

Fluid Pumping Apparatuses Powered By Waves Or Flowing Currents

Field of Invention

[001] The present invention relates to fluid pumps and their applications in extracting energy from waves or flowing currents. The fluid pumps are suitable for pumping water or air to drive a fluid motor or a turbine.

Background

[002] Wave powered devices for extracting energy from wave action generally use a float to actuate a pump. Most of these known devices use a complex system of piping and valves.

[003] Therefore, there exists a need for other wave powered devices that are simple in design with the aim of lowering the cost of energy conversion from renewable wave forces or water currents.

Summary

[004] The following presents a simplified summary to provide a basic understanding of the present invention. This summary is not an extensive overview of the invention, and is not intended to identify key features of the invention. Rather, it is to present some of the inventive concepts of this invention in a generalised form as a prelude to the detailed description that is to follow.

[005] In one embodiment, the present invention provides a fluid pump mechanism comprising: a first inlet that allows fluid to enter into a piston chamber on one side of a piston, which is disposed to translate inside said piston chamber; a second inlet that allows fluid to enter into a second chamber, which is fluidly in communication with an opposite side of said piston; and an outlet that alternately receives fluid from said piston chamber and said second chamber when said piston and its piston rod are driven according to rising and falling waves or flowing currents.

[006] In another embodiment, the present invention provides a pumping mechanism comprising: a first inlet that allows fluid to enter into a piston chamber on one side of a piston, which is disposed to translate inside said piston chamber; a second inlet that allows fluid to enter into said piston chamber on an opposite side of said piston; an outflow chamber in fluid communication with said opposite side of said piston; and an outlet that alternately receives fluid from said piston chamber and said outflow chamber when said piston is driven according to rising and falling waves or flowing currents.

[007] In yet another embodiment, the present invention provides a pumping mechanism comprising: a piston disposed to reciprocate inside a piston chamber; an outflow chamber in fluid communication with a piston rod side of said piston chamber; an inlet plate and a valve plate cooperating to allow fluid to enter into said piston chamber according to partial vacuum generated by said piston or to prevent fluid from flowing out from said piston chamber according to increased fluid pressure generated by said piston; and an outlet that alternately receives fluid from said piston chamber and said outflow chamber when said piston and piston rod are driven according to rising and falling waves or flowing currents.

[008] The above pumping mechanisms are suitable for pumping water and/or air to drive a fluid motor M or a turbine T, which in turn operates a generator G to produce electricity. Each inlet or outlet of each pump mechanism is controlled by a flap or a ball, whilst the piston or piston rod is driven by a float, a laterally oscillating pontoon, an oscillating paddle, an impeller, a vertical rotary wheel or a pendulum member.

Brief Description of the Drawings

[009] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0010] FIGs. 1A and 1B illustrate a pump mechanism according to embodiments of the present invention;

[0011] FIGs. 2A and 2B illustrate a pump mechanism according to another embodiment of the present invention;

[0012] FIGs. 3A, 3B and 3C illustrate double-piston pump mechanisms according to other embodiments of the pump mechanism shown in FIG. 1A;

[0013] FIGs. 4A and 4B illustrate a pump mechanism according to another embodiment of the present invention;

[0014] FIGs. 5A and 5B illustrate a pump mechanism according to another embodiment of the present invention;

[0015] FIGs. 6A and 6B illustrate a pump mechanism according to another embodiment of the present invention;

[0016] FIGs. 7A and 7B illustrate pumping systems for use with any one of the above embodiments according to the present invention;

[0017] FIGs. 8A-8F illustrate yet other pumping systems for use with any one of the above embodiments according to the present invention;

[0018] FIG. 8G illustrates two sections of an aerofoil vane shown in FIG. 8F; and

[0019] FIG. 9 illustrates a network of the above pumping system.

Detailed Description

[0020] One or more specific and alternative embodiments of the present invention will now be described with reference to the attached drawings. It shall be apparent to one skilled in the art, however, that this invention may be practised without such specific details. Some of the details may not be described at length so as not to obscure the invention. For ease of reference, common reference numerals or series of numerals will be used throughout the figures when referring to the same or similar features common to the figures.

