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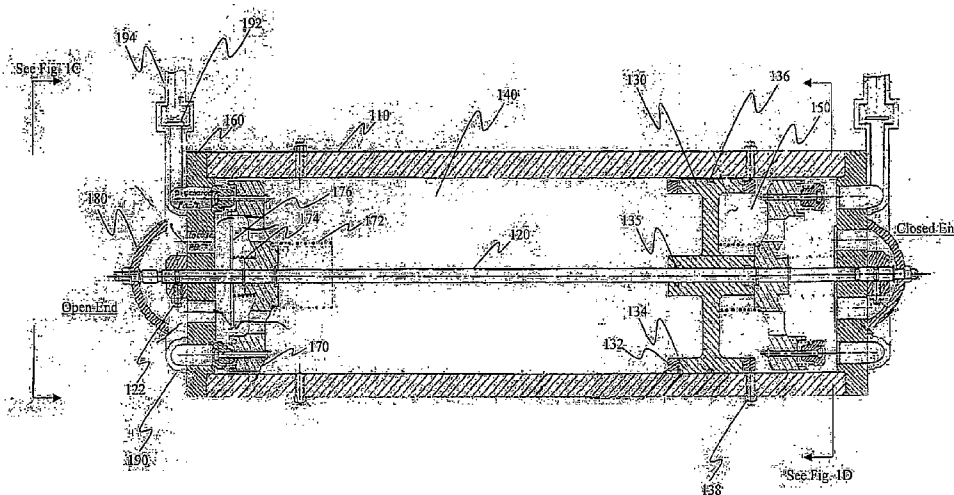
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(54) Title: POSITIVE DISPLACEMENT HYDRO PUMP



(57) Abstract: A pressure-powered liquid pump is provided which includes a housing having opposite ends and configured to allow an actuator to move along a center axis. The pump also includes a first and second intake assembly, as well as a first and second discharge assembly, coupled to the actuator and respectively proximate to the opposite ends of the housing. At least one discharge conduit is coupled to the housing and extends to an atmosphere external to the liquid. The pump also has a piston configured to slide along the actuator so as to create a first chamber having a first variable pressure, and a second chamber having a second variable pressure. A method is also provided and includes the steps of submerging and maintaining the pump at an optimal depth, so as to create an inversely proportional oscillation between the first variable pressure and the second variable pressure.

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5 **POSITIVE DISPLACEMENT HYDRO PUMP**

 This application claims the benefit of U.S. Provisional Application No. 60/817,983, filed June 30, 2006, and entitled Positive Displacement Hydro Pump, and which is incorporated herein by reference in its entirety.

10 **DISCLOSURE DOCUMENT INCORPORATED BY REFERENCE**

 This application claims all benefits of Disclosure Document Number 556374, entitled "Lyons Hydro Motor," by inventor Norman V. Lyons, which was received by the United States Patent and Trademark Office on July 6, 2004, and which is fully and completely incorporated herein by reference.

15 **FIELD OF THE INVENTION**

 This invention generally relates to the pumping of liquids from one location to another for various purposes, and more particularly, to a positive displacement hydro pump for pumping liquids from a region of high pressure to a region of low pressure.

BACKGROUND

20 Pumps are used to move liquids from one location to another, such as liquids residing in a state of rest or near rest such as in tanks, reservoirs, lakes, and the like. The term "liquid" will be used hereafter to represent any other liquid for which the pump may be useful (water, oil, and the like). Consequently, the term "hydro" will have the same connotation. The resultant flow of liquid generated by the Lyons hydro motor pump
25 ("Lyons hydro motor") can be used for many purposes, e.g., water to a residential or commercial building, irrigation, generation of electricity, and the like.

 Currently there are many ways of creating electricity. A great majority utilize non-renewable energy sources, such as natural gas, oil, coal, and the like, to supply power to turbines which turn generators that produce electricity. This results in worldwide
30 pollution of many sorts. Other methods such as wind and solar do not pollute as much but are subject to the uncertainties of nature and location limitation, availability. Hydropower electric generation facilities, while considered by many as being highly environmentally friendly, require the use of huge amounts of water from dams and reservoirs. This often

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5 results in wasted water, damage to fish populations and shortages of domestic and irrigation water. New dams are not likely to be constructed for many years. Other methods utilizing water wave action, water wheels, diaphragms, etc., limit location and have other restrictive constraints.

Atomic energy presents a multitude of potential catastrophic consequences in case
10 of failure and waste disposal. It has also presented a multitude of possible catastrophic consequences involving radiation, meltdown and waste disposal. New plants are not likely to be built for many years, if then. In some installations "waste" water is stored in a reservoir below the dam until "off peak" hours (the lower electricity demand hours). It is then pumped back up to the original source by energizing the generators, which then
15 become motors that drive huge pumps. This practice is inefficient and in fact costly, due to the added cost of electricity and increased maintenance of the generators. It would therefore be desirable to provide a hydro pump that can be used to generate electricity.

SUMMARY OF THE INVENTION

The present invention solves the aforementioned problems by providing a method
20 and apparatus for efficiently pumping liquids

In one embodiment, a pressure-powered liquid pump is provided. Within this embodiment, the liquid pump is submerged in a liquid and includes a cylindrical housing having opposite ends and a center axis perpendicular to the opposite ends. The liquid pump further includes an actuator configured to move along the center axis. The liquid
25 pump also includes a first and second intake assembly coupled to the actuator and respectively proximate to the opposite ends of the housing, as well as a first and second discharge assembly which are also coupled to the actuator and respectively proximate to the opposite ends of the housing. For this embodiment, at least one discharge conduit is coupled to the housing and extends to an atmosphere external to the liquid. The liquid
30 pump has a piston coupled to the actuator and configured to slide along the actuator so as to create a first chamber within the housing having a first variable pressure, and a second chamber within the housing having a second variable pressure, such that the first variable pressure and the second variable pressure vary according to the positioning of the piston along the actuator.

