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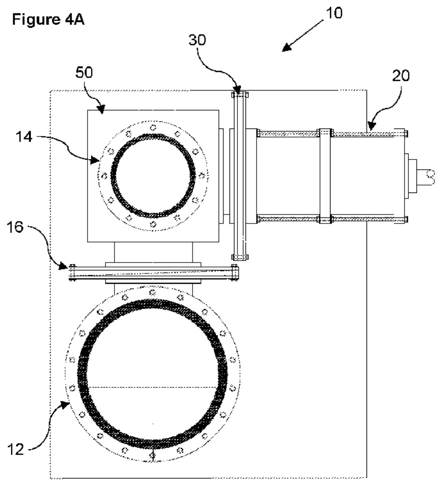

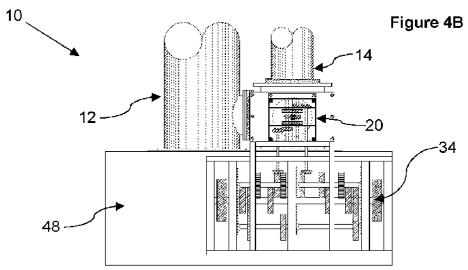

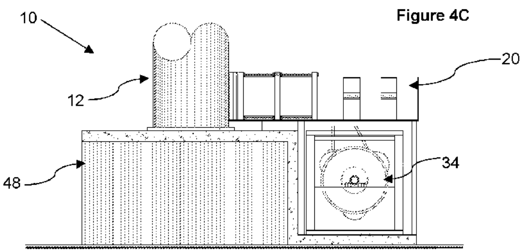

(57) **Abstract:** A hydrodynamic energy storage and electricity generator (10) is provided which comprises first and second fluid storage columns (12, 14), and an openable and closable conversion valve (16) therebetween. A return conduit (42) connects the first and second fluid storage columns (12, 14), with a turbine and generator assembly (26) being 5positioned on a fluid flow path of the return conduit (42). There is at least one energy storage device (36) associated with at least one hydrostatic cylinder (20) connected to the second fluid storage column (14). On opening of the conversion valve (16), fluid in the first fluid storage column (12) is permitted to flow into the second fluid storage column (14) to drive the at least one energy storage device (36) to store energy, and upon closing 10the conversion valve (16), fluid in the second fluid storage column (14) is hydromechanically directed via the return conduit (42) to the first fluid storage column (10), thereby driving the turbine and generator assembly (26) to generate electricity.

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Hydrodynamic Energy Storage and Electricity Generator

The present invention relates to a hydrodynamic energy storage and electricity generator, particularly for the generation of clean, renewable energy. The invention further relates to a method of generating electricity using hydrostatic potential energy as a storage and applied with mechanical processes as non-depletive static heads by reformation as renewable energy resources for a generator.

The world is currently experiencing the effects of climate change, and as such, there is a growing movement among heads of state, the general public, and the scientific community to attempt to mitigate and reverse the effects of global warming as a result of man-made events. There is significant research directed towards the generation of green or renewable energy that will underpin developments for new industries, new manufacturing, new jobs and skills opportunities based on low-cost clean energy solutions.

Despite the fact that existing environmentally-friendly power generation techniques are available, such as solar, wind, wave, geothermal, undersea current energy, or indeed salinity gradient generation, they have largely struggled to achieve wide adoption due to the high infrastructure cost including but not limited to transmission and distribution due to remoteness for the renewable energy sources when compared with mature fossil fuel technology and nuclear power, as well as often have additional undesirable features such as lack of aesthetic appeal, alongside other enduring downstream adverse effects.

It is therefore an object of the present invention to provide an apparatus for the generation of electricity which does not have the detrimental features known in the art.

According to a first aspect of the invention, there is provided a hydrodynamic energy storage and electricity generator comprising: a first fluid storage column; a second fluid storage column which is coupled to at least one hydrostatic cylinder; a valve assembly comprising at least an openable and closable conversion valve connecting the first and second fluid storage columns; a return conduit connecting the first and second fluid storage columns; a turbine and generator assembly being positioned on a fluid flow path of the return conduit; and an energy storage system comprising at least one energy storage device associated with the at least one hydrostatic cylinder; wherein, on opening of the conversion valve, fluid in the first fluid storage column is permitted to flow into the second fluid storage column, converting the potential energy difference into kinetic energy of the at least one hydrostatic cylinder, the at least one hydrostatic cylinder driving the at least one energy storage device of the energy storage system to store energy; and upon closing the conversion valve, fluid in the second fluid storage column being hydromechanically directed via the return conduit to the first fluid storage column, thereby driving the turbine and generator assembly to generate electricity.