[0021] FIGs. 1A and 1B show a fluid pump 100 according to an embodiment of the present invention. As shown in FIGs. 1A and 1B, the pump 100 has two chambers 102, 104, which are fluidly communicated at channel 106. In the chamber 102, a piston 120 is arranged to reciprocate as its piston rod 122 is actuated by a float 110. As seen in FIG. 1A, when the float 110 moves up as a rising wave passes, it pushes the piston 120 upward and resulting

dynamic flow of the fluid closes a flap 130 at an inlet 150. At the same time, fluid pressure on the lower side of the piston 120 becomes lower and it causes fluid to flow through an inlet 152 into the chamber 104 and then into the piston chamber 102 through the channel 106. The dynamic flow of the fluid near the inlet 150 and partial pressure at the inlet 152 cause a flap 134 at an outlet 160 to flip over to chamber 104 to prevent fluid from flowing back into the chamber 104. As a result, fluid is pumped in through the inlet 152 in an up stroke of the piston 120 and the fluid taken in through the inlet 150 is pumped out through the outlet 160.

[0022] As seen in FIG. 1B, when the float 110 moves down a trough of a passing wave, it pulls the piston 120 downward and partial vacuum generated at the inlet 150 causes the flap 130 to open. At the same time, fluid pressure on the lower side of the piston 120 becomes higher and it causes fluid to flow through the channel 106 into the chamber 104. The dynamic flow of the fluid in the chamber 104 closes the flap 132 at the inlet 152 but causes the flap 134 at the outlet 106 to flip over to chamber 102 to prevent fluid from flowing back into the chamber 102. As a result, fluid is pumped in through the inlet 150 in a down stroke of the piston and fluid taken in through the inlet 152 is pumped out through the outlet 160. In this manner, as seen in FIGs. 1A and 1B, fluid is pumped in through the inlets 150, 152 but out through the outlet 160 in a double acting manner as the piston 120 is reciprocated inside the piston chamber 102 as it is actuated by the rising and falling of the float 110.

[0023] In one embodiment of the pump 100, each flap is actuated to its closed position by a light spring force, for example by a torsion spring, such that the dynamic flow of the fluid over the flap generates a force that is larger than the spring force. In another embodiment, a piston stopper ring 129 is provided in the piston chamber 102. The piston stopper ring 129 is useful to prevent over-travel of the piston 120 and thus to prevent the inlet flaps 130, 132 from being damaged during operation of the pump 100.

[0024] FIGs. 2A and 2B show a pump 100a according to another embodiment of the present invention. Pump 100a is similar to the above pump 100 except that the flaps are now configured as balls 130a, 132a, 134a. The balls 130a, 132a, 134a are guided in their

respective places by a net or mesh 136. The balls are dimensioned so that they are operable to close or open respective inlet 150, 152 and outlet 162, 163 according to pressure or partial vacuum generated by the piston 120, and fluid is thus pumped through the outlets 160 in a double acting manner.

[0025] FIG. 3A shows a pump 100b according to another embodiment of the present invention. As shown in FIG. 3A, the pump 100b is similar to the pump 100 except that there is another piston 124 arranged to reciprocate inside the chamber 104 and that the two piston rods 122 are connected by a link bar 170. As shown, the link bar 170 is pivoted about axis 171 whilst the piston rods are slidable along respective slots 172, 174 in the link bar 170. Preferably, the slots 172, 174 are equidistant from the pivot axis 171, and the pistons 120, 124 and piston rods 122 are of the same respective sizes so that displacements at the rod side of the two pistons 120, 124 are the same and fluid flow between the chambers 102 and 104 through the channel 106 allows the two pistons 120, 124 to synchronise. Whilst not shown, the pump 100b can be similar in construction to the pump 100a according to another embodiment.

[0026] FIG. 3B shows a pump 100c according to another embodiment of the present invention. As shown in FIG. 3B, the pump 100c is similar to the pump 100b except that the two pistons 120, 124 are connected by a pulley 175 and rope 177 system or sprocket 175 and chain 177 system instead of the link bar 170.