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5 In another embodiment of the invention, a method for pumping liquid is provided. This method includes submerging a cylindrical housing in a liquid. The cylindrical housing for this method has opposite ends and a center axis perpendicular to the opposite ends, such that an actuator is configured to move along the center axis. A first and second intake assembly is coupled to the actuator and respectively proximate to the opposite ends of the housing. A first and second discharge assembly are also coupled to the actuator and respectively proximate to the opposite ends of the housing. The housing also includes at least one discharge conduit which extends to an atmosphere external to the liquid. Within this embodiment, a piston is coupled to the actuator and configured to slide along the actuator so as to create a first chamber within the housing having a first variable pressure, and a second chamber within the housing having a second variable pressure. And finally, the method also includes the step of maintaining the cylindrical housing at an optimal depth, so as to create an oscillation between the first variable pressure and the second variable pressure, such that the first variable pressure and the second variable pressure oscillate inversely proportional to each other.

20 These and other aspects, features, and advantages of the present invention will become apparent from a consideration of the following specification and the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

25 Figure 1A is a cross-sectional schematic of a hydro pump showing an open end and a closed end in accordance with the present invention.

 Figure 1B is a cross-sectional schematic of a hydro pump illustrating a transitional stroke in accordance with the present invention.

 Figure 1C is an external cross-sectional end-view of a hydro pump in accordance with the present invention.

30 Figure 1D is an internal cross-sectional end-view of a hydro pump in accordance with the present invention.

 Figure 2 is a three-dimensional illustration of a hydro pump in accordance with the present invention.

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5 Figure 3 is a cross-sectional schematic of a hydro pump with an anti-stall spring in accordance with the present invention.

DETAILED DESCRIPTION

One embodiment of the present invention provides a hydro motor pump that does not require, consume or utilize external fuel of any kind. Instead, the hydro motor pump is energized by the weight of the water in which it is submerged. This 'latent' energy expressed as pounds per square inch (PSI) exists at all levels of water everywhere water exists on earth. The PSI increases by approximately .434 PSI per foot of depth and exerts that force in all directions from any given point. By harnessing the pressurized force of the surrounding water, the hydro motor pump provides a pollution-free solution that conserves water and may enhance electrical generation, irrigate land, and provide many other benefits.

The hydro motor pump essentially captures the pressure (PSI) of surrounding water, causing it to bear against a piston, which is free to slide longitudinally inside a tube (the pump housing). A conduit of smaller diameter than the tube is rigidly attached to the end of said housing, and is directed upward to and beyond the surface of the water in which the piston and its housing are submerged. Thus, the liquid in such conduit is exposed only to atmospheric pressure at its uppermost end, not submergence depth pressure.

The piston, having a seal against the inside surface of the tubular housing, divides the housing into two chambers. One chamber of the pump housing therefore is subjected to X PSI at the level in the liquid at which the pump is submerged, and the other chamber to a lesser Y PSI, as the smaller conduit contains only a small amount of water and is open to the atmosphere. This creates an unbalanced pressure condition and the piston is urged by the greater depth pressure to move axially along the cylinder thus expelling the water in the lower pressure chamber up through and out of the smaller conduit.

The foregoing design elements may be embodied in the pump design together with other features to facilitate making the hydro motor pump a double-stroke pump where the piston is made to reverse direction at the end of its travel toward the discharge conduit.

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5 *Definitions of terms:*

10 Pump Housing: The tubular component having other components contained therein or attached to it. It may or may not contain discharge ports (see pump housing end caps).

15 Actuator Shaft: The longitudinally oriented rod shaped component extending beyond the pump housing. It is located along the axis of the cylindrical housing bore. The two intake valves and the two discharge valve assemblies are attached to the shaft such that all must move in unison.

20 Discharge Slide Valve Assembly: The plate-like assembly having openings through which liquid within the housing may pass freely. It is firmly attached to the actuator shaft. When Closed, liquid within the pump is prevented from being discharged through the discharge ports. The anti-stall spring is retained by, and attached to, the inside face of the slide valve body.

25 Actuator Shaft Restraint Device: This device provides a means for temporarily holding the actuator shaft from lateral movement until the anti-stall spring has been completely compressed. This device may be magnetic, a spring loaded detent assembly, a friction device, a cam device or any combination thereof.

30 Housing End Cap: A plate- or dome-like device that is removable, and fastened to each end of the housing. Openings are provided through which intake liquid must pass. An intake check valve or multiple check valves oriented to allow the entry but not the exit of liquid are located in this component. Discharge ports may also be located in this component separately or in combination with other discharge ports located elsewhere.

35
40 Detents Detents (e.g., "spring plungers") can include devices having spring loaded balls or plungers. Common usage includes holding components temporarily in place. The amount of force required to release the detent plunger is adjustable within predetermined ranges.

45 In one embodiment, the pump housing is a basic device formed from a metal cylinder with openings on each end. A piston is centered on an actuator shaft which runs

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5 the length of the cylinder. A water-tight "cap" is attached to each end of the shaft. When one "cap" is open, i.e. away from the cylinder, the other end is closed. Water enters the open end and pushes the piston to the other end. This forces the water in the cylinder up through a separate discharge port at the closed end. In the process, it automatically closes the open end and the process repeats itself with the piston moving in the other direction.

10 The hydro pump may be considered to be a double-action, positive displacement type of pump. It is actuated by latent energy existing at all depths of a liquid due to the weight of that liquid; e.g., water weighs 62.425 pounds per cubic foot (ref. Machinery Handbook, 26th ed.). The pressure at any given depth exists in all directions. This description will use water and its weight as representing any liquid hereafter. A special
15 "priming" technique may not be required. Lowering the pump to a pre-determined submergence depth will start it.

