of water a height h**2** from the Body Floor, which height h**2** may range from approximately 5 to 30 feet, and more preferably from about 10 to 20 feet. The wedge **3** has a height h that ranges from approximately 10 to 100 feet, and more preferably from approximately 20 to 30 feet. The ratio of the height h of the wedge **3** to a depth d of the body of water may range from approximately 0.2 to 0.8, and more preferably from approximately 0.4 to 0.6.

[0033] In FIG. **1***a*, fluid intake **4** allows at least a portion of the first flow portion **16** to flow approximately horizontally into a first fluid engine **8**. The first fluid engine **8** may be a tangential fluid engine having a rotor and an approximately vertical axis (i.e., vertical as shown in FIG. **1***a*), whereby the engine **8** is configured to convert kinetic energy of a fluid impinging tangentially on the rotor to rotational kinetic energy of the rotor. Another feature of a tangential fluid engine may be that the rotor spins on an axis that is approximately perpendicular to a vector of the moving fluid. One such tangential fluid engine is a Pelton wheel, as known in the art, but other examples of tangential fluid engines are within the scope of the present invention.

[0034] Engines **9** may comprise axial fluid engines, each having a rotor having an approximately vertical axis (i.e., vertical as shown in FIG. **1***a*), whereby the axial fluid engine is configured to convert kinetic energy of water impinging axially on the rotor to rotational kinetic energy of the rotor. Another feature of an axial fluid engine may be that the rotor spins on an axis that is approximately parallel to a vector of the moving fluid. One such axial fluid engine is an axial turbine, but other examples, such as the suction propeller described with reference to FIG. **5**, are within the scope of the present invention.

[0035] The engines **8**, **9** in FIG. **1***a* are shown sharing a common shaft or axle **20**, connecting the engines to the electrical generator **19**. In one embodiment, the rotors of each of engines **8**, **9** are directly connected to each other via the axle **20**, but in other embodiments: a) rotors of some engines are connected to each other via gears and/or gear boxes, so that differential rotation rates of the respective rotors can be accommodated; or b) the power plant includes multiple axles (such as will be discussed with reference to FIG. **2**), and only some of the rotors are directly connected to each other.

[0036] In one embodiment, at least a portion of the fluid path **10** inside the wedge **3** is substantially or approximately vertical, so that the fluid (in this case, water of the body of water) flows downward at some points in the wedge **3**.

[0037] The fluid exhaust **6** may be located at a back end **7** of the wedge **3**, where a lower pressure is induced by suction caused by first and second flow portions **16**, **17** flowing around the wedge **3** (along upper and lower surfaces **12**, **14**, respectively). Alternatively or in addition, the fluid exhaust **6'** may be located at a distal region (i.e., opposite the wedge point **13**) of the lower surface **14**, where a lower pressure is induced by the fast moving flow of the second flow portion **17**.

[0038] The fluid intake **4** may have a width (in a direction perpendicular to the page of FIG. **1***a*) that spans approximately the entire width of the wedge **3**, or only a portion of the width of the wedge **3**, such as 10% to 50%.

[0039] Further, any combinations of engines **8**, **9** (such as using one or more of each of tangential fluid engines and axial fluid engines in any order along fluid path **10**) is within the scope of the present invention. Further, engines **8**, **9** may include any engines capable of extracting power from a fluid having static and/or dynamic pressures (i.e., not moving or moving).

[0040] In one embodiment, wedge **3** is pivotable along a vertical axis (vertical as shown in FIG. **1***a*), such as along the axis of axle **20**, to allow the wedge point **13** to be pointed in a direction parallel to but opposite the vector of fluid flow **15**, thus maximizing efficiency of the power plant **2**.