The ability to utilise the fluid storage columns as a gravitational battery, and thereby use direct and reverse hydrodynamic power to store and generate electricity, advantageously provides a sustainable and clean power source which does not consume fossil fuel.

Preferably, the at least one energy storage device may include at least one flywheel.

A flywheel provides a suitable means of both instantly storing kinetic energy generated, and then be imparted for returning the stored energy to drive a reverse hydrostatic action at a later date.

Optionally, the energy storage system may comprise at least one drive means for effecting reverse hydrostatic action to the at least one hydrostatic cylinder.

Reverse hydrostatic action is the mechanism by which the pressure differential between the first and second fluid storage columns can be regenerated, in order to begin the energy generation cycle anew.

Preferably, the drive means of the energy storage system may be coupled with a mechanical linkage connected to the at least one hydrostatic cylinder.

The coupling of the drive means from the hydrostatic cylinder directly to the energy storage system allows for minimal losses as work is performed on the output, improving the efficiency of the apparatus.

The drive means may comprise at least one recovery flywheel.

The provision of a recovery flywheel allows for coupling to a recovery motor, which may assist with plant start-up, as well as balancing the system when there is over-powering due to the hydrostatic potential.

Optionally, the energy storage system may comprise a modulating clutch associated with the at least one energy storage device.

A modulating clutch allows for quick change between the energy input to the energy storage system for storage, recovery, and motor modulation, as well as rapid discharges of high inertia energy to operate the system.

The turbine and generator assembly may be positioned at or adjacent to a top of at least one of the first and second fluid storage columns.

An elevated turbine and generator assembly ensures that the fluid flow passing over the assembly occurs on the reformation step of the process, that is, the regeneration of the pressure differential for the system.

Preferably, the hydrodynamic energy storage and electricity generator may operate in a closed-cyclical manner.

Since this is a closed system, the losses due to work on external parts of the system are significantly reduced, creating a highly efficient energy generation system.

The valve assembly may further comprise an openable and closable cylinder valve connecting the second fluid storage column with the at least one hydrostatic cylinder.

The cylinder valve allows for the sealing of the hydrostatic cylinder with respect to the second fluid storage column, advantageously providing a mechanism by which the fluid can be returned under pressure to the first fluid storage column.

The hydrodynamic energy storage and electricity generator may further comprise a valve controller for operating the conversion valve and cylinder valve in a disruptive sequence.

A disruptive sequence of valve opening and closing is the preferred mechanism by which the necessary fluid pressure imbalances in conjunction with the physical phenomenon of equilibration can be created in order to generate electricity.

Preferably, the valve assembly may comprise one or more rapid-valves.

Rapid, non-restrictive valves are important to ensure that there are minimal losses in the closed system, and reduce the cycle duration, improving the energy efficiency of the apparatus.

The hydrodynamic energy storage and electricity generator may further comprise a further hydrostatic cylinder associated with the first fluid storage column, the hydrostatic cylinder and further hydrostatic cylinder being connected via a mechanical linkage.

The use of a further hydrostatic cylinder on the first fluid storage column provides a means by which reverse hydrostatic action can drive fluid back into the first fluid storage column, via a negative relative pressure generation.

Preferably, the first fluid storage column may have a greater diameter than the second fluid storage column.

The greater diameter in the first, ballast storage column allows for the use of hydraulic mass to counter-cycle for the reversed thrust.

According to a second aspect of the invention, there is provided a vessel having a propulsion system comprising a hydrodynamic energy storage and electricity generator in accordance with the first aspect of the invention.

A vessel utilising a hydrodynamic energy storage and electricity generator in accordance with the present invention may be well suited towards super-long-range activities, since there is no need for refuelling with conventional fossil fuels to continue on its journey.