The cylindrical (tube-like) housing is divided into two chambers by a movable piston, and is fitted with certain devices integral with the pump body as well as devices within and exterior to the pump housing. These devices, described below, are strategically
20 arranged such that the resulting functional interaction results in a double stroke, submergence pressure actuated pump. The pump causes the liquid in which it is submerged to be extruded through the discharge ports located at opposite (both) ends of the pump body. This is accomplished by utilizing the latent energy created by the weight of the liquid in which the pump is submerged. No other fuel or other energy source is
25 required. However, electrical/electronic methods of monitoring/ controlling or otherwise recording functional and empirical data are probably desirable.

The hydro pump is capable of operation in still liquid(s), and unlike conventional hydro generators, does not require rapidly flowing liquids to operate. It should be noted that the terms "hydro" and "liquid" as used herein are to be considered synonymous. The
30 term "still" also does not preclude flowing liquids as may be encountered in lakes, reservoirs, and the like.

The hydro pump is actuated by the latent energy that exists due to the weight of the liquid in which it is submerged. For example water weighs approximately 62.425 pounds per cubic foot. (Reference Machinery Handbook, 26th Edition.) The latent energy

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5 expressed as pound per square inch (PSI) at any given depth exists in all directions from any given point. The pressure (PSI) increases by approximately .434 PSI per foot of depth. The hydro pump captures that pressure (PSI) by causing it to bear against a piston which is free to move longitudinally inside a cylinder (the pump body.) The piston essentially divides the cylinder into two chambers. The inlet chamber is subjected to a
10 much greater pressure (PSI) than the discharge chamber. The movement of the piston toward the discharging end of the pump forces the liquid ahead of it out through discharge ports located at the end of the chamber. Such ports having a conduit directed upward and extending above the liquid surface and open to atmosphere at its uppermost end. Provisions to reverse the piston travel to accomplish a "double stroke" action are provided
15 as an integral part of the design.

In Figures 1A-1D, various cross-sectional schematics are provided showing a hydro pump in accordance with an embodiment of the present invention. In particular, Figures 1A and 1B show cross-sectional schematics of a hydro pump in a non-transitional stroke and transitional stroke, respectively. External and internal cross-sectional end-
20 views of a hydro pump are then respectively provided in Figures 1C and 1D.

As illustrated in Figure 1A, Pump 100 includes Pump Body 110 which is coupled to Actuator Shaft 120, Piston 130, End Caps 160, Discharge Control Valve Assemblies 170, Intake Control Valves 180, and Discharge Manifold 190, as shown.

Pump Body 110 functions as the primary "housing" of Pump 100. In a preferred
25 embodiment, Pump Body 110 is a cylindrical tube shape having a generally smooth diameter-sealing inner surface along which Piston Seal 136 may slide. Pump Body 110 may be of any length, diameter, material, wall thickness, and geometry, as the end use of Pump 100 dictates.

In a preferred embodiment, End Caps 160 are plate-like, multi-function members
30 attached to each end of Pump Body 100. End Caps 160 support Actuator Shaft 120 in its axial position and also provide sealing surfaces for Discharge Control Valve Assemblies 170, Intake Check Valves 176, Intake Control Valves 180, and Discharge Manifold 190. Actuator Shaft Detent Assemblies 122 are also preferably mounted on End Caps 160 as shown.

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5 Meanwhile, Actuator Shaft 120 is coupled to Discharge Control Valve Assemblies 170 and Intake Control Valves 180, as illustrated, so as to open and close these valves in unison. It should, however, be appreciated that this movement occurs only during transitional "strokes" of Piston 130 (i.e, when Piston 130 begins to reverse its direction).

 As illustrated, Intake Check Valve Springs 176 and Reverse Stroke Energizer
10 Springs 172 are also attached to Assemblies 170, wherein a keyway-like guide device is preferably implemented to keep Valve Assemblies 170 in alignment with the seats located in End Caps 160. Reverse Stroke Energizer Springs 172 are preferably retained in an inwardly-facing position toward Piston 130 by Discharge Control Valve Assembly 170. Energizer Springs 172 can have different structural configurations including a single-
15 spring configuration or multiple springs used in a circular pattern. Energizer Springs 172 are compressed by Piston 130 as its mounting allows the use of the shims to achieve precise longitudinal location of the detents installed in this assembly. The spring loaded ball (or plunger) in each detent release pressure is adjustable within predetermined ranges.

 In a preferred embodiment, Intake Control Valves 180 allow water at submergence
20 depth pressure to enter Pump 100 at one end, while keeping water from entering at the other end. Intake Control Valves 180 are secured to Actuator Shaft 120 and are moved to their opposite positions by Actuator Shaft 120. The movement of Actuator Shaft 120 is stopped when either of Intake Control Valves 180 are seated on End Cap 160.

 In a preferred embodiment, Piston 130 is preferably coupled to Piston Seal 136,
25 Piston Stabilizers 134, and Piston Detent Rings 132. Piston 130 may also incorporate an "O" ring seal 135 at the center bore. Piston Seal 136 preferably rests against the inside diameter of Pump Body 110, so as to separate Pump 100 into chambers 140 and 150, as shown. Piston Detent Rings 132 are preferably attached to each face of Piston 130 and do not bear against the inside diameter of Pump Body 110. Within this embodiment, each of
30 Piston Detent Rings 132 has a diametrical-wide groove extending around its circumference which is engaged by Piston Anchor Detents 138 as Piston 130 reaches the end of its travel in either direction. This "wide" groove allows Piston 130 to move a short distance further after the initial engagement, which causes the detents of the Actuator Shaft Detent Assembly 122 to release from their grooves in the Actuator Shaft 120.