[**0041**] In operation, the power plant **2** produces electricity in the following manner. Wedge **3** (if rotatable about an axis) is rotated so that wedge point **13** faces a direction that is approximately parallel but opposite to the vector of fluid flow **15**. If the angle Θ is adjustable, then at least one of surfaces **12**, **14** is adjusted so that the optimal angle Θ is achieved, depending on the flow speed (and perhaps other factors) of the fluid flow **15**. Fluid flow **15** is broken into first and second portions **16**, **17**, by the wedge **3**, causing at least one of the portions **16**, **17** to speed up relative to fluid flow **15** (due to a reduction in cross sectional area through which a constant mass flow rate of fluid can pass). At least a portion of the first portion **16** enters into fluid intake **4**, the portion having a high total pressure (sum of static and dynamic pressures), and first engine **8** extracts power from the fluid and converts the power to rotational power transferred to the electrical generator **19** via axle **20**. The fluid continues along the fluid path **10** to second fluid engines **9**, in which more power is extracted from the fluid and power is converted to rotational power transferred to the electrical generator **19** via axle **20**. Finally, the fluid is exhausted via fluid exhaust **6** (or **6'**) into the body of water.

[**0042**] The increase in velocity of the first portion **16** due to the wedge **3** is useful in extracting power from the fluid (and increasing efficiency over a comparable system that does not increase the velocity of the fluid). Further, the suction created at the fluid exhaust **6** (**6'**) further increases the velocity of the fluid passing through the fluid path **10**, thus allowing the system to extract more power and increase efficiency. In other words, in one embodiment, the fluid is “pushed” into the fluid intake **4** at a velocity higher than in the absence of the wedge **3**, and “pulled” from the fluid exhaust **6** at a velocity higher than otherwise.

[**0043**] Referring now to FIG. **1***b*, a power plant **2'** has been modified somewhat. Power plant **2'** is similar to power plant **2** in FIG. **1***a*, except for the following differences: it includes a wedge **3'** having a finned **30** that serves as the fluid intake **4'**; and a tangential fluid engine may (or may not) be lacking. In this embodiment, at least a portion of the first portion **16** enters into fluid intake **4'** and then immediately funnels downward into the funnel **30** toward fluid engines **9**, which may be axial fluid engines. The combination of a high total pressure of the first portion **16** above upper surface **12** and a low pressure at the fluid exhaust **6** (**6'**) induces a high velocity flow of fluid along fluid path **10'** and through engines **9**, allowing power to be extracted and transferred to the electrical generator **19** via axle **20**. In this embodiment, fluid flowing along path **10'** may flow approximately vertically at some points.

[**0044**] In one embodiment, one or more fluid engines **9** may be located along the fluid path **10'** in a substantially horizontal region just preceding the fluid exhaust **6**.

[**0045**] Referring now to FIG. **1***c*, a power plant **2"** has been modified somewhat. Power plant **2"** is similar to power plant **2'** in FIG. **1***b*, except for the following differences: it includes a wedge **3"** having a funnel **30'** that protrudes upward from the upper surface **12** and approaches the Water Level of the body of water; fluid flows into the fluid intake **4"** and takes a fluid path **10"** that may rotate around the inside of funnel **30'** and eventually proceeds downward toward and through engines **9**, and finally out fluid exhaust **6** (**6'**). In FIG. **1***c*, the fluid flowing into funnel **30'** may take on the form of a cyclone inside the funnel **30'**. The funnel **30'** may or may not include ridges or protrusions about the inside of the funnel **30'** that are configured to induce the water to flow in a predetermined fashion. The ridges may take on a screw shape or any other shape.

[**0046**] Referring now to FIG. **2**, a power plant **21** comprises a wedge **27** having a plurality of fluid intakes **25**, a funnel **28**, a plurality of tangential fluid engines **22** each having an approximately vertical axis of rotation, and a plurality of axial fluid engines **24** each having an approximately vertical axis of rotation and located after the funnel **28** along the fluid path. The power plant **21** further comprises a generating station **25** having a plurality of electrical generators **26** connected to engines **22**, **24** via axles **23**. As shown in FIG. **2**, the rotor of exactly one of the tangential fluid engines **22** is directly connected to exactly one electrical generator **26** via exactly one axle **23**, the rotor of another one of the tangential fluid engines **22** is directly connected to another one of the electrical generators **26** via another one of the axles **23**, and the rotor of another one of tangential fluid engines **22** is directly connected to another one of the electrical generators **26**, as well as the rotors of all three axial fluid engines **24**, via the remaining axle **23**.