According to a third aspect of the invention, there is provided a power plant having a hydrodynamic energy storage and electricity generator in accordance with the first aspect of the invention.

A distributed or localized power plant system can advantageously produce clean energy on a large scale base load, depending on the plant configuration.

According to a fourth aspect of the invention, there is provided a method for generating electricity using hydrostatic energy, the method comprising the steps of: a] using a pressure differential between fluid in first and second fluid storage columns to generate a hydromechanical thrust power; b] regenerating the pressure differential by transporting fluid from the second fluid storage column to the first fluid storage column; and c] providing a turbine and generator assembly on a fluid flow path during step b] to generate electricity as the fluid is transported from the second fluid storage column to the first fluid storage column.

A method of using hydrostatic energy to generate electricity based on pressure differentials in different fluid columns has the advantage of creating a gravitational battery without the need for fossil fuel input. This provides a clean source of energy.

Preferably, during step a], the hydromechanical thrust power may be stored prior to step b] to effect reverse hydromechanical thrust power.

Optionally, during step b] the stored energy may be utilised to transport the fluid from the second fluid storage column to the first fluid storage column.

The generation of energy via the pressure differentials in the columns provides the means of returning the fluid to generate the imbalance. This requires a storage mechanism which is also capable of providing drive to create a reverse hydrostatic energy further downstream in the apparatus by the use of the hydraulic-mass sized to counter-cycle for the reverse thrust.

The hydrodynamic thrust power may be generated via a disruptive process.

Optionally, the disruptive process may be a disruptive sequential valve opening and/or closing process.

A disruptive instantaneous valve opening and closing sequence, in a contemporaneous sequence of active and reactive conversion, transformation and reformation processes, may be the simplest way to operate the apparatus to obtain a net energy gain, which is clearly a pre-requisite for continuous electricity generation.

The invention will now be more particularly described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a diagrammatic representation of a first embodiment of the hydrodynamic energy storage and electricity generator in accordance with the first aspect of the invention;

Figure 2 shows a process diagram for the operation of the hydrodynamic energy storage and electricity generator of Figure 1;

Figure 3 shows a graphical representation of the net energy gain at the flywheel over a plurality of CTER cycles of the hydrodynamic energy storage and electricity generator of Figure 1;

Figure 4A shows a plan view of the hydrodynamic energy storage and electricity generator in accordance with the first aspect of the invention;

Figure 4B shows a front view of the hydrodynamic energy storage and electricity generator of Figure 4A; and

Figure 4C shows a side view of the hydrodynamic energy storage and electricity generator of Figure 4A.

Referring to Figure 1, there is illustrated a hydrodynamic energy storage and electricity generator, referenced globally at 10.

The hydrodynamic energy storage and electricity generator 10 comprises a first, ballast, hydrostatic fluid storage column 12 and a second, converter, hydrostatic fluid storage column 14, the first fluid storage column 12 preferably having a greater diameter or width than that of the second fluid storage column 14.

The working fluid in question is preferably water-based silicone in liquid form; however, other fluids could be used, including other liquids of various specific gravities, oils, or gases, including air, in various methodologies that can be constituted as static heads.

The first and second fluid storage columns 12, 14 are connected via an openable and closable conversion valve 16, preferably positioned at or adjacent to the bases of the first and second fluid storage columns 12, 14. The conversion valve 16 is preferably a rapid non-restrictive valve system that is capable of being rapidly opened and closed in a fraction of a second, or in quick succession.

The first fluid storage column 12 is connected to a first hydrostatic cylinder 18 and the second fluid storage column 14 is connected to a second hydrostatic cylinder 20. The first and second hydrostatic cylinders 18, 20 are interlinked with one another, preferably via mechanical linkages 22, which include advanced mechanical devices, such as a high precision super critical compressive entrapment device, for transfer of energy via direct hydrostatic conversion and reverse hydraulic thrust. Whilst the hydrostatic cylinders 18, 20 are described in the singular, it will be appreciated that a plurality of cylinders arrange in series would work in much the same manner. This also ensures that the thrust-cycle per second is made to produce output electricity as kWh or MWh.