5 Multiple detents, such as Piston Anchor Detents 138, may also be placed around the circumference of Pump Body 110. This placement may coincide with the position of Piston Detent Ring 132 during the transition of Piston 130 traveling from one direction to the opposite direction. Here, it should be appreciated that the combined "release force" is greater than that exerted by Reverse Stroke Energizer Springs 172 as it urges Actuator
10 Shaft 120 and its attached components to move. Appropriate design adjustments may nevertheless be made so that Piston 130 may temporarily function as a stationary base causing the Reverse Stroke Energizer Springs 172 to expend its kinetic energy in the desired direction.

15 In operation, the respective pressures within chambers 140 and 150 vary inversely proportional to each other, such that one chamber is subjected to a higher submergence depth pressure, while the other chamber 150 is subjected to a lower pressure due to the weight of the liquid existing in the Discharge Conduit 194. This dynamic causes the entire piston assembly to move back and forth within Pump Body 110 thereby causing the liquid in which Pump 100 is submerged to be alternately expelled into Discharge Manifold 190
20 at each end of Pump 100 and hence to atmosphere. It should also be appreciated that Discharge Manifold Check Valves 192 are preferably installed at each end above Discharge Manifold 190 so as to keep the discharge liquid residing in the Discharge Conduit 194 from returning to the chamber from which it was discharged.

25 The discharge of Pump 100 (i.e., volume (head) and pressure (velocity)) is virtually as unlimited as applications may demand. For instance, a certain size pump designed to create a specific head (flow) and velocity at a specific submergence depth could be submerged to greater depths, substantially increasing the discharge characteristics. Similarly, a large pump submerged to less depth could be substituted. The discharge ports located at each end of the pump body (or end caps) may be merged into a
30 manifold configuration with individual discharge conduits extending to atmosphere. Such plumbing should include a check valve near the manifold. The discharge conduit size, tube, bends, etc., will impact the head and pressure, friction loss, and the like.

In order to better illustrate the dynamic nature of the present invention, a step-by-step operational narrative is now provided according to a preferred embodiment, wherein
35 Figures 1A and 1B should be used as references. Within such embodiment, Pump 100

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5 begins to operate as it is lowered to its designed submergence depth. However, to prevent possible damage to Piston Seal 136, chambers 140 and 150 should each be filled with water. This can be accomplished by cycling Pump 100 manually when beginning to submerge it. Intake Control Valve 180 should be fully seated and Actuator Shaft Detent Assembly 122 should be engaged with Actuator Shaft 120. Installing a shut-off valve in
10 one of the Discharge Conduits 194 is also recommended.

Upon being lowered to its designed depth, water begins to enter the left-hand (LH) chamber 140 through the open Intake Control Valve 180 and Intake Check Valve 176, as well as the openings in the Discharge Control Valve Assembly 170. At this point, Piston 130 has been pushed to the right-hand (RH) end of chamber 140. As Piston 130
15 approaches the Discharge Control Valve Assembly 170 it compresses the Piston Detent Ring 132 and engages the Piston Anchor Detent 138. The Actuator Shaft Detent Assembly 122 at both ends of Actuator Shaft 120 holds Discharge Control Valve Assemblies 170, Actuator Shaft 120, and Intake Control Valves 180 in place as the compression and engagement take place. During this time, water in the RH chamber 150
20 discharges through the ports in End Cap 160, then into the Discharge Manifold 190, and then into the atmosphere via Discharge Conduit 194. (Note: If Pump 100 has a ten inch diameter piston and is submerged to a depth of fifty feet, the force against the piston would be approximately 1,704 pounds. However, a discharge conduit having a two inch diameter which extends three hundred feet above the pump (i.e., two hundred feet above
25 the surface of the water), and is open to the atmosphere, only contains approximately 408 pounds of water.)

Meanwhile, Piston 130 slides along the Actuator Shaft 120, which is attached to Discharge Control Valve Assemblies 170 and Intake Control Valves 180 (Note: Discharge Control Valve Assemblies 170 and Intake Control Valves 180 are preferably
30 shim adjustable to compensate for cumulative machining tolerance build-up and proper timing of events). The recessed area of Piston Detent Rings 132 allows Piston 130 to move beyond the engagement of the Piston Anchor Detents 138, thus causing Piston 130 to "bump" Discharge Control Valve Assembly 170. Since Discharge Control Valve Assembly 170 is attached to Actuator Shaft 120, the Actuator Shaft Detent Assemblies
35 122 at both ends are forced to release from their grooves in Actuator Shaft 120. Piston

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5 130, however, is still held in place by Piston Anchor Detents 138. The instant that Piston Anchor Detents 138 release, Reverse Stroke Energizer Spring 172 expands, which causes Actuator Shaft 120 to continue to travel to the right. Actuator Shaft 120 is eventually stopped by the seating of the LH Intake Control Valve 180. When the RH Intake Control Valve 180 opens, both chambers 140 and 150 become momentarily subjected to depth
10 pressure. When the LH Intake Control Valve 180 closes, the RH chamber 150 remains at depth pressure and the LH chamber 140 becomes the lower pressure discharge chamber. Depth pressure is now against the right hand face of Piston 130. At this point, Piston 130 begins to travel to the left, which forces the RH Piston Anchor Detent 138 to disengage from Piston Detent Ring 132. As a result, the second (reverse) stroke begins.