[**0047**] In FIG. **2**, the plant **21** comprises at least one tangential fluid engine **22** (i.e., the upper two, as shown in FIG. **2**) for each of the plurality of fluid intakes **25**. Further, the lower tangential fluid engine **22** is located within the funnel **28** to take advantage of the speed of water rotating inside the funnel **28**. The axial fluid engines **24** then take advantage of the speed of water flowing downward from the lower portion of the funnel **28**.

[**0048**] In operation, at least a portion of water flowing up the upper surface of the wedge **27** enters the fluid intakes **25** at high velocity. The high velocity fluid then impinges tangentially on the cups or blades of each respective tangential fluid engine **22**, causing the rotor of each respective tangential fluid engine **22** to rotate, thus powering respective electrical generators **26** via respective axles **23**. Next, water flows cyclonically and downward in a predetermined rotation direction within the funnel **28** toward the lower tangential fluid engine **28**, which then extracts further energy from the water as the water pushes the cups, blades, etc. of the lower tangential fluid engine **28**. The energy extracted by the rotor of the lower tangential fluid engine **22** is transferred to the respective electrical generator **26** via respective axle **23**.

[**0049**] Next, water flows downward from the funnel **28** toward the fluid exhaust (not shown) of the wedge **27**, passing through a plurality of axial flow engines **24**, which extract energy from the downward flow of the water. This energy is transferred to the respective electrical generator **26** via respective axle **23**.

[**0050**] Any of the features of FIG. **2** may be mixed, matched, added, or eliminated to suit design requirements. For example, each fluid engine **22**, **24** may have its own associated axle **23** and/or electrical generator **26**. Alternatively or in addition, any set of fluid engines **22**, **24** may share an axle **23** and/or electrical generator **26**. For example, in one embodiment, rotors of all fluid engines **22**, **24** are directly connected to each other via a single axle **23** that transfers power to the generating station **25**. Further, any fluid engine **22**, **24** may comprise a gear box or other gearing mechanism to allow for differential preferred rotation rates of the various elements of plant **21**— e.g., to allow the rotor of an axial fluid engine **24** to rotate much more quickly than the rotor of an electrical generator **26** to which it is connected.

[0051] Further, the plant **21** may include only a single fluid intake **25** or several, and may include only one tangential fluid engine **22** or a plurality, or one axial fluid engine **24** or a plurality, etc. The plant **21** may include any type of fluid engine capable of extracting usable energy from a fluid having dynamic and/or static pressure. Further, the funnel **28** (and/or the lower tangential fluid engine **22** that makes use of the cyclonic fluid flow induced by the funnel **28**) may be eliminated or modified. Further, the rotors of any or all of the engines **22**, **24** may rotate at different rates.

[0052] Referring now to FIG. **3**, a power plant **42** comprises a generating station **46** and a wedge **48** connected via an axle **60**. The wedge **48** comprises an upper surface **50** and a lower surface **52**, and a funnel **54** having a fluid intake **56**, an elbow **62**, and a fluid exhaust **58**. The wedge **48** further comprises at least one fluid engine (not shown), which may be located inside the funnel **54**, the rotor of which is connected to the axle **60** and transfers power extracted from the moving water to an electrical generator (not shown) inside the generating station **46**.

[0053] In operation, water flowing toward the wedge point of the wedge **48** divides along the upper and lower surfaces **50**, **52**, and thus accelerates along these surfaces. Because of the higher velocity of water flowing along surfaces **50**, **52** and eventually past the wedge **48**, a total fluid pressure along back surface **44** (and at fluid exhaust **58**) is lower than the total fluid pressure of the water before reaching the wedge point. Thus, a suction is induced, causing water to be sucked into the fluid intake **56**, through the funnel **54** and corresponding fluid engine(s), and out the fluid exhaust **58**. Power is extracted from this high velocity fluid and transferred to the generating station **46** via axle **60**.