At the equilibration, the liquid column of the first hydrostatic fluid storage column 12 can be entirely applied as a force in the first hydrostatic cylinder 18. The negative pressure can be optimized by computations whereby the pressure is greater at a smaller diameter to the first hydrostatic fluid storage column 12 and given the formula P=F/A. This negative pressure is later also converted into force and kinetic energy.

To facilitate liquid weight into an unimpeded force at the first hydrostatic fluid storage column 12, a disc can be provided equipped with regulated valves to open and close as the disc transvers in the liquid column. Further this disc is connected by a steel wire coupled to a sun gear and a planetary wheel that drives the piston and shaft at the first hydrostatic cylinder 18.

The first and second fluid storage columns 12, 14 have air-breather ports at the top ends. The first fluid storage column 12 is connected to the second fluid storage column 14 at or adjacent to their respective top ends. In the bridging connector 24 between the first and second fluid storage columns 12, 14, there is provided a fluid turbine and generator assembly 26 comprising a fluid turbine, preferably a water turbine, and a generator. An electrical governor is provided with the generator to stabilize electrical frequency and voltage.

The second hydrostatic cylinder 20 is a high-pressure hydrostatic cylinder configured to generate linear motion in response to a change in fluid pressure in the second fluid storage column 14. In a preferred embodiment, the second hydrostatic cylinder 20 comprises a piston 28 and a shaft acting as a rack gear to turn an associated set of gears, thereby transferring the linear kinetic energy into rotation energy. The shaft may be guided by a gland fixed on an end head-block of the second hydrostatic cylinder 20. Whilst this is a preferred option, any appropriate transmission apparatus 32 can be considered.

There is preferably a cylinder valve 30 which is positioned between the second fluid storage column 14 and the second hydrostatic cylinder 20, which can be operated in sequence with the conversion valve 16 in a disruptive manner to generate the necessary pressure imbalances. The cylinder valve 30 and conversion valve 16 are both rapid-valves. One example might be an impulse reactive valve having very large vanes for instant opening and closing. This disruptive sequence may be controlled via a dedicated valve controller having a pre-determined opening and closing sequence.

The transmission apparatus 32 is then coupled to an energy storage system 34, comprising at least one energy storage device. In the depicted and preferred embodiment, a first energy storage device is provided in the form of one or more flywheels 36, and more preferably, as an array of flywheels, capable of storing the kinetic energy from the second hydrostatic cylinder 20.

A further flywheel, formed as a recovery flywheel 38 is also provided as part of the energy storage system 34, which may be directly or indirectly connected to a stand-by recovery motor 40.

The array of flywheels may be fitted with one or more rapid and high-precision mechanical clutches to modulate the flywheels 36, 38 between energy input for energy storage, recovery, and motor modulation, and rapid discharges of high inertia energy to do specific work, according to predetermined or calculated sequences or timings.

One or more of the flywheels 36 is then coupled to an electrical generator that is governed by an electric governor at the flywheel 36, in order for correct voltage and frequency output.

The circulation of fluid from the second fluid storage column 14 to the first fluid storage column 12 is via a return conduit 42 which preferably starts at or adjacent to the second hydrostatic cylinder 20 and extends up past the fluid turbine in the bridging connector 24. Fluid flowing along the flow path of the return conduit 42 with high inertia will drive the fluid turbine to generate electricity.

The first fluid storage column 12 has a fluid level FL1 therein, and the second fluid storage column 14 has a fluid level FL2. The fluid in the hydrodynamic energy storage and electricity generator 10 is preferably a proprietary liquid having a density of or around 1.35. When the conversion valve 16 is closed, then a pressure differential can be generated between the first and second fluid storage columns 12, 14. When the conversion valve 16 is opened, however, the pressure differential performs a specific work to circulate the fluid medium.

The pressure differential is generated by an imbalance in the fluid levels FL1, FL2 created by a disruptive process between the first and second fluid storage columns 12, 14. Fluid from the second fluid storage column 14 is diverted vis the return conduit 42 into the first fluid storage column 12 whilst the conversion valve 16 is closed.

Once a pressure differential is present, the cyclical process of energy generation can be implemented, known as a CTER process, having the steps of conversion, transformation, equilibration, and reformation.