[0027] FIG. 3C shows a pump 100d according to another embodiment of the present invention. As shown in FIG. 3C, the pump 100d is similar to the above pump 100b or 100c in that there are two pistons except that the piston rods extend in opposite directions to each other and that the piston rods are connected to an actuating frame 180. The actuating frame 180 is connected to a float 110 by a rod 111. Whilst not shown, the actuating frame 180 is guided to translate linearly as it is actuated by the float 110 according to the rising and falling of waves, and fluid is pumped out through the outlet 160 in a double acting manner.

[0028] FIG. 4A shows a pump 100e according to another embodiment of the present invention. As shown in FIG. 4A, the pump 100e has three chambers, an inner chamber 102 and two outflow chambers 105. In the inner chamber 102, a piston 120 is arranged to reciprocate as its piston rod 122 is actuated by a float 110 when the float rides on a rising and falling wave. The inner chamber 102 also has two inlet ports, 151a, 151b, with each being disposed at opposite ends of the inner chamber 102. As shown in FIG. 4A, when the float 110 is moved upwards as a rising wave passes, it creates a partial vacuum below the piston 120 and a flap 151c at the inlet port 151a opens. At the same time, as the piston 120 is pushed upwards, fluid flow closes a flap 151d at the second inlet 151b but flips flaps 134 over to chambers 105 so that fluid is pumped out through an outlet 160.

[0029] FIG. 4B shows a pump 100f similar in construction as pump 100e but with the flaps being configured as balls. FIGs. 4A and 4B share the same or similar features and reference numerals and FIG. 4B is also used to illustrate operation of the pump 100e with the piston acting in the downward direction. As shown in FIG. 4B, when the piston 120 is moved downwards, partial vacuum above the piston 120 is created and as a result, the upper inlet port 151b becomes opened. The pressure below the piston 120 is increased and lower inlet port 151a becomes closed whilst ports 154 become opened. As a result, fluid flows through the outflow chambers 105 and the balls 134a near the outlet 160 are shifted to allow the fluid to flow out through the outlet 160. In this manner, fluid taken in through the inlet 151a is pumped out of the outlet 160 through the outer channels 105.

[0030] FIGs. 5A and 5B show a pump 100g according to another embodiment of the present invention. As shown in FIGs. 5A and 5B, the pump 100g has a piston chamber 102 and an outflow chamber 105. The piston chamber 102 has two inlet ports 151a, 151b, with each being disposed on opposite ends of the piston chamber 102. As shown in FIG. 5A, when the float 110 pushes the piston 120 upwards, inlet port 151a becomes opened whilst the inlet port 151b is closed. At the same time, a flap 134 at an outlet 160 is flipped over to chamber 105 so that water is pumped out through the outlet 160. Operation of the pump 100g with the float 110 pulling the piston 120 downward is illustrated with the pump shown in FIG. 5B: As the piston 120 is moved downward, partial vacuum is created above the piston 120 and the inlet port 151b becomes opened. At the same time, pressure below the piston 120 is

higher and the inlet port 151a becomes closed; thus, water is pumped out through the channel 106 and the outflow chamber 105 to the outlet 160. As shown in FIG. 5B, the ball 134a at the outlet 160 is shifted to close the piston chamber 102 but it allows water to flow from the outflow chamber 105 out through the outlet 160. As in the above embodiments, the pump 100g is operable in a double acting manner.

[0031] FIGs. 6A and 6B show a pump 100h according to another embodiment of the present invention. The pump 100h is similar in construction to the above pump 100g except that the inlet ports are configured along a side of the piston chamber 102 with an inlet plate 190 and a valve plate 195. As shown in FIGs. 6A and 6B, the inlet plate 190 has a plurality of holes 191; in each hole 191 is disposed a ball 192. As seen in FIGs. 6A and 6B, the left hand side of each hole 191 is conical in shape. The right hand side of the inlet plate 190 is in contact with the valve plate 195, which has a plurality of holes 196 that are offset from the associated holes 191. In use, when the balls 192 in the respective holes 191 are pushed outward by positive pressure in the piston chamber 102, each ball 192 contacts the respective conical end to form a seal. When the balls 192 are pulled inward by suction pressure in the piston chamber 102, each ball 192 is moved to the right and contacts the valve plate 195 but the holes 196 on the valve plate 195 allow fluid flow into the piston chamber 102. With flipping of the flap 134, water is pumped out through the outlet 160 from the piston chamber 102 or outflow chamber 105.