15 In Figure 2, a three-dimensional illustration of a hydro pump in accordance with the present invention is provided. Here, it should be appreciated that Pump 200 and its corresponding elements are substantially similar, with respect to structure and functionality, to Pump 100 and its corresponding elements, as illustrated in Figures 1A-1D. It should be further appreciated that, for simplicity, not all elements illustrated in
20 Figures 1A-1D are labeled in the three-dimensional illustration of Figure 2. Nevertheless, Pump 200 is shown to include Pump Body 210 which is coupled to Actuator Shaft 220, Piston 230, End Caps 260, Discharge Control Valve Assemblies 270, Intake Control Valves 280, and Discharge Manifold 290. Also illustrated, are Chambers 240 and 250, Reverse Stroke Energizer Springs 272, and Discharge Manifold Check Valves 292.

25 Referring now to Figure 3, there is shown a hydro pump according to another embodiment of the present invention. For this embodiment, Pump 300 is assembled to include Pump Housing 310 coupled to Pump Housing End Caps 360, Intake Valves 380, Discharge Slide Valve Assemblies 370, Piston Assembly 330, Actuator Shaft 320, and External Plumbing Assembly 390, as shown. The structure and operation of each of these
30 components is described below.

Pump Housing 310 is preferably a tubular structure which contains and/or allows for the external attachment of other components providing the pump's functional capabilities. Size parameters (length, wall thickness diameter material, geometry, etc.) may be variable based on the application.

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5 Pump Housing End Caps 360 provide a mechanism for closing off the ends of Pump Housing 310 such that the liquid in which the pump is submerged cannot enter or exit the pump housing except through specific openings (valves, ports, etc.) controlled and/or actuated by other forces and components.

10 Intake Valves 380 are located external to Pump Housing 310 (one at each end) and are mechanically linked via Actuator Shaft 320. This link is such that when one Intake Valve 380 is open at one end, the Intake Valve 380 at the other end is closed via Intake Valve Seals 384, wherein Intake Valve Seals 384 are formed either onto Intake Valves 380 or Pump Housing End Caps 360. Whichever of the two valves that is in its closed position seals that end of Pump 300, so that the submergence pressure of the liquid cannot enter
15 Pump Housing 310. Intake Valve Seals 384 also stop the movement of Actuator Shaft 320 when Intake Valves 380 achieves a closed position. The open position of the other Intake Valve 380 allows the liquid in which Pump 300 is submerged to enter that end of Pump 300 under submergence pressure. This in turn causes the liquid pressure to bear against the piston. This forces the piston to move axially along the bore of Pump Housing 310.

20 In a preferred embodiment, Intake Valves 380 further include Intake Valve Shaft Seals 382, Intake Check Valve Discs 388, and Intake Check Valve Springs 386, as illustrated. During operation, the Intake Check Valve Disc 388 located at the end at which Intake Valve 380 is open allows the liquid in which the pump is submerged to enter Pump 300. At the same time, the Intake Check Valve Disc 388 located at the opposite end of
25 Pump 300 is closed, thereby keeping the liquid being discharged from exerting discharge pressure against the closed Intake Valve 380 and possibly causing it to partially open. Intake Check Valve Spring 386 then urges the Intake Check Valve Disc 388 to a closed position during the discharge cycle, while the opposite intake liquid pressure opens the Intake Check Valve Disc 388 at the opposite end of Pump 300.

30 The function of Piston Assembly 330 is to move transversely back and forth within Pump Housing 310 thereby causing the liquid in which the pump is submerged to be alternately expelled through the discharge ports at each end of Pump 300. Piston Assembly 330 incorporates Circumferential Seals 336 which are positioned against the inside diameter of Pump Housing 310. Circumferential Seals 336 separate the pump
35 chambers and prevent the fluid in the higher pressure chamber from migrating to the lower

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5 pressure chamber. Piston Assembly 330 also includes Piston Shaft Seal 334, which is positioned in the piston axial bore so as to prevent the liquid from transferring to either pump chamber as Piston Assembly 330 slides along the Actuator Shaft 320. Piston Assembly 330 causes Anti-Stall Spring 340 to be compressed at the end of its travel to each end of Pump Housing 310, which initiates the release of Actuator Shaft Restraint Device 322. Anti-Stall Spring 340 then causes Actuator Shaft 320 shaft to move, which causes Piston Assembly 330 to move in the opposite direction so as to start the next piston stroke.

Piston Restraint Device 332 may also be used in some applications, depending on depth pressures, discharge requirements, and the like. The function of Piston Restraint Device 332 is to hold Piston Assembly 330 in a stationery position until Anti-Stall Spring 340 has caused Actuator Shaft 320 to move to its limit of travel. When Actuator Shaft 320 reaches that position, the submergence pressure overcomes the force of Piston Restraint Device 332, which causes Piston Assembly 330 to move in the opposite direction (i.e., the second stroke begins).

20 Actuator Shaft 320 is located along the longitudinal axis of Pump Housing 310 and is supported at each end by the End Cap 360 through which it passes. Both Discharge Slide Valve Assemblies 370 and both Intake Valves 380 are adjustably secured to Actuator Shaft 320 (i.e., one at each end of Pump Housing 310). In a preferred embodiment, Spring Clips 350 (also known as "c" clips, spiral clips, and other nomenclature) are used to hold components in a specific position relative to another components. In this case, for example, Spring Clips 350 may be used to hold Discharge Slide Valve Assemblies 370, Intake Valves 380, and Actuator Shaft 320. Nevertheless, it should be appreciated that other types of attachment pins and/or threaded components may be used in lieu of Spring Clips 350.