Conversion is the process of converting the pressure differential between the first and second fluid storage columns 12, 14 into hydrostatic potential energy by direct opening of the conversion valve 16, which creates a hydromechanical implosive thrust power. Opening the conversion valve 16 increases the hydrostatic potential energy of the second hydrostatic cylinder 20. The kinetic energy of the linear motion generated is stored by the flywheel 36, which is driven by the second hydrostatic cylinder 20, which thereby creates a storage step.

Transformation of the process of utilising the pressure differential between the first and second fluid storage columns 12, 14, effectively turning the first and second fluid storage columns 12, 14 into a gravitational battery.

Reformation is the hydromechanical reverse cycle, that is the means by which the fluid medium is transferred back into the first fluid storage column 12 against gravitational forces.

The CTER process is outlined in Figure 2.

Where there is a pressure differential present between the first and second fluid storage columns 12, 14, the hydrostatic pressure being greater in the first fluid storage column 12, opening of the conversion valve 16 and the cylinder valve 30 in a disruptive sequence creates thrust to drive the second hydrostatic cylinder 20. In this sense, a disruptive sequence directly relates to the equilibrium states which are disrupted to produce work and at the same time to naturally produce pressure gradients that, through equilibration, produces further work for the overall process flow that provides a net mechanical advantage, and thus net energy. A disruptive process can also refer to the induced production of work on energy conversion, energy reformation, and energy transformation using the natural physical phenomenon in mass, gravity and equilibration, the net mechanical power value potential of which is much greater on equilibration and transformation than at conversion. As such, the reformation process is countered, resulting in a mechanical advantage and net energy gain. The induced hydrostatic conditions may be created by any means, with the fluid medium being water, or any liquid, oil, or gas.

Preferably, the conversion valve 16 is opened first to permit fluid to flow from the first fluid storage column 12 to the second fluid storage column 14, and the cylinder valve 30 is opened once the conversion valve 16 has been closed.

The mechanical linkage 22 to the first hydrostatic cylinder 18 ensures that the drive of the second hydrostatic cylinder 20 urges the first hydrostatic cylinder 18 to create a negative pressure or vacuum in the first fluid storage column 12 upon equilibration of the fluid pressures in the first and second fluid storage columns 12, 14. The mechanical linkage 22 may be provided with on or actuators 46 associated respectively with the first and second hydrostatic cylinders 18, 20 in order to correctly transmit the mechanical power therebetween in response to hydrostatic thrust or drive from the energy storage system 34.

The kinetic energy of the second hydrostatic cylinder 20 is stored in the energy storage system 34 via one or more flywheels 36, utilising a kinematic linkage 32. By the use of electronically actuated mechanical clutches, the kinetic energy stored in the array of flywheels is modulated automatically.

In the event that there is excess mechanical power to the flywheels 36 or if a generator is faulty, the recovery motor 40 is provided, or indeed an output generator 44 could be provided.

The recovery flywheel 38 then stores and imparts mechanical power to do work on the reverse action, that is, to provide reverse thrust to the second hydrostatic cylinder 20. The net gain of energy at the flywheels 36 is indicated in Figure 3, showing how energy gain is achievable in the closed system.

If the cylinder valve 30 is closed, then the fluid trapped in the second hydrostatic cylinder 20 will be driven by the piston up through the return conduit 42, thereby being directed back into the first fluid storage column 12. This will return the pressure differential between the first and second fluid storage columns 12, 14, provided that the conversion valve 16 remains closed.

The mechanical linkage 22 between the first and second hydrostatic cylinders 18, 20 also has the advantage of providing a negative pressure or vacuum in the first fluid storage column 12, thus reducing the energy burden of returning the fluid via the return conduit 42 at high inertia.

In the process of returning the fluid via the return conduit 42, the fluid passes the fluid turbine, driving it so as to produce electricity at the generator. This electricity can then be used as required. The cycle can then begin anew.

The pressure differential in the first and second fluid storage columns 12, 14 is pre-computed and pre-determined to provide the correct mechanical power by the reversed hydrostatic mass to do the work returns of fluid medium by passing through the turbine and generator assembly 26.

