

Assembly and System for Pumping a Volume of Fluid through a Body of Water

Field of Invention

The present invention relates to an assembly and system for pumping a volume of fluid
5 through a body of water. More particularly, the present invention relates to an assembly
and system for pumping a large volume of fluid such as water over a large body of water
such as rivers, lakes, and oceans.

Background of the Invention

10 The world is facing serious challenges in the management of water due to climate change,
which has caused rainfall patterns to become unpredictable and creating serious
ramifications for food production and survival of communities living in these areas prior to
changed rainfall patterns. Further, arid areas of the world are expanding and one of the
more serious consequences is conflict over water resources especially in rivers shared by
15 two or more countries.

The expanding area of desert caused by the warming of the planet is reducing the areas
of the earth covered by plant life. Compounded by the activities of man that also destroy
the areas of green plant life and replacing them with hardscapes of roads, cities and the
like have led to an acceleration of the conversion of the solar radiation on the planet into
20 heat rather than stored energy in plants had the surface been green rather than
hardscape and desert.

To address rising temperatures in a significant manner it is imperative that we increase
the area of coverage of green plants and reduce areas of hardscape and desert that are
exposed to solar radiation. Whilst in theory this is good, supplying the volume of water to
25 support this increased area for the growth of plants remains a major challenge as rivers in
areas around the arid regions of the world are also experiencing lower and unpredictable
flows due to climate change and supporting activities of increased populations in their
respective areas.

Whilst some areas of the world face water shortage, there are also many other areas in the world that have too much rainfall. This excess water problem often results in death and destruction of property due to flooding. Also in recent times scientists have discovered large supplies of fresh water under the oceans, which remain an untapped resource as a water supply source for arid regions.

Due to water security issues, more and more desalination plants are being built to meet the water needs of cities around the world, some of these even in regions of the world with adequate annual rainfall. Most of these desalination plants are powered by fossil fuel sources which compounds further the problem of climate change.

The solution for the world lies in moving fresh water from sources where water is plentiful to areas that are arid. Many large rivers in the world could be a source of this fresh water. As an example the volume of water required to green arid land is of the magnitude of 1 cubic metre of water per square metre of land per year. This would require a volume of 1,000,000 cubic metres of water per square kilometre **per year**. By comparison the top 30 rivers in the world in total dump about 600,000 cubic metres **per second** into the oceans. Calculations will show that sacrificing just 3% of their normal flows would provide enough agricultural grade water to green more than 500,000 square kilometres of currently arid land around the planet. This would reduce solar conversion to planet heating and offer opportunities for increased food security and employment. Another environmental benefit that will be seen is the additional care that will be taken to ensure these “revenue” rivers that currently are a source of pollution to the oceans will be better maintained to higher quality standards.

Existing bulk handling of water across water bodies has been limited to large ships or bulk carriers. These bulk carriers with thick steel hulls and holding areas are expensive and take very long periods of time to build. The use of these carriers which currently are used to transport primarily oil, gas and other more expensive chemicals would be too prohibitive for the transport of agricultural grade water.

In recent times the use of large floating zippered flexible bags containing as much as 3,000 cubic metres of water has also been attempted but the acceptance has been slow due to damage and tearing of the bags during towing operations that can extend to hundreds or even thousands of kilometres. The main reason for the failure of this has been that transport of the bags has been limited to the shallow water depths below the

surface of the water body which area is both turbulent during storms as well as the area in which a lot of floating debris are present and can damage and tear the membrane of the bags.

5 The scope of the present invention is to address these concerns and to allow for a more economical and energy efficient method and system to move large volumes of water, or other fluids, over long distances in the rivers, lakes and oceans.

Summary of the invention

10 The present invention allows for energy efficient pumping of a fluid by combining the movement of large quantities of low pressure gas – less than 100000 Pa (1 bar) – with at least one large floating vessel, a pipeline system and control valves. The vessel is easily filled and discharged by the use of air vacuum-blower pumps which move gas which is about 1/800th the density of water resulting in very energy efficient movement of the fluid.

15 The present invention also relates to a system for collecting, storing and delivering water from surface rivers and reservoirs as well as from sources under the seas and oceans into a floating vessel via an interconnecting pipeline using a method of pumping air out of the vessel that is floating in water with a corresponding submerging of the vessel as the vessel is gradually filled with the fresh water from an incoming pipeline. When the vessel is full of water, the invention also allows for air to be pumped into the submerged vessel to
20 displace the water in it causing the vessel to rise out of the water and forcing the water in the vessel to an outflow pipeline connected to it. A system of control valves are used to control the flow of water in the required direction. The process is repeated to allow the combination of the vessel, air vacuum blower, pipe system and valve control system to act as a water pumping system.

25 During the process of filling and emptying the vessel of water a system of valves separate the inflows and outflows into separate pipes, with the inflow pipe coming in from the source of the water and the outflow pipe connected to a receiving or transporting source that might be a rigid, semi-rigid or flexible vessel used to transport the water to its final destination. The invention allows the vessel to move to varied depths in the water body to
30 stay out of harm's way in a turbulent water body that may be created by winds and adverse weather changes.

The present invention allows a large floating body of fluid and gas within a vessel with a large fluid-gas interface area being subjected to small pressure differences created by alternate large inflows and outflows of low pressure gas into and out of the vessel creating a very large pneumatic force when connected to a pipe system for fluid pumping purposes.

The present invention also allows for the use of large diameter pipes to be the fluid inflow and outflow pipes for these large vessels with the intent that these feeder pipes will increase in length and reduce the distance the vessels need to move over time. Ultimately it is envisaged that the pipelines will interconnect with these vessels which will act as fixed intermediate storage vessels and pumping stations forming a grid for the movement of water from source to destination countries overcoming political rivalry typical with neighbours in water strided regions.

Another aspect of the invention is to have one or more pumping systems described above to feed one or more large reservoir bladders submerged within the seas and oceans via a pipe network or grid. Similarly there would be one or more pumping systems to remove water from the reservoir. As the flow of water through the pumping system is easily reversed by controlling the valves in the pipe system and the alternating vacuum-pressure air flow to the vessels, the system allows a water supply source to become a receiving source.

Besides water, the present invention can also be used to collect and move other non-hazardous fluids, slurries, hazardous spills, leaks and the like in an efficient manner.

Brief Description of the Drawings

The drawings constitute part of this specification and include an exemplary or preferred embodiment of the invention, which may be embodied in various forms. It should be understood, however, the disclosed preferred embodiments are merely exemplary of the invention. Therefore, the figures (not to scale) disclosed herein are not to be interpreted as limiting, but merely as the basis for the claims and for teaching one having ordinary skill in the art of the invention.

Figures 1 and 2 show diagrammatically a section of a preferred embodiment of the present invention embodied in an exemplary form of a vessel capable of pumping fluid from a first location to a second location.

Figures 3 and 4 show diagrammatically a section of an alternative embodiment of the present invention wherein the vessel shown in Figures 1 and 2 further comprise a bladder.

Figures 5 and 6 show diagrammatically a section of at least two vessels arranged in series in a pipeline.