[0054] Referring now to FIGS. **4***a* and **4***b*, a power plant **72** comprises a generating station **76** and a wedge **78**, the wedge **78** having upper and lower surfaces **80**, **82** and a funnel **84** having a fluid intake **86**, a fluid exhaust **88**, an elbow **92**, and at least one fluid engine (not shown) connected to the generating station **76** via axle **90**. The embodiment shown in FIGS. **4***a* and **4***b* is similar to that shown in FIG. **3**, with several differences. First, the fluid intake **86** allows approximately horizontally flowing water to flow into a fluid engine (such as a tangential fluid engine) so that the water does not need to substantially change directions before power is extracted from it. Further, the lower surface **82** includes a curvature or contoured shape **83** to help smoothly direct and accelerate the flow of water to and around the fluid exhaust **88**. Further, the upper surface **80** may also or alternatively include such a curvature or contoured shape (not shown) to help smoothly direct and accelerate the flow of water into the fluid intake **86**. The curvatures (if implemented) may be convex or concave, depending on the design requirements. Either of the embodiments shown in FIGS. **3**, or **4***a*/**4***b* may have a smoother elbow than shown, to allow for a more laminar flow of water through the wedge.

[0055] Referring now to FIG. **4***c*, a power plant **72'** is similar to power plant **72** shown in FIG. **4***a*, including a wedge **78'** similar to wedge **78** in FIG. **4***a*, with an exception that the wedge **78'** may include, alternatively or in addition, a vertically aligned fluid intake **96** that allows water to flow into funnel **84** (and/or any fluid engine located therein) in an approximately vertical direction.

[0056] Finally, FIG. **5** shows one possible embodiment of a suction propeller type fluid engine. The fluid engine **100** comprises an outer casing **102** and a rotor **104** having rotor blades **106**. The fluid engine **100** may be located inside any of the funnels discussed with respect to previous embodiments. Thus, the outer casing **102** may or may not correspond to such funnels. The rotor **104** may be connected to an electrical generator via an axle (not shown), and/or may be connected to rotor(s) of other fluid engine(s). In operation, a flow **108** of water from the top of the engine **100** (top as shown in FIG. **5**) impinges on blades **106**, causing the rotor **104** to rotate. The suction propeller type fluid engine **100** shown in FIG. **5** may be used alone, in conjunction with one or more tangential-type, axial-type, or other known fluid engines, or may be omitted altogether, in any of the power plant embodiments previously discussed.

[0057] Most of the embodiments described herein have represented simple versions for clarity of explanation. As understood by one of ordinary skill in the art, many of the features and/or aspects of the embodiments described herein may be "mixed and matched" to the extent physically possible to satisfy individual design requirements. As merely an example of such allowable mixing and matching, an axial fluid engine may be used in place of a tangential flow engine, particularly where a device (as known in the art) is used to change the axis of rotation of the axial fluid engine's rotor (such as allowing a rotor having a horizontal axis to rotate a vertical axis). Any fluid engine known in the art (e.g., Pelton, Francis, Kaplan, etc.) may be used with the present invention. Further, any of the fluid intakes described herein may include a screen or other known device for preventing fish and other debris from entering fluid engines of the power plant. Further, in all embodiments shown, the lower surface is approximately horizontal. However, this need not be the case. For example, the upper surface and lower surface may both be angles with respect to the horizon. For example, the upper surface may be angled positively relative to the horizon at, say, 15°, the lower surface may be angled negatively relative to the horizon at, say, 20°, thus resulting in a relative angle between the upper and lower surfaces to be 35°. The fluid exhaust may exhaust fluid in a direction substantially parallel to a direction of fluid flow along the lower surface (e.g., see FIGS. **3** and **4***b*), or may exhaust the fluid in a direction substantially angled with respect to the direction of fluid flow along the lower surface (e.g., exhaust **6'** in FIG. **1***b*).