30 Actuator Shaft 320 further includes two or more Actuator Shaft Restraint Devices 322, which are axially-oriented adjustable components commonly called detents. These detents preferably have spring-loaded spherical balls or plungers that engage with cylindrical depressions in Actuator Shaft 320. The function of Actuator Restraint Device 322 is to prevent the Discharge Slide Valve Assembly 370 from moving and thereby causing Actuator Shaft 320 to move until Anti-Stall Spring 340 is fully compressed. Since

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5 Anti-Stall Spring 340 is compressed by the movement of Piston Assembly 330 toward the open discharge ports, full compression of Anti-Stall Spring 340 causes further movement of Piston Assembly 330 to override Actuator Restraint Device 322. This mechanism allows Anti-Stall Spring 340 to release its stored energy, which enables it to move Actuator Shaft 320 together with its attached components. Moreover, since the Discharge
10 Slide Valve Assembly 370 is secured to Actuator Shaft 320, Actuator Shaft 320 together with all the components attached to it move until it is stopped by virtue of the Intake Valve 380 at the opposite end of the Pump Housing 310.

The Discharge Slide Valve Assemblies 370 are secured to Actuator Shaft 320 (one at each end of Pump Housing 310), wherein they are actuated in unison so that when one
15 of them is closed (closing off the discharge ports in Pump Housing 310), the other is open (allowing the liquid in which the Pump 300 is submerged to enter the discharge conduits). The movement of Discharge Slide Valve Assemblies 370 is caused by the combined interaction of the Anti-Stall Spring 340, Piston 330, Actuator Restraint Device 322, and Piston Restraint Device 332 (if present). Discharge Slide Valve Assemblies 370 have
20 openings through which the liquid can freely flow. Discharge Slide Valve Seal Pads 374 provide sealing surfaces for Discharge Slide Valve Assemblies 370 at the discharge ports, and may be separate or integral with the valve body structure. Discharge Valve Guides 376 are also included, which prevent Discharge Slide Valve Assemblies 370 from rotating about Actuator Shaft 320. Guides 376 are fastened to Pump Housing 310 (but removable)
25 and are positioned such that Discharge Slide Valve Seal Pads 374 are kept in alignment with the pump discharge ports according to both their axial and rotational orientations.

The discharge ports of Pump 300 are externally connected to conduits, wherein the conduits extend upward beyond the liquid in which Pump 300 is submerged. Within this embodiment, multiple discharge ports at each end are connected together into a common
30 manifold or conduit. An External Plumbing Check Valve 392 installed at each end above the manifold or common conduit connection is required to keep the discharge liquid residing in the conduit from returning to the chamber from which it was discharged.

Within this embodiment, either Pump Housing 310 or End Caps 360 have provisions for the attachment of discharge plumbing such as External Plumbing Assembly
35 390. This plumbing may include an External Plumbing Check Valve 392 for each set of

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5 discharge ports. For example, if Pump 300 has four discharge ports, the two or more ports at each end can be plumbed together to one External Plumbing Check Valve 392. The plumbing can then be merged into a single discharge conduit. However, an individual External Plumbing Check Valve 392 for each port can also be used and all plumbed into a common conduit. The discharge conduits may also incorporate vanes, twists, and the like,
10 to promote vortex and/or venturi technology.

The present invention has been described above with reference to several different embodiments. However, those skilled in the art will recognize that changes and modifications may be made in the above described embodiments without departing from the scope of the invention. Furthermore, while the present invention has been described in
15 connection with a specific processing flow, those skilled in the art will recognize that a large amount of variation in configuring the processing tasks and in sequencing the processing tasks may be directed to accomplishing substantially the same functions as are described herein. These and other changes and modifications which are obvious to those skilled in the art in view of what has been described herein are intended to be included
20 within the scope of the present invention.

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5 What is claimed is:

1. A pressure-powered liquid pump, comprising:
a cylindrical housing having opposite ends and a center axis perpendicular to said
opposite ends, wherein said housing is submerged in a liquid;
an actuator configured to move along said center axis;
10 a first and second intake assembly coupled to said actuator and respectively
proximate to said opposite ends of said housing;
a first and second discharge assembly coupled to said actuator and respectively
proximate to said opposite ends of said housing;
at least one discharge conduit coupled to said housing and extending to an
15 atmosphere external to said liquid; and
a piston coupled to said actuator, wherein said piston is configured to slide along
said actuator so as to create a first chamber within said housing having a first variable
pressure, and a second chamber within said housing having a second variable pressure,
wherein said first variable pressure and said second variable pressure vary according to the
20 positioning of said piston along said actuator.
2. The liquid pump of claim 1 further comprising an electronic monitoring
device, wherein said monitoring device monitors functional characteristics of said liquid
pump.
3. The liquid pump of claim 1 further comprising an electronic monitoring
25 device, wherein said monitoring device gathers empirical data of associated with the
proximate environment of said liquid pump.
4. The liquid pump of claim 1 further comprising an electronic control
device, wherein said control device controls functional characteristics of said liquid pump.
5. The liquid pump of claim 1, wherein said piston is coupled to an anti-stall
30 spring.
6. The liquid pump of claim 1 further comprising a first and second actuator
detent assembly respectively proximate to said opposite ends of said housing, so as to
momentarily hold said actuator stationary.

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5 7. The liquid pump of claim 1 further comprising a first and second piston
detent assembly respectively proximate to said opposite ends of said housing, so as to
momentarily hold said piston stationary.

 8. A method for pumping liquid comprising:
 submerging a cylindrical housing in a liquid, wherein said housing comprises:
10 opposite ends and a center axis perpendicular to said opposite ends;
 an actuator configured to move along said center axis;
 a first and second intake assembly coupled to said actuator and respectively
proximate to said opposite ends of said housing;
 a first and second discharge assembly coupled to said actuator and
15 respectively proximate to said opposite ends of said housing;
 at least one discharge conduit coupled to said housing and extending to an
atmosphere external to said liquid; and
 a piston coupled to said actuator, wherein said piston is configured to slide
along said actuator so as to create a first chamber within said housing having a first
20 variable pressure, and a second chamber within said housing having a second variable
pressure; and
 maintaining said cylindrical housing at an optimal depth, so as to create an
oscillation between said first variable pressure and said second variable pressure, wherein
said first variable pressure and said second variable pressure oscillate inversely
25 proportional to each other.