An exemplary arrangement of the hydrodynamic energy storage and electricity generator 10 is shown in Figures 4A to 4C, showing how the various components might interconnect. A base unit 48 may be provided upon which the first and second fluid storage columns 12, 14 are mounted, with the second fluid storage column 14 being mounted on top of a dedicated chamber 50 from which the second hydrostatic cylinder 20 extends in a horizontal direction. The flywheel 34 can then be mounted internally to the base unit 48.

The process is a closed cycle of active and reactive liquid-mass rapid-flows on contemporaneously continuous energy conversion, transformation, and reformations. Energy here could be any of potential energy, gravitational energy, kinetic energy, or mechanical energy, depending on where the cycle of energy conversion is at any given time.

The resultant energy gain of a closed system can be defined as:

$$\Delta Ed = Qd - W$$

Where Qd is the sum of mechanical power derived by the conversion, transformation, and reformation cycle, and W is the work done by the system on its surroundings and mechanical losses. If contemporaneous disruptive conversion and reformation works are continued, so at the sums of Qd and ΔEd.

ΔEd can therefore be categorised as follows:

$$\Delta Ed = E1 + E2 - E3 + E4 + E5$$

Where E1 is the hydromechanical implosive thrust power, generated during the conversion process at the second hydrostatic cylinder 20, E2 is the kinetic energy stored in the flywheel (herein having a stated value of 1, such that E2=1), E3 is the hydromechanical reverse cycle power to return the liquid in the hydrostatic cylinder subsequent to the conversion process, and mechanical loss in the system, E4 is work performed at the turbine generator upon liquid in the second hydrostatic cylinder 20 being returned with inertia to the top of the first hydrostatic storage column 12, and E5 is the work done at the second hydrostatic storage tower 14 during subsequent equilibration on the transformation process. Provided that a net gain can be made during the kinetic energy storage sequence, which, using the mechanical clutch arrangement, is possible, then an efficient mechanical process is produced to yield a mechanical advantage, and an energy gain is achieved.

The aforementioned technology for electricity generation is designed as distributed power systems or as an embedded or base load generator, which generally refers to a generator which is installed within the demand-load systems to supply electricity for a specific area, or for a dedicated power supply for a specific usage. Examples of such specific usages include factories, data centres, building complexes, such as hospitals or residential complexes, as well as remote island states or regional centres.

In particular, the technology could be used to construct a power plant. In one embodiment, a plant could be constructed as a 1MW module consisting of four 250kW units, each unit comprising a hydrostatic energy storage and electricity generator as previously described. The output would be 23MWh per day for each 1MW installed capacity, and the plant availability or capacity factor would be 95% since the system is not dependent on environmental factors. This would allow for 24/7 operation.

The electrical output could be provided as pure sine-wave VAC or HVDV, and a typical generator output terminal would be 6.6kVAC 50Hz PF0.95.

Additionally, the technology could be used in other installations, such as fixed land-based, on seafaring vessels, particularly for super-long-range vessels, and as a mobile generator unit.

The present invention is therefore an open-cycle system of a one energy boundary with a conversion of positive hydrostatic potential energy into mechanical or kinetic energy. The net amount of mechanical energy converted into electricity is equal to the hydrostatic potential energy of the height difference between the first and second columns. Fluid flowing out after conversion to mechanical energy is returned and reformed or re-stored in a storage such as a tower, silo, or other type of storage vessel, as energy input in the power cycle, and thus the continuous fluid circulations and/or reformation in a closed-cycle as inflows as energy input which is needed to repeat the power cycle.

It is therefore possible to provide a hydrodynamic energy storage and electricity generator which is able to provide clean energy via a closed cycle process and is therefore suitable for use in many new and existing contexts.

The words ‘comprises/comprising’ and the words ‘having/including’ when used herein with reference to the present invention are used to specify the presence of stated features, integers, steps or components, but do not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable sub-combination.

The embodiments described above are provided by way of examples only, and various other modifications will be apparent to persons skilled in the field without departing from the scope of the invention as defined herein.