[0058] As another example, the word "wedge" as used herein is not limited to an object having two flat surfaces that are angled with respect to each other, or an object that is perfectly triangular in cross section. Both upper and lower surfaces (e.g., **12** and **14** in FIG. **1***a*) may be curved, contoured, rounded, or shaped other than as flat surfaces. More generally, a "wedge" used herein is a device used to separate fluid flow **15** (FIG. **1***a*) into first and second flow portions, and preferably reduces or limits turbulence that may arise from such separation. In other words, preferably, the wedge divides the fluid flow **15** into two portions having substantially smooth or laminar flow. The wedge may, for example, be an incline. As one possible example in which at least one surface of the wedge is not flat, the upper surface may be curved concave so that angle Θ is very shallow (e.g., less than 5° or 10°) near the wedge point **13**, and increases (e.g., to greater than 30°) further from the wedge point.

[0059] As another example, one or more fluid engines may be located in a substantially horizontal region just preceding (in the fluid path **10'** in FIG. **1***b*) the fluid exhaust **6**. In other words, instead of or in addition to fluid engines **9** being located in a substantially vertical region of the fluid path **10'**, fluid engines may be located in a substantially horizontal region of the fluid path **10'**. As another example, the portion of the fluid path (e.g., **10** in FIG. **1***a*) that is substantially vertical may, e.g., be at an angle of between 75° and 105° with respect to the body floor.

[0060] The present invention also includes a method of generating electricity, including providing any of the power plants described herein and inserting said plant(s) into a body of water, such as an ocean, a lake, a river, a sea, or any other body of water. The method may include selecting a body of water and a location within the body such that a ratio of a height of the wedge (h in FIG. **1***a*) relative to a depth of the body (d in FIG. **1***a*) falls within a particular range, such as approximately 20% to 80%, and more preferably 30% to 70%, and more preferably 40% to 60%, and more preferably approximately 50%. The method may include inserting the plant(s) into the water body such that the lower surface is approximately flush with, or at least approximately 10 feet above, or at least approximately 20 feet above, or at least approximately 30 feet above, the floor of the water body. The method may include placing the generating station above the water level of the water body.

[0061] Referring now to FIG. **6***a*, a hydroelectric power plant **200** comprises a wedge **202** comprising a fluid intake **204**, and a fluid engine **210** located in a fluid path **206** between the fluid intake **204** and a fluid exhaust **208**. The wedge **202** comprises upper surface **212** and lower surface **214**, and the surfaces **212**, **214** may be angled with respect to each other by at least approximately 15° or any of the angles or angle ranges previously mentioned. The wedge **202** is shaped to receive a fluid flow in the fluid intake **204**. The wedge **216** includes a flow constriction device **216**, which is configured to increase a velocity of the fluid flow into the fluid intake **204**. The flow constriction device **216** includes any device known in the art for constricting the flow of a fluid, and may include two sides **216** connected to the upper surface **212** and extending above the upper surface **212**. The sides **216** may taper toward each other in a direction approaching the fluid intake **204**, as shown, for example, with reference to FIG. **7***b*. Further, the flow constriction device **216** (e.g., sides **216**) may be configured to be adjusted and/or raised and lowered to allow a desired amount of flow constriction to take place. For example, sides **216** may be mounted on a track system, allowing the sides **216** to move up and down, and may be controlled and moved using a motor, gear, and electronic control system (not shown), as understood by one of ordinary skill in the art. Alternatively or in addition, the sides **216** may be movable inward and outward like flaps on an airplane, and/or their degree of tapering may be adjustable.

[0062] Flow intake **204** is shown with an approximately hemispherical shape, with a guard, screen, or net covering a portion facing the incoming fluid flow, for example to prevent the introduction of impurities and other unwanted objects in the fluid flow.

[0063] In the embodiment shown in FIG. **6***a*, wedge **202** is located such that the lower surface **214** is approximately flush with the Body Floor of the body of water. Further, fluid engine **210** is located on land, above the Water Level of the body of water. Further, fluid exhaust **208** is located above the Water Level of the body of water. Further, upper surface **212** (or lower surface **214** or both) may be curved or contoured, as shown, to allow for a more laminar flow of fluid along the upper surface **212** of the wedge **202**.