Figures 7 and 8 show diagrammatically a section of an alternate embodiment of the vessel shown in Figures 1 and 2.

Figure 9 shows diagrammatically an exemplary pipeline delivering water from a first reservoir to a second reservoir having a plurality of vessels arranged in series in the pipeline.

Figure 10 shows diagrammatically another exemplary pipeline wherein the pipeline further comprises an intermediate reservoir capable of storing fluids while being in a body of water.

Detailed Description of Preferred Embodiments

Detailed description of preferred embodiments of the present invention is disclosed herein. It should be understood, however, that the embodiments are merely exemplary of the present invention, which may be embodied in various forms. Therefore, the details disclosed herein are not to be interpreted as limiting, but merely as the basis for the claim and for teaching one skilled in the art of the invention. The numerical data or ranges used in the specification are not to be construed as limiting.

Figures 1 and 2 show a diagrammatic cross-sectional view of a vessel (10) which is an exemplary form of a preferred embodiment of the present invention. The vessel (10) is floating in a body of water and connectable to undersea pipelines (30) that are adapted to be placed in a body of water. While the present invention is chiefly concerned with pumping water from a first location to a second location, it is envisioned that the invention

is capable of pumping other types of fluids which are Newtonian and non-Newtonian such as, but not limited to oil spills, sewage, clay, slurries, petroleum, and such like.

The vessel (10) comprises a shell (12) with a first valve (16a) and second valve (16b) that permit or restrict flow of fluids, particularly liquids such as water into and out of the vessel (10). The shell (12) defines a volumetric space within the vessel (10) into which air may be introduced or extracted from. The first and second valves (16a & 16b) are preferably bladder valves, gate, ball valves or any mechanism which can permit and restrict flow of fluid. The first and second valves (16a and 16b) work cooperatively to allow water to be pumped through the vessel (10) in one direction and also in reverse. At least one opening (18) is provided at the shell (12) to allow air to be pumped out of or into the vessel (10).

An exemplary means of pumping air into or out of the vessel (10) is a pump (20) such as a bidirectional air pump or a single directional air pump with a pipe header system with valves to allow for bidirectional flow in the air pipe network. Alternatively, a mechanically actuated piston may be used to force air out of and into the vessel (10). Still alternatively, other means for pumping air into and out of the vessel (10) known to a person having ordinary skill in the art are envisioned to be equally suited.

In the preferred embodiment, the pump (20) is located above water surface (50) of the body of water in which the vessel (10) is floating. By way of example, the pump (20) may be situated on a boat, a floating platform, or a fixed platform. A variation to the aforementioned may be to house the pump (20) at upper quadrant of the vessel (10) which would be above the water level within the vessel (10) as well as the body of water in which the vessel (10) is floating.

By removing air from the vessel (10), fluid is drawn into the vessel (10) from the pipeline (30) due to low air pressure created in the vessel (10) which is lower than air pressure outside the vessel (10). The first valve (16a) opens to allow fluid from the pipeline (30) connected to the first valve (16a) to be drawn into the vessel (10) while the second valve (16b) closes to prevent fluid at pipeline (30) connected to the second valve (16b) which has already passed out of the vessel (10) from flowing back into the vessel (10).

Conversely, when air is supplied into the vessel (10), fluid is expelled out of the vessel (10) due to the high air pressure created in the vessel (10) which is higher than pressure of the fluid in the pipeline (30) connected to the second vessel (16b). As in the foregoing,

the first valve (16a) closes to prevent fluid held in the vessel (10) from flowing back into pipeline connected to the first valve (16a) while the second valve (16b) opens to allow fluid into the pipeline (30) through the second valve (16b).

5 In an alternative embodiment, the vessel (10) may be weighted, and the opening (18) is configured to allow air to escape to the atmosphere, such that air is not trapped within the vessel (10), allowing the vessel (10) to sink and be filled with water when the first valve (16a) is opened to allow water to enter. When the vessel (10) is filled, air is then supplied into the vessel (10) to force water out through the second valve (16b).

10 Fluid level within the vessel and the water level of the body of water outside the vessel are naturally balanced based on their respective densities by the principles of buoyancy of the vessel (10) combined with the fluid floating in the body of water outside the vessel (10). It is therefore possible that small pressure differences inside the vessel created by the supply or removal of gas at a low pressure – less than 100000 Pa (1 bar) – to cause fluid to enter or be expelled out of the vessel (10). The vessel (10) is easily filled and
15 discharged by the use of vacuum-blower pumps which move the gas. As an example if the gas is air and the fluid is freshwater it results in an energy efficient movement of the fluid with low maintenance compared to pumping the fluid directly using traditional electromechanical pumps.

20 In the preferred embodiment, the vessel (10) is sized to be capable of holding a preferred amount in a magnitude of 4,000m³ of fluid. It is envisioned that other embodiments are in sizes that are able to hold amounts in magnitudes of up to 4,000,000m³ of fluid. Accordingly, it is envisioned that the shell (12) is constructed in very large diameters of 20m to 200m to accommodate the volume of fluid.

25 In the preferred embodiment, the vessel (12) is a rigid protective structure that may be fitted with a bladder (14) within it. Preferably, the shell (12) is constructed as a whole from one or more rigid sheets or arched formed interlocking components capable of resisting both positive and negative pressures within the shell. The shell (12) may have further an external skin with strong tensile strength to resist positive pressures from within the vessel (10). The shell (12) of the vessel (10) is impermeable to both air and water except through
30 designated portholes designed and constructed in the shell (12).

The shell (12) is preferably constructed of rigid materials with corrosion resistance such as aluminium, galvanized steel, stainless steel or protected reinforced concrete although formed plastics like polyurethane and such like is also envisioned to be suitable. Additionally, the shell (12) may be lined externally with concrete and epoxy or polymeric material for increased resistance against degradation. Conceivably, the shell (12) is 75mm to 300mm thick or at a thickness that is sufficient to structurally withstand external and internal pressures exerted upon the shell (12). Preferably, the shell (12) is disposed in a substantially spherical shape as it is known to a person having ordinary skill in art that such spherical shapes have good strength and can well withstand high internal and external pressures exerted on the shell (12). Alternatively, ellipsoid and rounded or domed cylindrical shapes are also contemplated, and are envisioned to be suited for lower pressure applications. Optionally, additional internal and external bracing and reinforcement means known to a person having ordinary skill in the art may be provided to improve strength of the shell (12).

As the vessel (10) contains a volume of air and fluid which varies as air and fluid are supplied into and expelled out of the vessel (10), it will be appreciated by a person having ordinary skill in the art that the vessel (10) will float and sink depending on the amount of air and fluid that is present in the vessel (10).

The pipeline (30) to which the vessel (10) is connectible to is envisioned to be flexible in nature to allow the vessel (10) to float and sink freely in the body of water which the vessel (10) is floating in. In the preferred embodiment, the pipeline (30) is a flexible high density polyethylene "HDPE" pipe having a diameter of 1m to 4m which are already commercially available. Other flexible and hardwearing materials are envisioned to be equally suited. Additionally, the pipeline (30) may comprise rigid ringed segments instead of utilizing flexible materials. Also, the pipeline may be concrete pipes adapted for marine use.