[0032] As shown in the above figures, the pumps 100, 100a-100h of the present invention provide double acting pump mechanisms when the piston reciprocates inside the piston chamber 102 as the piston 120 is driven by a float 110 according to rising and falling waves. These pumps 100, 100a-100h are operable to pump air or water. As seen in the above figures, when the pump mechanisms are above the waves, they are suited to pump air. When the pump mechanisms are inverted so that they are submerged under water, they become suited to pump water. For example, FIG. 7A shows a submerged pump 100 being operable to pump water to an elevated storage tank 702. Water from the storage tank 702 is channeled to rotate a fluid motor M or a turbine T, which in turn rotates a generator G (not shown in FIG. 7A) to produce electricity. FIG. 7B shows a pump 100 being disposed above the water level and is operable to pump air to drive a turbine T and a generator G. As shown

in FIG. 7B, the air supply line near the turbine T has an accumulator A and a flow control valve 705. The accumulator A and flow control valve 705 help to regulate air flow rate to the turbine T to maintain a more constant speed of the generator G. A plurality of pumps 100, 100a-100h can be connected in parallel, as shown in FIG. 9, to supply water to the elevated storage tank 702 or to supply compressed air to the turbine T or fluid motor M.

[0033] FIG. 8A shows a pump system 200a according to another embodiment of the present invention. The pump system 200a includes a pump 201, which is similar in construction to the above pump 100b except that each end of the piston rods 122 terminates with a roller 273. An T-shaped actuator bar 270 is pivoted at 271 to the body of the pump 201 such that when the float 110 is pushed up and down by wave forces, the actuator bar 270 oscillates about pivot 271 and, in turn, reciprocates pistons 120. As a result, fluid (air or water) enters through inlets 150, 152 and fluid is pumped out through outlet 160 in a double acting manner. The fluid from the outlet 160 is then channeled to drive a turbine T or fluid motor M, which in turn drives a generator G to produce electric power.

[0034] FIG. 8B shows a pump system 200b according to another embodiment of the present invention. The pump system 200b includes any one of the above pumps 100, 100a-100h. As shown in FIG. 8B, the pistons 120 of two pumps 100 are interconnected but are linked to a floating structure or pontoon 210. The floating structure/pontoon 210 is constrained to oscillate laterally with respect to the pump system 200b. A lower part of the floating structure/pontoon 210 that is submerged in a body of water has vanes 211 such that when the floating structure 210 is oscillated laterally by wave forces, it reciprocates the two pistons 120. In this way, fluid (air or water) is pumped in a double acting manner from the outlets 160 of the pumps to drive a turbine T or fluid motor M, which in turn drives a generator G to produce electric power.

[0035] FIG. 8C shows a pump system 200c according to another embodiment of the present invention. As shown in FIG. 8C, the pump system 200c is built on a floating pontoon 212. The pump system 200c includes any one of the above pumps 100, 100a-100h. A paddle 213 is pivoted on the pontoon 212 such that when under-currents oscillate the paddle 213, it reciprocates two pistons 120 and fluid (air or water) is then pumped in a double acting

manner through the outlets 160 to drive a turbine T or fluid motor M, which in turn drives a generator G to produce electric power.

[0036] FIG. 8D shows a pump system 200d according to another embodiment of the present invention. As shown in FIG. 8D, the pump system 200d includes two or more of the above pumps 100, 100a-100h. The pump system 200d has an impeller 214 mounted on an underside of a horizontal, rotary wheel 215. On the topside of the rotary wheel 215, there is a crank pin or shaft 216 that is located at a radius R from the centre of the rotary wheel 215. As shown in FIG. 8D, two piston rods of pumps 100 are separately connected to the crank shaft 216 through two link bars 217. The impeller 214 is made up of a plurality of aerofoil sections disposed around the periphery of the rotary wheel 215. When the impeller 214 is submerged or partially submerged in a body of flowing currents, the impeller 214 rotates. Rotation of the rotary wheel 215 reciprocates the pistons 120 in the respective piston chambers 102. With the pump system 200d, operation of the pistons 120 in the pumps 100 conveys fluid (water or air) out through the respective outlets 160 in a double acting manner to drive a turbine T or fluid motor M, which in turn drives a generator G to produce electric power.