 9. The method of claim 8 further comprising the step of electronically
monitoring functional characteristics of said liquid pump.

 10. The method of claim 8 further comprising the step of electronically
gathering empirical data associated with the proximate environment of said liquid pump.

30 11. The method of claim 8 further comprising the step of electronically
controlling functional characteristics of said liquid pump.

 12. The method of claim 8, wherein said piston is coupled to an anti-stall
spring.

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5 13. The method of claim 8, wherein said housing further comprises a first and second actuator detent assembly respectively proximate to said opposite ends of said housing, so as to momentarily hold said actuator stationary.

 14. The method of claim 8, wherein said housing further comprises a first and second piston detent assembly respectively proximate to said opposite ends of said housing, so as to momentarily hold said piston stationary.

 15. A pressure-powered liquid pump, comprising:
 an actuator coupled to a first and second end cap of a cylindrical housing;
 a first and second intake valve rigidly attached to said actuator and respectively proximate to said first and second end caps;
15 a first and second discharge assembly rigidly attached to said actuator and respectively proximate to said first and second end caps;
 at least one discharge conduit coupled to said housing and extended to an atmosphere external to said liquid; and
 a piston coupled to said actuator and configured to exert a first force on said first
20 discharge assembly so as to facilitate the opening of said first intake valve substantially simultaneous with the closing of said second intake valve, and wherein said piston is also configured so as to exert a second force on said second discharge assembly so as to facilitate the opening of said second intake valve substantially simultaneous with the closing of said first intake valve.

25 16. The liquid pump of claim 15 further comprising an electronic monitoring device, wherein said monitoring device monitors functional characteristics of said liquid pump.

 17. The liquid pump of claim 15 further comprising an electronic monitoring device, wherein said monitoring device gathers empirical data of associated with the
30 proximate environment of said liquid pump.

 18. The liquid pump of claim 15 further comprising an electronic control device, wherein said control device controls functional characteristics of said liquid pump.

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5 19. The liquid pump of claim 15, wherein said piston is coupled to an anti-stall spring.

 20. The liquid pump of claim 15 further comprising a first and second actuator detent assembly respectively proximate to said first and second end caps, so as to momentarily hold said actuator stationary.

10 21. The liquid pump of claim 1 further comprising a first and second piston detent assembly respectively proximate to said first and second end caps, so as to momentarily hold said piston stationary.