Alternatively, if the floating and sinking of the vessel (10) requires greater stability, means such as adding concrete weights or ballast to the vessel (10) may be contemplated. Anchoring of the vessel (10) may be achieved by means of cable and winch systems connected to weighted anchors or solid foundations on piles.

Figures 3 and 4 show a diagrammatic cross-sectional view of another preferred embodiment of the present invention, wherein the vessel (10) further includes a bladder

(14). Such a configuration is preferred where the fluid to be pumped is a difficult to clean or non-Newtonian fluid such as a slurry, oil spill or contains particulate matter which may settle in the vessel (10).

In this embodiment, the bladder (14) contracts and expands with fluid by pumping air into or out of the vessel (10). Alternatively, instead of using air as a working fluid, water or other types of hydraulic fluids is pumped into and out of the vessel (10) to cause the contraction and expansion of the bladder (14). Since the bladder (14) is impermeable, working fluid used will not mix with fluid which is being pumped. The bladder (14) is preferably fabricated from elastomeric material such as a natural or synthetic rubber like or other tear resistant plastic derived materials. Preferably, the bladder (14) is sized to be capable expanding to hold a preferred amount in a magnitude of $4,000\text{m}^3$ of fluid. It is envisioned that other embodiments are in sizes that are able to expand to hold amounts in magnitudes of up to $4,000,000\text{m}^3$ of fluid.

By removing air from the vessel (10) the fluid is drawn into the bladder (14) from the pipeline (30) causing the bladder to expand. The first valve (16a) opens to allow fluid from pipeline (30) connected to the first valve (16a) to be drawn into the bladder (14) while the second valve (16b) closes to prevent fluid at pipeline (30) connected to the second valve (16b) which has already passed out of the bladder (14) from flowing back into the bladder (14).

Alternately, when air is supplied into the vessel (10), the fluid is expelled from the bladder (14) which contracts. As in the foregoing, the first valve (16a) closes to prevent fluid held in the bladder (14) from flowing back into pipeline (30) connected to the first valve (16a) while the second valve (16b) opens to allow fluid to flow into pipeline (30) through the second valve (16b).

Figures 5 and 6 show a diagrammatic cross-sectional view of another preferred embodiment of the present invention, wherein at least two vessels are arranged in series to work in opposite but complementary motion.

As shown in Figure 5, fluid is conveyed through the pipeline (30) by alternately supplying and removing air from a first vessel (80) to a second vessel (90). Air is withdrawn from the first vessel (80) and supplied into the second vessel (90) by means of a pump (20). When air is withdrawn from the first vessel (80), fluid is drawn into the first vessel (80) through a

first entry valve (82) due to low air pressure created in the first vessel (80) while simultaneously, any fluid present in the second vessel (90) is expelled through a second exit valve (94) due to air entering the second vessel (90) from the first vessel (80) and creating high air pressure in the second vessel (90). Once air from the first vessel (80) is sufficiently evacuated, direction of air supply is reversed and now air is removed from the second vessel (90) and supplied into the first vessel (80).

Referring now to Figure 6, fluid is now drawn into the second vessel (90) through a second entry valve (92) and fluid is expelled from the first vessel (80) through a first exit valve (84). By alternating air pressure in the first vessel (80) and second vessel (90), the first vessel (80) and second vessel (90) work in tandem to pump fluid in the pipeline (30) to travel from upstream of the first vessel (80) and second vessel (90) to downstream of the first vessel (80) and second vessel (90).

It will be appreciated by a person having ordinary skill in the art that this configuration can further include an expendable bladder, each in the first vessel (80) and second vessel (90) and function in a similar manner as described in the foregoing, wherein when air is withdrawn from the first vessel (80), the bladder located in the first vessel (80) expands due to low air pressure, and fluid is drawn into the bladder in the first vessel (80) while simultaneously, any fluid present in the bladder in the second vessel (90) is expelled from the bladder in the second vessel (90) due to high air pressure and conversely, when air is withdrawn from the second vessel (90), the bladder located in the second vessel (90) expands due to low air pressure, and fluid is drawn into the bladder in the second vessel (90) while simultaneously, any fluid present in the bladder in the first vessel (80) is expelled the bladder in the first vessel (80) due to high air pressure.

In a non-limiting example, the first vessel (80) and second vessel (90) are 20 meters in diameter and have a capacity of volume 4,187 cubic metres to work in tandem with the pump (20) being a blower-suction system of electrical power 15 kW capable of delivering 1.67 cubic metres per second (m^3/s) or 6,000 cubic metres per hour (m^3/h) at a total pressure of $4413\text{N}/\text{m}^2$ or $450\text{ kgf}/\text{m}^2$ which will blow air into the second vessel (90) whilst sucking air out of the first vessel (80).

Assuming optimal air-water interface between air and water present within both vessels, initial conditions at both vessels are water levels at a 25% depth in the first vessel (80) and 75% depth in the second vessel (90), and a pipeline having a diameter of 2 meters.

Flow of the pump (20) will be reversed when water level in the first vessel (80) reaches 75% depth and water level in the second vessel (90) reaches 25% depth. Assuming that 50% of the total pressure will be delivered as a positive pressure to the second vessel (90) and 50% will be delivered as vacuum to the first vessel (80), the first intake valve (82) is
 5 opened to allow the flow of water into the first vessel (80) and the second exit valve (94) is opened to allow discharge of water from the second vessel (90). When the pump (20) starts to suck air out of the first vessel (80) and into the second vessel (90), the water levels will rise within the first vessel (80) and reduce within the second vessel (90).

However, as the vessels are both located in a body of water, buoyancy laws will result in
 10 the first vessel (80) sinking deeper into the body of water and the second vessel (90) rising within the body of water. This allows for the work done by the air movement to result in water being sucked into the first vessel (80) and discharged out of the second vessel (90), without any resulting pressure head difference relative to the body of water in which the vessels are floating. The suction force created in the first vessel (80) would generate a
 15 total suction force to pull water into the first vessel (80). The same thing would happen in reverse in the second vessel (90) where the water level within the second vessel (90) will drop as the force exerted on the surface of the water within the second vessel (90) to push the water out of the second vessel (90) and into the pipeline (30). The rate of flow of water through the system is estimated to be about 1.63 cubic metres per second or 5,880
 20 cubic metres per hour with a flow speed of about 0.5 m/s through the 2.0 m pipeline (30). Based on the flow rate (1.63 m³/s or 5,880 m³/h) and the fan motor power (15 kW) the water is moved at an energy rate of around 7.0833×10^{-4} Ws/m³ or 2.55 Wh/m³. Further, for a plastic pipe of diameter 2.0m with a water flow velocity of 0.5 m/s the head loss is approximately 1 kPa per 1,000m of pipe length. To achieve higher pumping pressures for
 25 longer pipe distances a blower-vacuum system with higher total pressure characteristics may be selected or alternatively more pumping stations can be added in series.