[0064] However, in alternative embodiments, any or all of these features may be changed. For example, the lower surface **214** of the wedge **202** may be located above the Body Floor of the body of water, in any of distances or ranges previously mentioned. Further, fluid engine **210** may be located within the water or, in an embodiment discussed with reference to FIG. **7***a*, may be located above the water on a floating or permanent platform. Further, the exhaust **208** may be located in several places, such as remotely from the wedge **202**, in or out of the water, in the same or different body of water, up current or down current from the wedge **202**, and so forth. For example, referring now to FIG. **6***b*, a hydroelectric power plant **220** is similar to the plant **200** shown in FIG. **6***a*, with common reference numbers indicating common features. The plant **220** includes a fluid exhaust **222** that is located in the body of water, remotely from the wedge **202**.

[0065] In operation of the plant **200** shown in FIG. **6***a*, upper surface **212** of wedge **202** causes current in the body of water to rise up toward the fluid intake **204**. The reduced cross sectional area through which fluid can flow causes the fluid to increase in velocity. Flow constriction device **216** further increases the velocity of the fluid as it enters the fluid intake **204**. The high velocity fluid then flows through fluid path **206** to fluid engine **210**, where energy in the fluid is transferred to usable energy via any of the methods and devices previously discussed, such as using a turbine or piston engine other fluid engine (which energy can then be transferred to electrical energy by an electrical generator, etc.), and then continues along fluid path **206** to fluid exhaust **208**, where the fluid is discharged back into the body of water.

[0066] Referring now to FIGS. **7***a* and **7***b*, a hydroelectric power plant includes a fluid engine **300** located on a platform **302** located above the Water Level (the platform **302** may be a floating platform or a permanent platform that is connected to the Body Floor), and a double wedge system having a first wedge **306** and a second wedge **308**. Each of the wedges **306**, **308** has a back (both generally designated by reference number **310**), with the backs **310** connected to each other. The first wedge **306** includes upper surface **312** and lower surface **314** (either or both of which may be contoured), and may be angled relative to each other in any way previously described (such as at least 15°, and preferably between 30° and 60°, etc.). The wedge **306** may further include a fluid intake **318**, a flow constriction device **324**, and a fluid accelerating device **316** (better shown with reference to FIG. **7***c*). The second wedge **308** has features similar to and corresponding to the first wedge **306**. (Referring to FIG. **7***c*, the second wedge **308** includes fluid intake

328, upper surface 330, and lower surface 332.) Fluid intakes 318, 328 (for both the first and second wedges 306, 308) and a fluid exhaust 320 may be connected via a fluid path 322, along which may include a pump 326 configured to increase a velocity of fluid traveling to the fluid engine 300. Fluid paths 304 and 322 are connected to ultimately connect the fluid engine 300 to the double wedge system. The pump 326 may be any pump known in the art, including a centrifugal pump, and may be configured to increase the velocity of a portion of the fluid flow at the expense of reducing the velocity of another portion of the fluid flow. For example, the pump 326 may be powered at least in part by converting energy from a part of the fluid flow into additional kinetic energy given to a different part of the fluid flow. Pump 326 may or may not be located inside one or more of the wedges 306, 308.

[0067] Referring now to FIG. 7*c*, the double wedge system shown in FIG. 7*b* further includes a region 334 in which at least a portion of the fluid flow is approximately vertical, a fluid exhaust 320 in which fluid from the fluid engine flows out, as well as a conduit 336 from the fluid intakes 318, 328 to the fluid engine via the flow paths 322, 304. The region 33 may or may not have a conical or siphon shape to direct fluid flow downward. The system may further include height adjustment devices 338 configured to enable raising and lowering of the wedges 306, 308. The devices 338 may use any technology known in the art, including but not limited to hydraulic, electric, and pneumatic lifts. The fluid accelerating devices 316, which are located adjacent to the fluid exhaust 320, are configured to accelerate fluid near the fluid exhaust 320 to provide further suction to suck fluid from the fluid exhaust 320. In FIG. 7*c*, fluid intakes 318, 328 are shown connected to fluid exhaust 320 via a common flow path 322, but in another embodiment the fluid intake 318 may be connected to its fluid exhaust by a different flow path than that connecting the fluid intake 328 with its fluid exhaust. An advantage to the double wedge system shown in FIGS. 7*b* and 7*c* is that a single system may take advantage of opposing flow directions resulting from, e.g., ocean tides.