Figure 1A

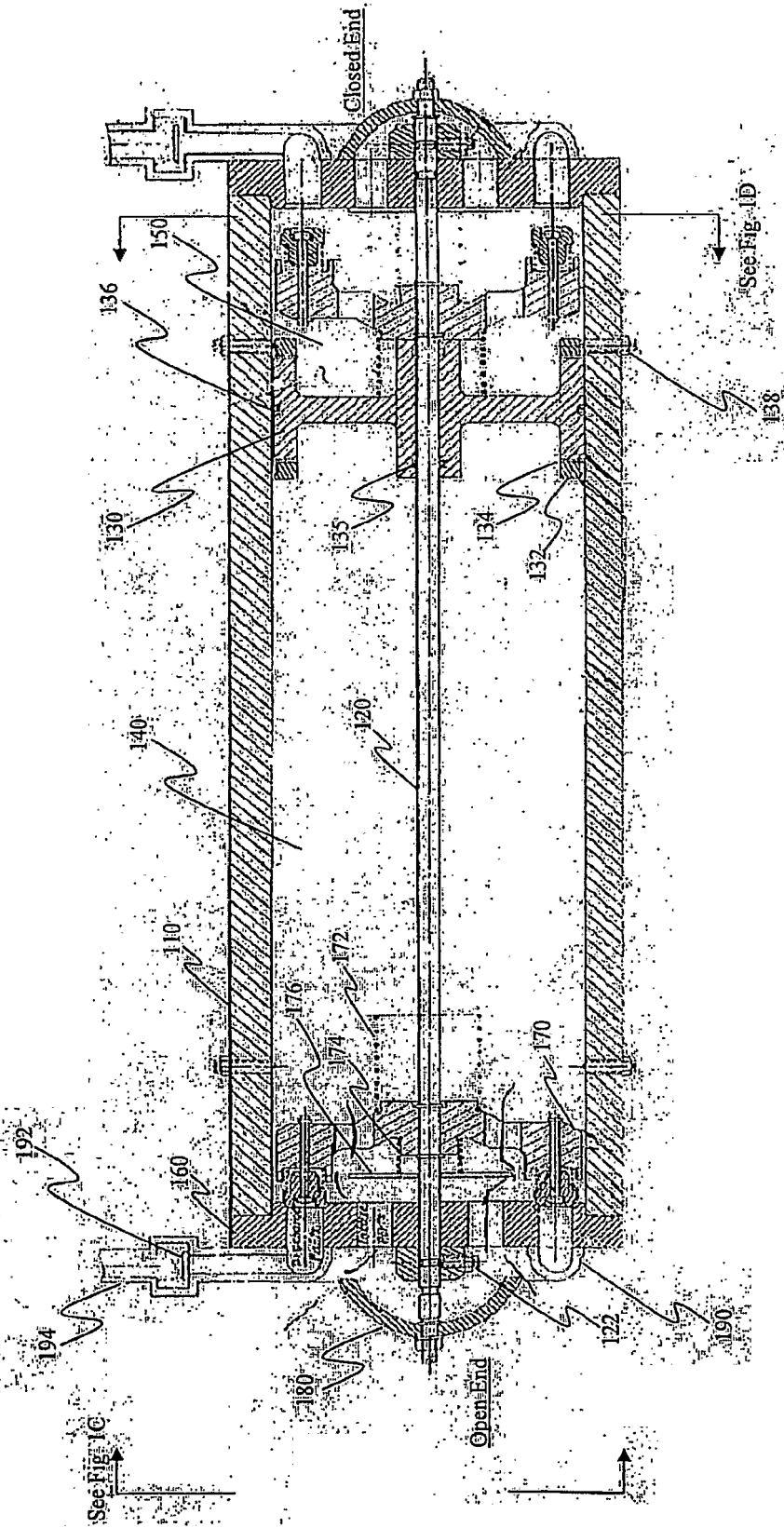


Figure 1B

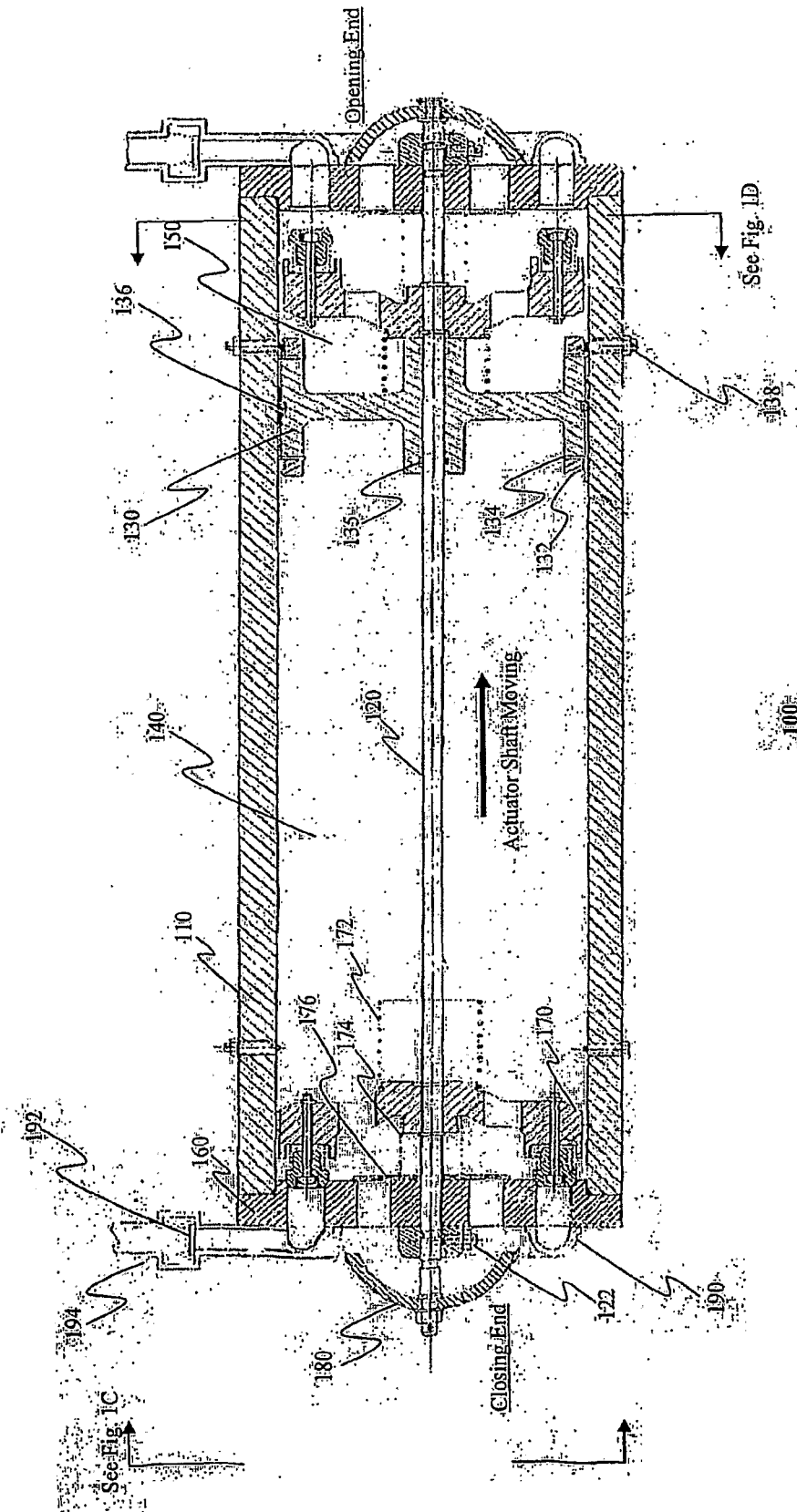


Figure 1D

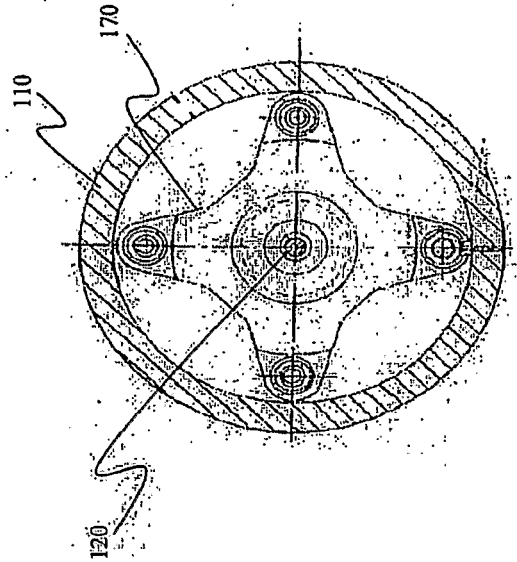


Figure 1C