[0037] FIG. 8E shows a pump system 200e according to another embodiment of the present invention. As in the above pump systems, the pump system 200e includes two or more of the above pumps 100, 100a-100h. The pump system 200e has a vertical, rotary wheel 218. The rotary wheel 218 has a plurality of peripheral cups 219 and it is partially submerged in a body of running water so that some of the cups 219 catch the running currents and cause the rotary wheel to rotate. As in the above embodiment, the pistons 120 of two pumps 100 are connected separately to a crank shaft 216 on the rotary wheel 218 by link bars 217. Rotation of the rotary wheel 218 is translated to reciprocal movements of the pistons 120 and water is thus pumped out through the outlet 160 of each pump 100 in a double acting manner to drive a turbine T or fluid motor M, which in turn drives a generator G to produce electric power.

[0038] FIG. 8F shows a pump system 200f according to yet another embodiment of the present invention. As shown in FIG. 8F, the pump system 200f has a pendulum member 220

that is operable to oscillate about pivot 221. A counter weight W is provided on an upper part of the pendulum member 220 to reduce the torque required to oscillate it. The lower edge of the pendulum member has a curved rake 230, which is in engagement with a gear 233. In turn, the gear 233 is in engagement with a linear rake 235, which is mounted on the actuating frame 180 of the the component pump 100d. The face of the pendulum member is lined with aerofoil vanes 223. Each aerofoil vane 223 is made up of a leading aerofoil section 223a and a trailing aerofoil section 223b. As shown in FIG. 8G, each leading aerofoil section 223a is fixed with respect to the face of the pendulum member 220 but the trailing section 223b is pivotable about an axis 225 by a toggle bar 227. In use, when water currents flow through the face of the pendulum member 220, a lifting force is generated at each aerofoil vane 223 in relation to the direction of the aerofoil trailing section 223b and the pendulum member 220 swings to one side. At the end of each swing, the pendulum member 220 hits an adjustable stopper (not shown in FIG. 8F or 8G), which then toggles the toggle bar 227; as a result, the toggle bar 227 turns each trailing section 223b to a second direction opposite from its first direction. In effect, the lifting forces on the vanes 223 change direction and swing the pendulum member 220 in a reverse direction. The swinging of the pendulum member 220 causes the gear 233 to turn, which in turn causes the actuating frame 180 of the pump 100d to oscillate and fluid is thus pumped from the outlets 160 to drive a fluid motor M/turbine T and a generator G to produce electric power.

[0039] In the above pump systems 200b-200f, only one set of pumps is illustrated. It is possible that another set of pumps is provided such that one set of pumps is operable to pump water whilst the other set pumps air.

[0040] While specific embodiments have been described and illustrated, it is understood that many changes, modifications, variations and combinations thereof could be made to the present invention without departing from the scope of the invention. For example, FIG. 9 shows a plurality of one or more of the above pumps 100, 100a-100h that are connected in a network, for instance, to a turbine T. It is also possible that the electric power generated by the above pumping systems 200a-200f are connected through a controller before power is supplied, for example, to the electricity grid system.

CLAIMS:

1. A fluid pump mechanism comprising:
a first inlet that allows fluid to enter into a piston chamber on one side of a piston, which is operable to reciprocate inside said piston chamber;
a second inlet that allows fluid to enter into a second chamber, said second chamber being disposed laterally adjacent to said piston chamber and which is fluidly in communication with an opposite side of said piston; and
an outlet that alternately receives fluid from said piston chamber and said second chamber when said piston and its piston rod are driven according to rising and falling waves or flowing currents.
2. A fluid pump mechanism according to claim 1, wherein each said inlet or outlet is controlled by a flap.
3. A fluid pump mechanism according to claim 1, wherein each said inlet or outlet is controlled by a ball.
4. A fluid pump mechanism according to any one of the preceding claims, further comprising a second piston, which is operable to translate in said second chamber.
5. A fluid pump mechanism according to claim 4, wherein piston rods of said piston and said second piston are connected by a link bar.
6. A fluid pump mechanism according to claim 5, wherein said link bar is T-shaped and each end of said piston rods terminates with a roller, which is contiguous with said T-shaped link bar.
7. A fluid pump mechanism according to claim 4, wherein said piston and said second piston are connected by a rope-pulley or chain-sprocket system.