Claims

1. A hydrodynamic energy storage and electricity generator (10) comprising:

a first fluid storage column (12);

a second fluid storage column (14) which is coupled to at least one hydrostatic cylinder (20);

a valve assembly comprising at least an openable and closable conversion valve (16) connecting the first and second fluid storage columns (12, 14);

a return conduit (42) connecting the first and second fluid storage columns (12, 14);

a turbine and generator assembly (26) being positioned on a fluid flow path of the return conduit (42); and

an energy storage system (34) comprising at least one energy storage device associated with the hydrostatic cylinder (20);

wherein, on opening of the conversion valve (16), fluid in the first fluid storage column (10) is permitted to flow into the second fluid storage column (14), converting the potential energy difference into kinetic energy of the at least one hydrostatic cylinder (20), the at least one hydrostatic cylinder (20) driving the at least one energy storage device of the energy storage system (34) to store energy; and

upon closing the conversion valve (16), fluid in the second fluid storage column (14) being hydromechanically directed via the return conduit (42) to the first fluid storage column (10), thereby driving the turbine and generator assembly (26) to generate electricity.

2. A hydrodynamic energy storage and electricity generator (10) as claimed in claim 1, wherein the at least one energy storage device includes at least one flywheel (36).

3. A hydrodynamic energy storage and electricity generator (10) as claimed in claim 1 or claim 2, wherein the energy storage system comprises at least one drive means for effecting reverse hydrostatic action to the at least one hydrostatic cylinder (20).

4. A hydrodynamic energy storage and electricity generator (10) as claimed in claim 3, wherein the drive means of the energy storage system is coupled with a mechanical linkage connected to the at least one hydrostatic cylinder (20).

5. A hydrodynamic energy storage and electricity generator (10) as claimed in claim 3 or claim 4, wherein the drive means comprises at least one recovery flywheel (38).

6. A hydrodynamic energy storage and electricity generator (10) as claimed in any one of the preceding claims, wherein the energy storage system comprises a modulating clutch associated with the at least one energy storage device.

7. A hydrodynamic energy storage and electricity generator (10) as claimed in any one of the preceding claims, wherein the turbine and generator assembly (26) is positioned at or adjacent to a top of at least one of the first and second fluid storage columns (12, 14).

8. A hydrodynamic energy storage and electricity generator (10) as claimed in any one of the preceding claims, wherein the hydrodynamic energy storage and electricity generator (10) operates in a closed-cyclical manner.

9. A hydrodynamic energy storage and electricity generator (10) as claimed in any one of the preceding claims, wherein the valve assembly further comprises an openable and closable cylinder valve (30) connecting the second fluid storage column (14) with the at least one hydrostatic cylinder (20).

10. A hydrodynamic energy storage and electricity generator (10) as claimed in claim 9, further comprising a valve controller for operating the conversion valve (16) and cylinder valve (30) in a disruptive sequence.

11. A hydrodynamic energy storage and electricity generator (10) as claimed in any one of the preceding claims, wherein the valve assembly comprises one or more rapid-valves.

12. A hydrodynamic energy storage and electricity generator (10) as claimed in any one of the preceding claims, further comprising a further hydrostatic cylinder (18) associated with the first fluid storage column (12), the at least one hydrostatic cylinder (20) and further hydrostatic cylinder (18) being connected via a mechanical linkage (22).

13. A hydrodynamic energy storage and electricity generator (10) as claimed in any one of the preceding claims, wherein the first fluid storage column (14) has a greater diameter than the second fluid storage column (12).

14. A vessel having a propulsion system comprising a hydrodynamic energy storage and electricity generator (10) as claimed in any one of the preceding claims.

15. A power plant having a hydrodynamic energy storage and electricity generator (10) as claimed in any one of claims 1 to 13.

16. A method for generating electricity using hydrostatic energy, the method comprising the steps of:

a] using a pressure differential between fluid in first and second fluid storage columns (12, 14) to generate a hydromechanical thrust power;

b] regenerating the pressure differential by transporting fluid from the second fluid storage column (14) to the first fluid storage column (12); and

c] providing a turbine and generator assembly (26) on a fluid flow path during step b] to generate electricity as the fluid is transported from the second fluid storage column (14) to the first fluid storage column (12).

17. A method as claimed in claim 16, wherein during step a], the hydromechanical thrust power is stored prior to step b] to effect reverse hydromechanical thrust power.

18. A method as claimed in claim 17, wherein during step b] the stored energy is utilised to transport the fluid from the second fluid storage column (14) to the first fluid storage column (12).