[0068] In operation, assuming fluid flow is initially toward the left in FIG. 7*c* (due, e.g., to a tide), a portion of water flow moving toward wedge 306 flows left upward along the upper surface 312 of first wedge 306, and a portion flows into fluid accelerating device 316. The upper portion is accelerated by the reduced cross sectional flow area of both the slope of the upper surface 312 as well as flow constriction device 324, and enters the fluid intake 318, where it travels to fluid engine 300 via region 334, fluid flows 322, 304, and pump 326. The fluid engine 300 the extracts some of the fluid's energy, and then returns the fluid to the fluid exhaust 320 via fluid flows 322, 304. The fluid from fluid accelerating device 316 moves past the fluid exhaust 320, and sucks the fluid out in a direction of the fluid accelerating device 316 of the second wedge 308. If and when the tide or current direction reverses, a similar process happens, this time with fluid entering fluid intake 328 via upper surface 330 of the second wedge 308, and with fluid being exhausted via fluid exhaust 320 in a direction of the fluid accelerating device 316 of the first wedge 306. Of course, all of the fluid eventually is exhausted back into the body of water.

[0069] Referring now to FIG. 8, a hydroelectric power plant 350 includes an electrical generator 354 and wedge 352 having an upper surface 356, a lower surface 358, a fluid constricting device 360, a fluid intake 362, a Francis turbine or other fluid engine 364 located inside the wedge 352 and connected to the generator 354 via a shaft 366, and a fluid accelerating device 368 for accelerating fluid past the fluid exhaust (not shown).

[0070] Referring now to FIG. 9, a hydroelectric power plant 400 includes an electrical generator 404 and a wedge 402 including an upper surface 406, a lower surface 408, a fluid constriction device 410, a plurality of fluid intakes 412, a shaft 414 connecting a fluid engine (not shown) to the generator 404, and a fluid accelerating device 416 adjacent to the fluid exhaust (not shown) configured to accelerate fluid past the fluid exhaust to provide further suction. The fluid accelerating device 416 may be approximately shaped as a portion of a cone, and/or may have an approximately circular cross section.

[0071] Any of the features described with respect to any of the embodiments herein may be applied, where possible, to any other disclosed embodiment. The invention may include further features. For example, the fluid engine may be located internally or externally to the wedge. An advantage to external location, particularly on land or on an above-water platform, is that corrosion can be limited or controlled. Further, the fluid exhaust may be located at, near, or remote to the wedge, even possibly in a different body of water, and in or out of water. Further, a plurality of wedges in series (i.e., one after the other in the direction of fluid flow) or parallel (i.e., parallel with respect to the fluid flow) may be used to extract even more power out of a fluid flow. The intakes of these wedges may all be connected to a single fluid engine via a common fluid flow, or a plurality of fluid engines may be used. The present invention may be used with fluid flows in oceans, lakes, tidal basins, rivers, and other bodies of water. In many of the embodiments, at least a portion of the fluid flow is approximately vertical, so as to take advantage of the "falling" of water that occurs after the water has been lifted along the upper surface of the wedge. The energy of the increased velocity of the flow due to the wedge may be extracted by other means than by falling, so a vertical portion is not a requirement for all embodiments of the present invention. In an embodiment, a hydroelectric plant may include a plurality of wedges, each wedge comprising a fluid intake, such as at least two wedges as shown in FIG. 7*c*. Alternatively or in addition, the plant may include a plurality of fluid engines, each fluid engine located in a fluid path between a fluid intake and a fluid exhaust, such as shown with reference to FIG. 2. Each wedge may have its own fluid engine, fluid intake, and fluid exhaust, or one or more of these features may be shared among more than one wedge. (For example, as shown in FIGS. 7*a*-7*c*, two wedges 306, 308 may share a common fluid engine 300 and a common fluid exhaust 320.) In an embodiment, the plant may include many, such as at least ten, wedges, each wedge having its own fluid intake and fluid engine. The wedges may or may not be connected in series or parallel.