It must be noted that the above example is not to be taken as a limitation of shape, size or capacity in any way, but merely to demonstrate under ideal conditions how low pressure air movement can be used to move water in an energy efficient manner and with minimum
 30 mechanically rotating or moving parts exposed to the transported water.

It is envisioned that the pipeline (30) is connected to a source of water located on the inflow side of the vessel (10), wherein the source of water is a river or a natural or

manmade water reservoir. In the preferred embodiment, the source of water is a facility that diverts a small percentage of river water which is discharged into the sea, in the range of 1-3% to minimize any adverse effect on the natural environment or biodiversity.

Other sources of water which are contemplated are pockets of freshwater reservoirs located beneath the seabed. Such reservoirs are believed to be formed over several million years ago, when sea levels are comparatively lower. Over time, layers of sediment formed over these pockets of water reservoirs as sea levels rose. It is contemplated that a facility constructed over such reservoirs can drill into these reservoirs and extract the freshwater contained therein. The pipeline (30) can then be connected to such a facility extracting freshwater from undersea reservoirs.

The pipeline (30) is envisioned to connect an area with surplus water discharge to an arid or desertified area with minimal or no water sources and convey water from the area with surplus water to the arid or desertified area so that greening of the arid or desertified area may be done.

Figures 7 and 8 show a diagrammatic cross-sectional view of yet another alternative embodiment, wherein the vessel (10) is now configured to store fluids instead of pumping the fluids from an upstream location to a downstream location.

Referring to Figure 7, fluid is drawn in and stored in the vessel (10) by removing air from the vessel (10). The valve (16) is bladder valve, ball valve or gate valve which prevents fluids from flowing out of the vessel (10) during storage.

In Figure 8, the fluid is removed from the vessel (10) by supplying air into the vessel (10). As the air pressure is increased, fluid is pushed out of the vessel (10).

This embodiment is envisioned to aid in management of excess water flow caused by rainy or monsoon seasons, where excess rainfall causes rivers and other bodies of water to swell and overflow, potentially causing floods that will damage infrastructure and industrial, residential and commercial properties. Such excess water can be stored inside the vessel and released when needed, for example when there is a shortage in water supply. This especially useful if the area or region is prone to extreme dry and wet seasons. By storing excess water during wet seasons and releasing stored water during dry seasons, water-related problems during these seasons can be addressed.

Figure 9 shows a diagrammatic cross-sectional view of yet another aspect of the preferred embodiment of the present invention. A series of vessels (100) arranged along a pipeline (30) to pump fluids such as water from a first reservoir (200) to a second reservoir (300). The pipeline (30) is envisioned to span great distances in the range of hundreds to thousands of kilometres over large bodies of water. In a non-limiting example, the pipeline (30) may connect a location in Asia with high annual rainfall and surplus of freshwater flowing into the sea to a location in the Middle East with low annual rainfall and water shortage. The pipeline (30) passes through the Indian and Arabic oceans and vessels (100) floating in distributed at intervals along the pipeline (30) pump the water from the freshwater source in Asia to the destination in the Middle East. Additionally, it is contemplated that the pipeline (30) may branch out to multiple sources and pump water from all these sources and send the water to a common destination. Conversely, the pipeline (30) may begin from a single source and terminate at multiple destinations. Conceivably, the pipeline (30) may form a network connecting multiple sources and multiple destinations.

Figure 10 shows a diagrammatic cross-sectional view of an alternative embodiment of the present invention. In Figure 10, the water is pumped from a first reservoir (200) via the vessel (100) to one or more intermediate reservoirs (400). The intermediate reservoir (400) can then allow water stored within it to be pumped to a second reservoir (300), or back to the first reservoir (200). These intermediate reservoirs (400) are preferably large sized elastomeric bags or bladders. The intermediate reservoirs (400) will act as undersea storage reservoirs and is envisaged to reach mammoth proportions as ocean depths of 3km to 7km can easily accommodate a combination of connected bladders ranging from 300m to 500m in length holding billions of cubic metres of water. The intermediate reservoirs (400) will also be connected to other vessels (100) at downstream location which will draw water from the intermediate reservoirs (400).

As appreciated by a person having ordinary skill in the art, the direction of flow of water in the pipeline (30) may be reversed by changing the sequence of opening and closing the respective entry and exit valves at the vessels (100) located along the pipeline (30). In this manner, the intermediate reservoir (400) may be utilized to store fluid from multiple sources and then return the water to these multiple sources.

List of Reference Signs

	10	vessel
	12	shell
	14	bladder
	16	valve
5	16a	first valve
	16b	second valve
	18	opening
	20	pump
	30	pipeline
10	50	water surface
	80	first vessel
	82	first entry valve
	84	first exit valve
	90	second vessel
15	92	second entry valve
	94	second exit valve
	100	vessel
	200	first reservoir
	300	second reservoir
20	400	intermediate reservoir

Claims

1. A system for pumping a volume of water from a source of water to a reservoir wherein the system comprises:
 - a pipeline (30) in fluid connection with the source of water and the reservoir and wherein a portion of the pipeline (30) passes through a body of water;
 - at least one vessel (10) disposed along and in fluid connection with the portion of the pipeline (30) passing through the body of water wherein the vessel (10) is floatable in the body of water and wherein air and water is extractible from and introducible into the vessel (10) and wherein the vessel (10) comprises:
 - a shell (12) defining a volumetric space within the vessel (10) in which air is extractible from and introducible into;
 - an opening (18) to allow air to be extracted from the vessel (10) to cause pressure in the vessel (10) to be lower than air pressure external to the vessel (10) to allow water to be drawn into the vessel (10) and air to be supplied into the vessel (10) to cause pressure in the vessel (10) to be higher than air pressure external to the vessel (10) to allow water to be expelled out of the vessel (10);
 - a first valve (16a) to permit water to enter the vessel (10) when air is extracted from the vessel (10) and to restrict water from exiting the vessel (10) when air is introduced into the vessel (10);
 - a second valve (16b) to restrict water from entering the vessel (10) when air is extracted from the vessel (10) and to permit water to exit the vessel (10) when air is introduced into the vessel (10); and
 - a pump (20) to extract and introduce air from and into the vessel (10);
 - wherein:
 - the pump (20) pumps air into the vessel (10) to create high air pressure in the vessel (10) to cause water to be expelled out of the vessel (10) and pumps air out of the vessel (10) to cause water to be drawn into the vessel (10); and

the vessel (10) sinks into the body of water as water enters the vessel (10) and rises within the body of water as water exits the vessel (10) to allow pressure differences caused by air being removed from the vessel (10) to draw water into the vessel (10) and air supplied into the vessel (10) to expel water from the vessel (10).

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2. The system as claimed in claim 1, wherein the vessel (10) further comprises a bladder (14) fillable with water wherein the bladder (14) expands to draw in water and contracts to expel water.

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3. The system as claimed in claim 2, wherein the first valve (16a) permits water to enter the bladder (14) when the bladder (14) expands and restricts water from exiting the bladder (14) when the bladder (14) contracts;

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4. The system as claimed in claim 2, wherein the second valve (16b) restricts water from entering the bladder (14) when the bladder (14) expands and permits water to exit the bladder (14) when the bladder (14) contracts.