8. A fluid pump mechanism according to claim 4, wherein said piston rods extend in directions opposite to each other and said piston rods are connected to an actuating frame.
9. A fluid pump mechanism comprising:
a first inlet that allows fluid to enter into a piston chamber on one side of a piston, which is operable to reciprocate inside said piston chamber;
a second inlet that allows fluid to enter into said piston chamber on an opposite side of said piston;
an outflow chamber being disposed laterally adjacent said piston chamber and which is in fluid communication with said opposite side of said piston; and
an outlet that alternately receives fluid from said piston chamber and said outflow chamber when said piston is driven according to rising and falling waves or flowing currents.
10. A fluid pump mechanism according to claim 8, wherein said outflow chamber comprises two outflow chambers.
11. A fluid pump mechanism comprising:
a piston disposed to reciprocate inside a piston chamber;
an outflow chamber being disposed laterally adjacent said piston chamber and which is in fluid communication with a piston rod side of said piston chamber;
an inlet plate and a valve plate cooperating to allow fluid to enter into said piston chamber according to partial vacuum generated by said piston or to prevent fluid from flowing out from said piston chamber according to increased fluid pressure generated by said piston; and
an outlet that alternately receives fluid from said piston chamber and said outflow chamber when said piston and piston rod are driven according to rising and falling waves or flowing currents.
12. A fluid pump mechanism according to any one of the preceding claims, where said piston rod is driven by a float.

13. A fluid pump mechanism according to claim 12, wherein said pump mechanism is located above said float so that air is pumped to drive a fluid motor M or turbine T, which in turn, operates a generator G to produce electric power.
14. A fluid pump mechanism according to claim 12, wherein said pump mechanism is located below said float so that water is pumped to drive a fluid motor M or turbine T, which in turn, operates a generator G to produce electric power.
15. A fluid pump mechanism according to any one of claims 1-11, wherein said piston rod is driven by a laterally, oscillating pontoon.
16. A fluid pump mechanism according to any one of claims 1-11, wherein said piston rod is driven by an oscillating paddle, which is pivoted on a pontoon.
17. A fluid pump mechanism according to any one of claims 1-11, wherein said piston rod is driven by a crank pin disposed on a rotary wheel.
18. A fluid pump mechanism according to claim 17, wherein said rotary wheel is horizontally disposed and it is driven by an impeller, which is made up of aerofoil vanes disposed on a peripheral underside of said rotary wheel.
19. A fluid pump mechanism according to claim 17, wherein said rotary wheel is vertically disposed and it is driven by cups disposed on a periphery of said rotary wheel.
20. A fluid pump mechanism according to claim 8, wherein said piston rods and said actuating frame are driven by a gear, which is operated by an oscillating pendulum member.
21. A fluid pump mechanism according to claim 20, wherein a face of said oscillating pendulum structure has a plurality of aerofoil vanes, with each of which comprising a leading section and a pivotable trailing section.

22. A fluid pump mechanism according to claim 21, wherein said pivotable trailing sections are toggled in either of two positions by a toggle bar linking said trailing sections.

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Abstract

[0041] The present invention describes several fluid pumping apparatuses (100, 100a-100h) and their applications (200a-200f) in extracting energy from waves or flowing currents. The pumping apparatuses (100, 100a-100h) are driven by a float (110), an oscillating pontoon (210), an oscillating paddle (213), an impeller (214), a vertical rotary wheel (218) or a pendulum member (220). The pumped fluid (water and/or air) is supplied to drive a fluid motor M or a turbine T, which in turn operates a generator G to produce electric power.

[0042] FIG. 2A for publication.