I claim:

1. A hydroelectric power plant, comprising:

a wedge comprising a fluid intake; and

a fluid engine located in a fluid path between the fluid intake and a fluid exhaust,

wherein the wedge comprises at least upper and lower surfaces, the upper and lower surfaces angled with respect to each other by at least approximately 15°, and

wherein the wedge is shaped to receive a fluid flow in the fluid intake.

2. The hydroelectric power plant as claimed in claim 1, wherein the fluid engine is located external to the wedge.

3. The hydroelectric power plant as claimed in claim 1, further comprising a second wedge comprising a back connected to a corresponding back of said wedge,

wherein the second wedge comprises a second fluid intake,

wherein the second wedge comprises at least second upper and lower surfaces, the second upper and lower surfaces angled with respect to each other by at least approximately 15°.

4. The hydroelectric power plant as claimed in claim 1, wherein the wedge further comprises a flow constriction device configured to increase a velocity of the fluid flow.

5. The hydroelectric power plant as claimed in claim 4, wherein the flow constriction device comprises at least two sides connected to the upper surface and extending above the upper surface, wherein the at least two sides taper toward each other in a direction approaching the fluid intake.

6. The hydroelectric power plant as claimed in claim 5, wherein the at least two sides are configured to be raised and lowered.

7. The hydroelectric power plant as claimed in claim 1, further comprising a fluid accelerating device located adjacent to the fluid exhaust and configured to accelerate fluid past the fluid exhaust.

8. The hydroelectric power plant as claimed in claim 7, wherein the fluid accelerating device is approximately shaped as a portion of a cone.

9. The hydroelectric power plant as claimed in claim 1, further comprising a pump located in the fluid path and configured to increase a velocity of fluid traveling to the fluid engine.

10. The hydroelectric power plant as claimed in claim 1, wherein at least a portion of the fluid path inside the wedge is approximately vertical.

11. The hydroelectric power plant as claimed in claim 1, wherein the upper and lower surfaces are angled with respect to each other by approximately 30° to 60°.

12. The hydroelectric power plant as claimed in claim 1, wherein the plant comprises:

a plurality of wedges, each wedge comprising a fluid intake; and

a plurality of fluid engines, each fluid engine located in a fluid path between a fluid intake and a fluid exhaust.

13. A hydroelectric power plant, comprising:

a wedge comprising a fluid intake; and

a fluid engine located external to the wedge and located in a fluid path between the fluid intake and a fluid exhaust,

wherein the wedge comprises at least upper and lower surfaces, the upper and lower surfaces angled with respect to each other by at least approximately 15°,

wherein the wedge is shaped to receive a fluid flow in the fluid intake,

wherein the wedge further comprises at least two sides connected to the upper surface and extending above the upper surface, and

wherein at least a portion of the fluid path inside the wedge is approximately vertical.

14. A method of generating electricity, comprising:

providing a hydroelectric power plant, the plant comprising:

a wedge comprising a fluid intake; and

a fluid engine located external to the wedge and located in a fluid path between the fluid intake and a fluid exhaust,

wherein the wedge comprises at least upper and lower surfaces, the upper and lower surfaces angled with respect to each other by at least approximately 15°, and

wherein the wedge is shaped to receive a fluid flow in the fluid intake; and

inserting the wedge into a body of water.

15. The method as claimed in claim 14, further comprising placing the lower surface of the wedge approximately flush to a bottom surface of the body of water.

16. The method as claimed in claim 14, further comprising placing the fluid exhaust above a water level of the body of water.

17. The method as claimed in claim 14, further comprising placing the fluid exhaust in a body of water remotely from the wedge.

18. The method as claimed in claim 14, further comprising placing the fluid engine on land.

19. The method as claimed in claim 14, further comprising providing a platform above the body of water and placing the fluid engine on the platform.

20. The method as claimed in claim 14, wherein the wedge further comprises at least two sides connected to the upper surface and extending above the upper surface.

21. The method as claimed in claim 14, wherein at least a portion of the fluid path inside the wedge is approximately vertical.

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