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5. The system as claimed in claim 2, wherein the pump (20) pumps air into the vessel (10) to cause the bladder (14) to contract and pumps air out of the vessel (10) to cause the bladder (14) to expand.

6. The system as claimed in claim 1, wherein the vessel (10) is disposed in a spherical, ellipsoidal or cylindrical shape.

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7. The system as claimed in claim 1, wherein the pump (20) is connected to the vessel (10) through the opening (18).

8. The system as claimed in claim 1, wherein the pump (20) is housed at upper quadrant of the vessel (10)

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9. The system as claimed in claim 1, further comprising an intermediate reservoir (400) connectible to the pipeline (30) and in the body of water, wherein the intermediate reservoir (400) is fillable with water.

10. The system as claimed in claim 1, wherein a pressure difference of less than 100000 Pa between air pressure within the vessel (10) and air pressure outside the vessel (10) causes water to be drawn into the vessel (10).

5 11. A system for pumping a volume of water from a source of water to a reservoir, comprising:

a flexible pipeline (30) in fluid connection with the source of water and the reservoir and wherein a portion of the pipeline (30) passes through a body of water;

10 a first vessel (80) disposed along and is in fluid connection with the portion of the pipeline (30) passing through the body of water and wherein the first vessel (80) is floatable in the body of water and further comprises a first entry valve (82) which permits entry of water into the first vessel (80) and a first exit valve (84) which permits exit of water out of the first vessel (80);

15 a second vessel (90) disposed along and is in fluid connection with the portion of the pipeline (30) passing through the body of water and wherein the second vessel (90) is floatable in the body of water and further comprises a second entry valve (92) which permits entry of water into the second vessel (90) and a second exit valve (94) which permits exit of water out of the second vessel (90); and

20 a pump (20) to transfer air from the first vessel (80) to the second vessel (90) or from the second vessel (90) to the first vessel (80);

wherein:

25 the pump (20) transfers air from the first vessel (80) into the second vessel (90) to cause pressure in the first vessel (80) to be lower than air pressure external to the first vessel (80) and cause pressure in the second vessel (90) to be higher than air pressure external to the second vessel (90) to cause water to be drawn into the first vessel (80) through the first entry valve (82) and water to be expelled from the second vessel (90) through the second exit valve (94);

30 the pump (20) transfers air from the second vessel (90) into the first vessel (80) to cause pressure in the second vessel (90) to be lower than air pressure external to the second vessel (90) and cause pressure in the first vessel (80) to be higher than air

pressure external to the first vessel (80) to cause water to be drawn into the second vessel (90) through the second entry valve (92) and water to be expelled from the first vessel (80) through the first exit valve (84); and

5 the first vessel (80) sinks deeper into the body of water while the second vessel (90) rises within the body of water as water enters the first vessel (80) while exiting the second vessel (90) and the first vessel (80) rises within the body of water while the second vessel (90) sinks deeper into the body of water as water exits the first vessel (80) while entering the second vessel (90).

10 12. The system as claimed in claim 11, further comprising a bladder located in the first vessel (80) and the second vessel (90) respectively wherein:

the first entry valve (82) permits entry of water into the bladder housed within the first vessel (80) and the first exit valve (84) permits exit of water out of the bladder in the first vessel (80);

15 the second entry valve (92) which permits entry of water into the bladder housed within the second vessel (90) and the second exit valve (94) permits exit of water out of the bladder in the second vessel (90);

20 the pump (20) transfers air from the first vessel (80) into the second vessel (90) to cause water to be drawn into the bladder housed in the first vessel (80) through the first entry valve (82) and water to be expelled from the bladder housed in the second vessel (90) through the second exit valve (94) and wherein the pump (20) transfers air from the second vessel (90) into the first vessel (80) to cause water to be drawn into the bladder housed in the second vessel (90) through the second entry valve (92) and water to be expelled from the bladder housed in the first vessel (80) through the first exit valve (84).

25

13. The system as claimed in claim 11, further comprising an intermediate reservoir (400) connectible to the pipeline (30) and in the body of water, wherein the intermediate reservoir (400) is fillable with water.

14. The system as claimed in claim 13, wherein the intermediate reservoir (400) is supplied or emptied by a first vessel (80) or second vessel (90) connected to the intermediate reservoir (400) through the pipeline (30).

Abstract**An Assembly and System for Pumping a Volume of Fluid through a Body of Water**

5 An assembly and system for pumping a volume of fluid over a body of water, comprising a shell (12) defining a volumetric space within a vessel (10) in which air is extractible from and introducible into, an opening (18) to allow air to be extracted from and supplied into the vessel (10) to allow fluid to be drawn in and expelled from the vessel (10), a first valve (16a) and a second valve (16b) to permit and restrict fluid entering and
10 exiting the vessel (10) and a pump (20) to extract and introduce air from and into the vessel (10) to cause fluid to be drawn into and expelled out of the vessel (10). The vessel (10) floats in the body of water.

Figure 1

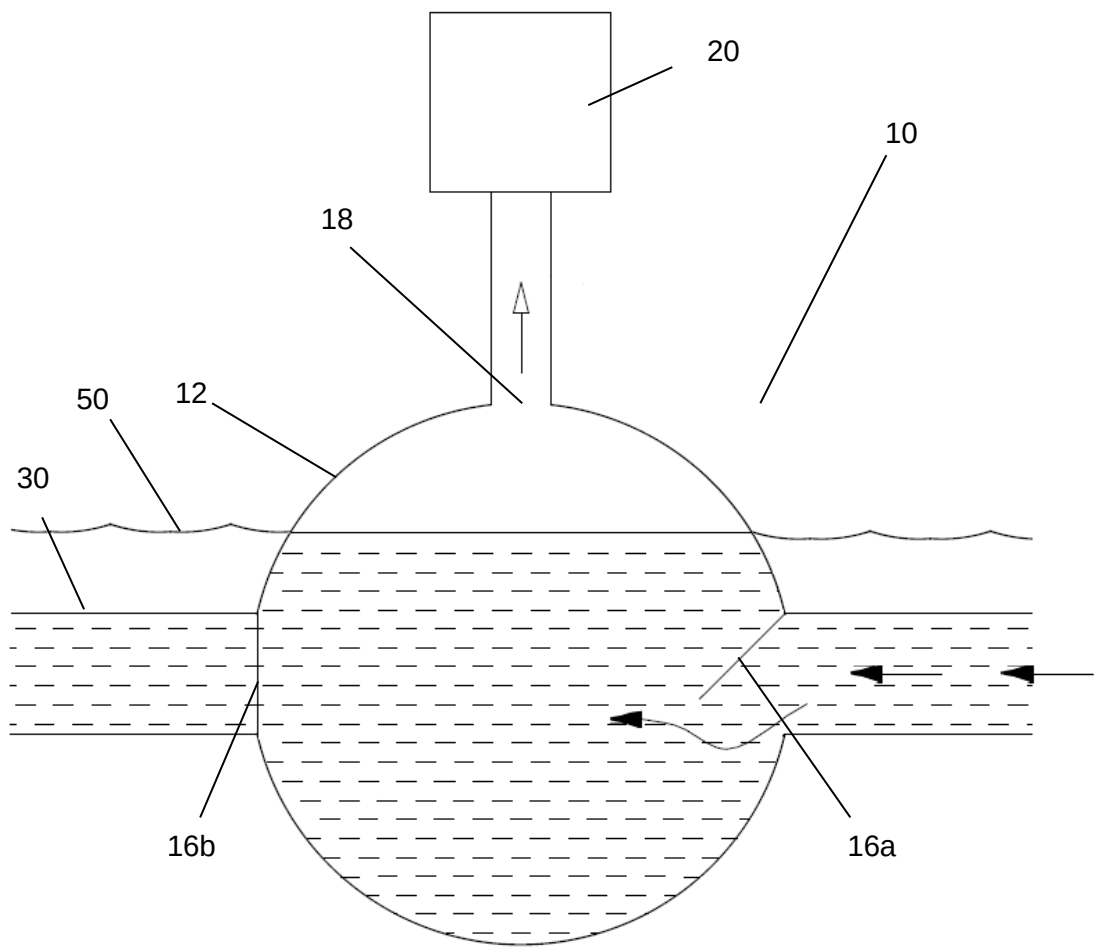


Figure 1

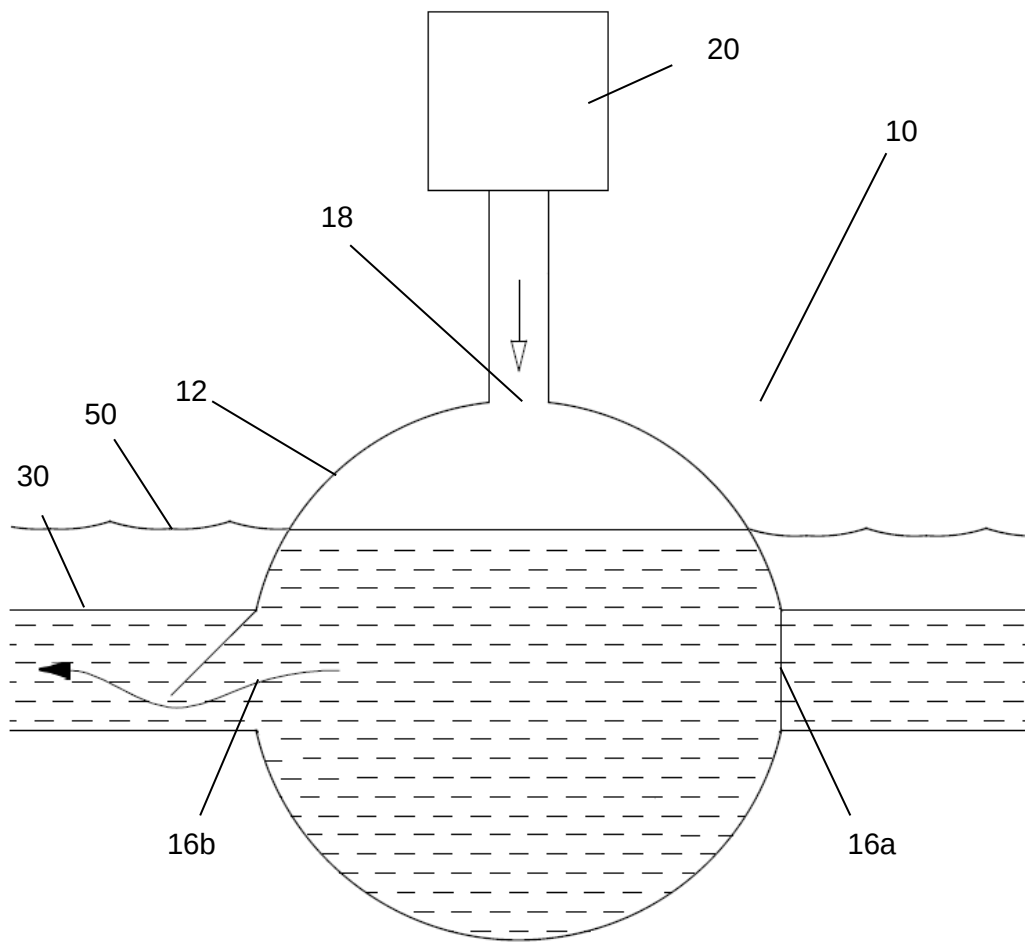


Figure 2

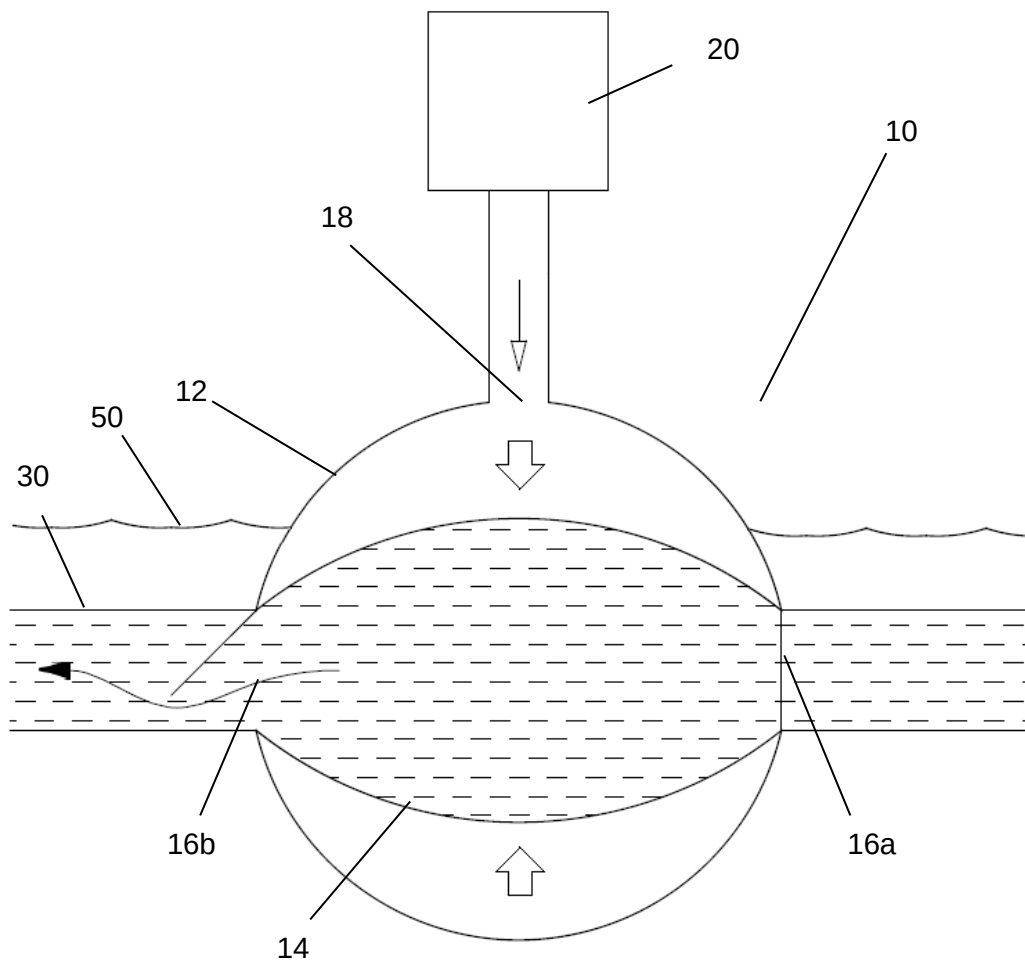


Figure 4

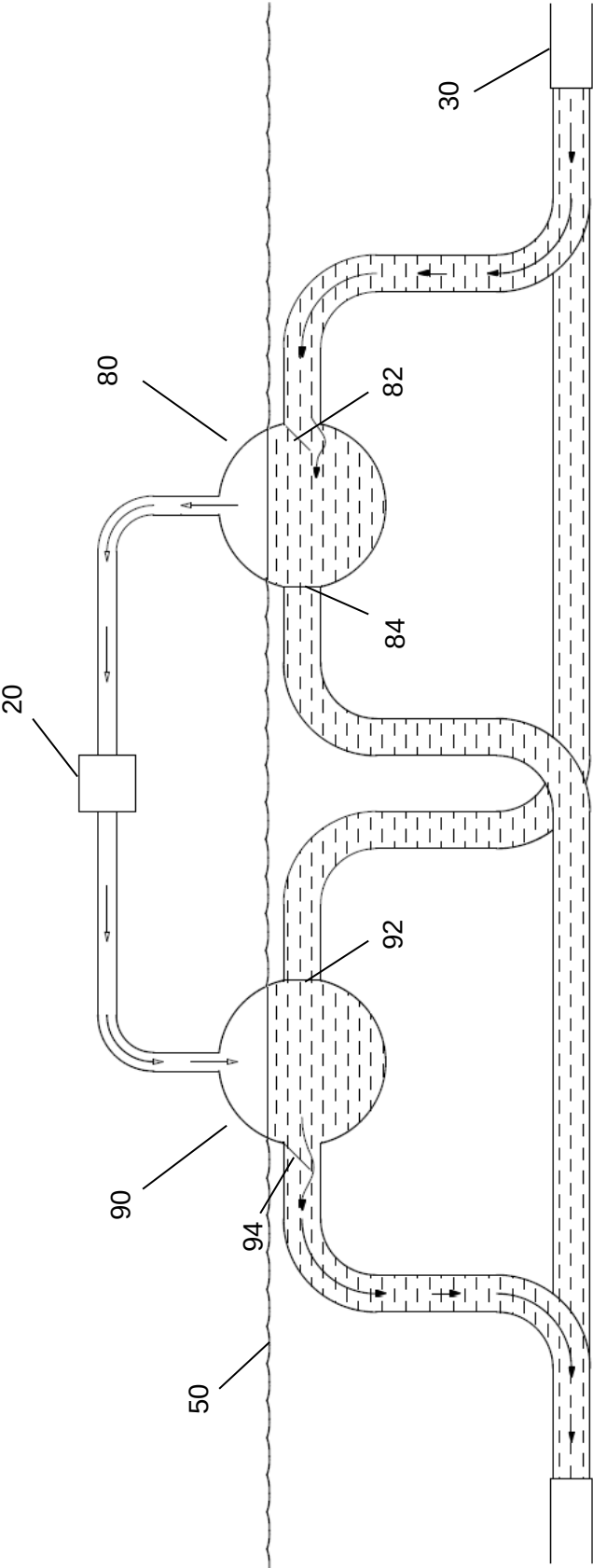


Figure 5



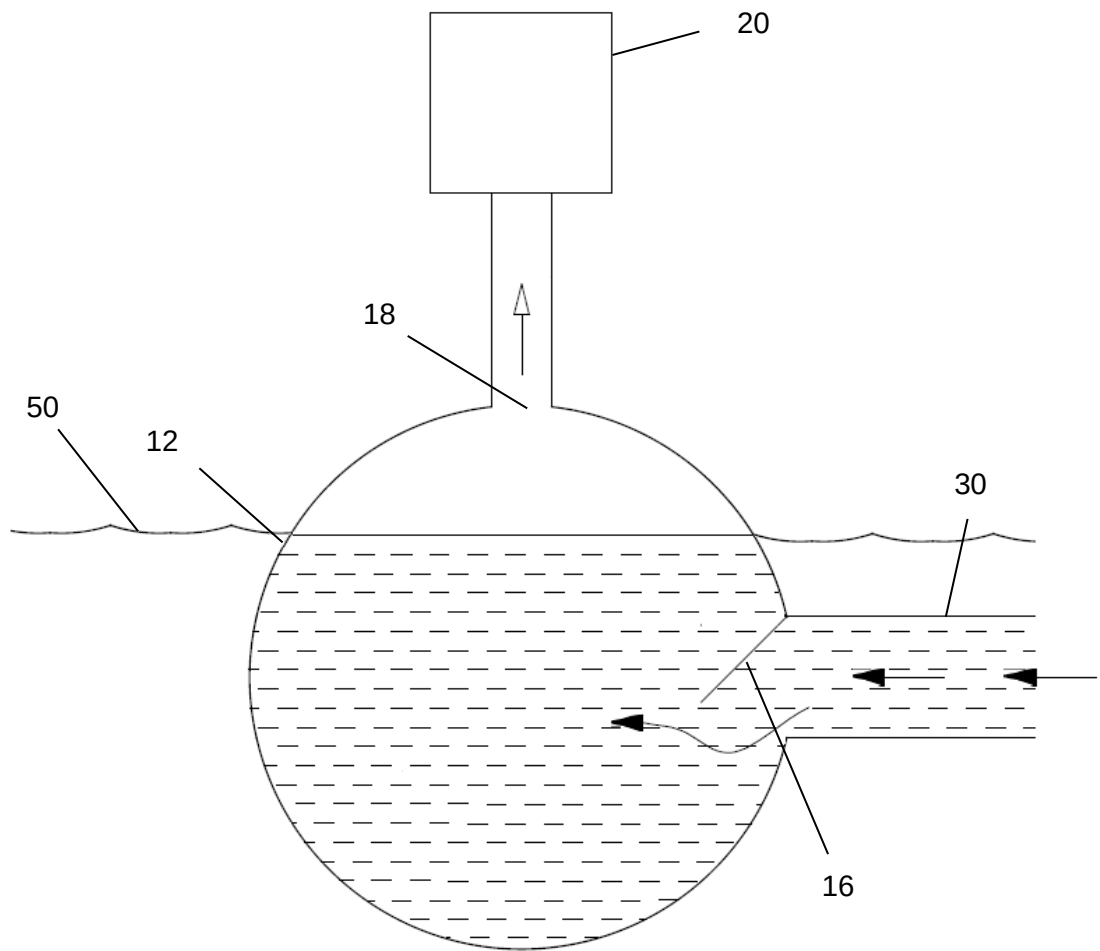


Figure 7

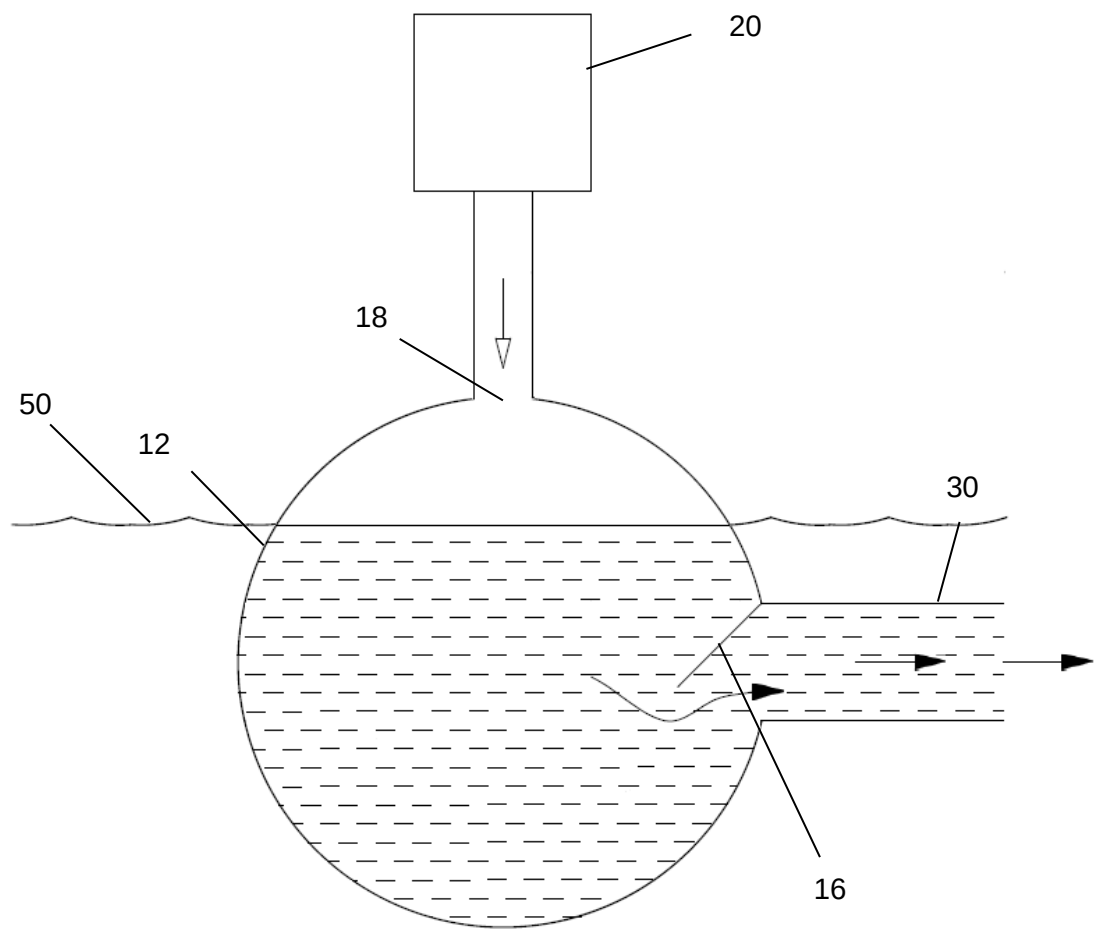


Figure 8

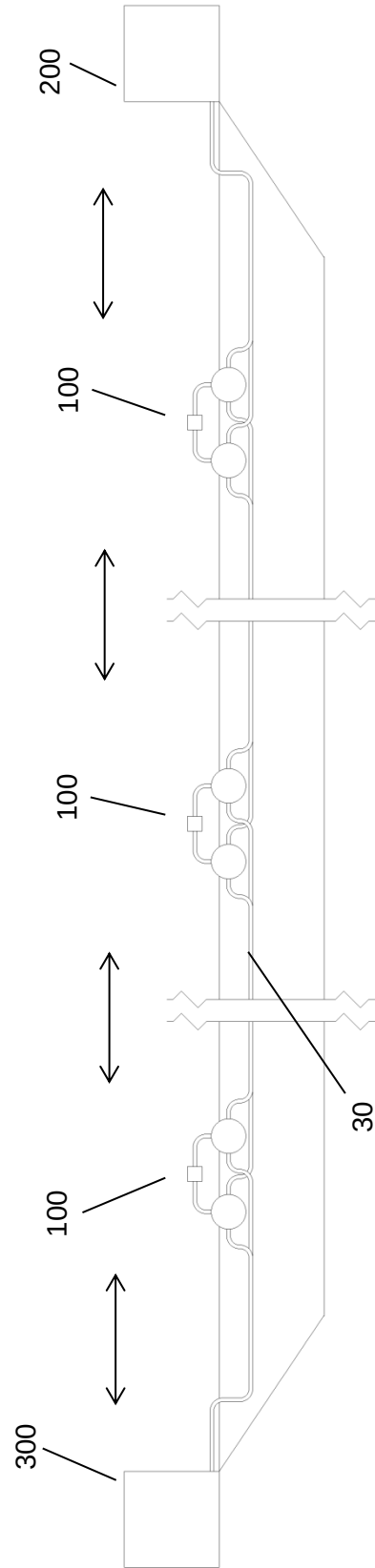


Figure 9

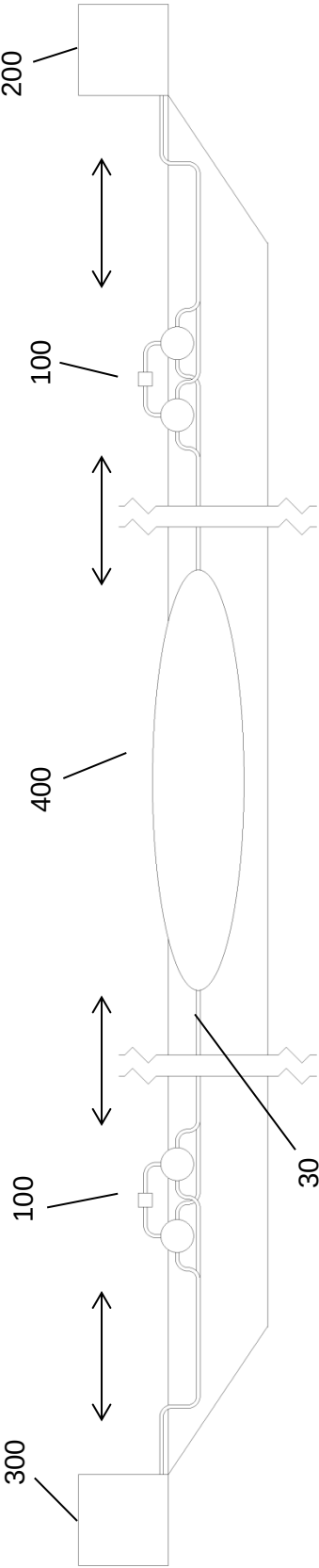


Figure 10