19. A method as claimed in any one of claims 16 to 18, wherein during step a], the hydrodynamic thrust power is generated via a disruptive process.

20. A method as claimed in claim 19, wherein the disruptive process is a disruptive sequential valve opening and/or closing process.

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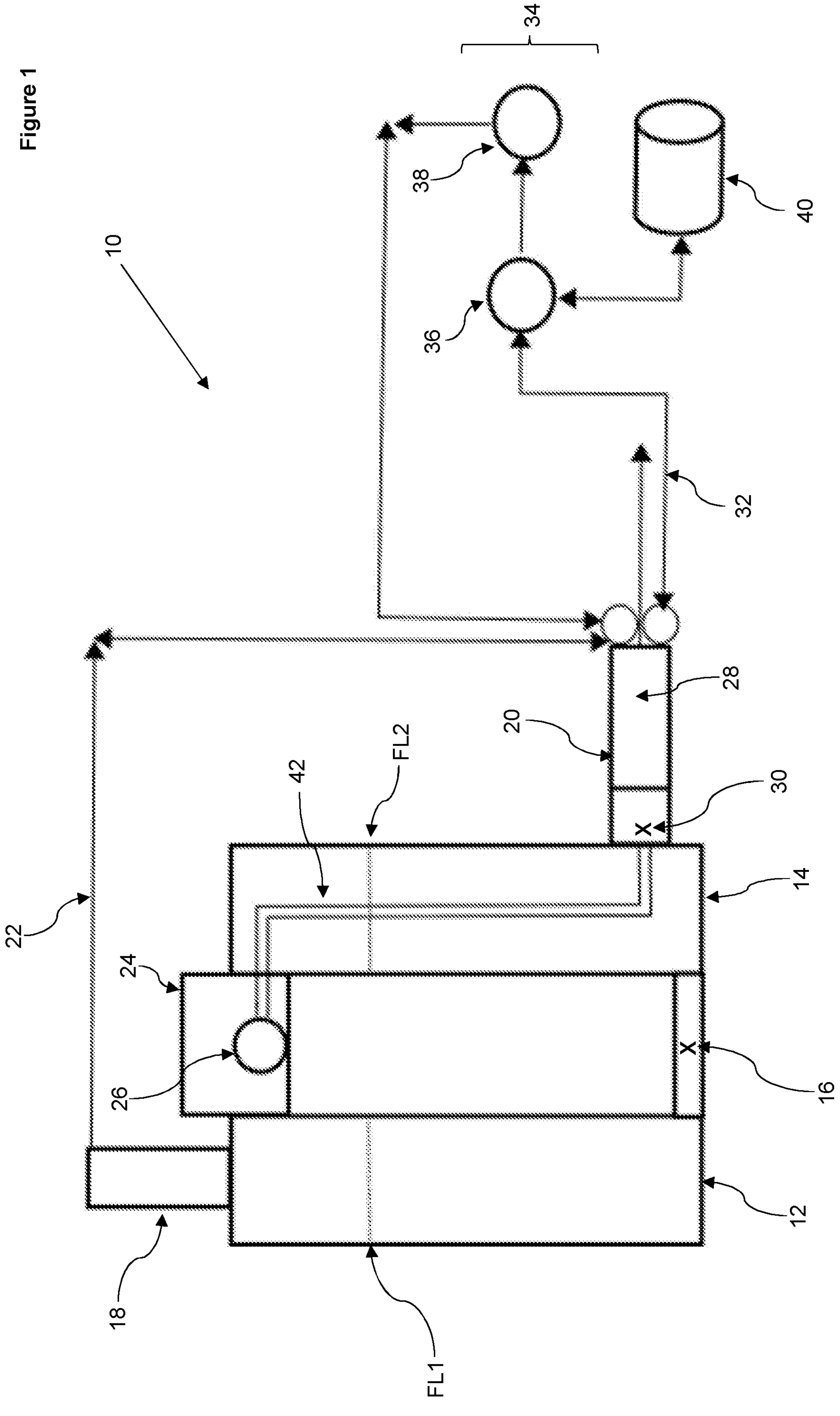
Figure 1



2/4

Figure 2

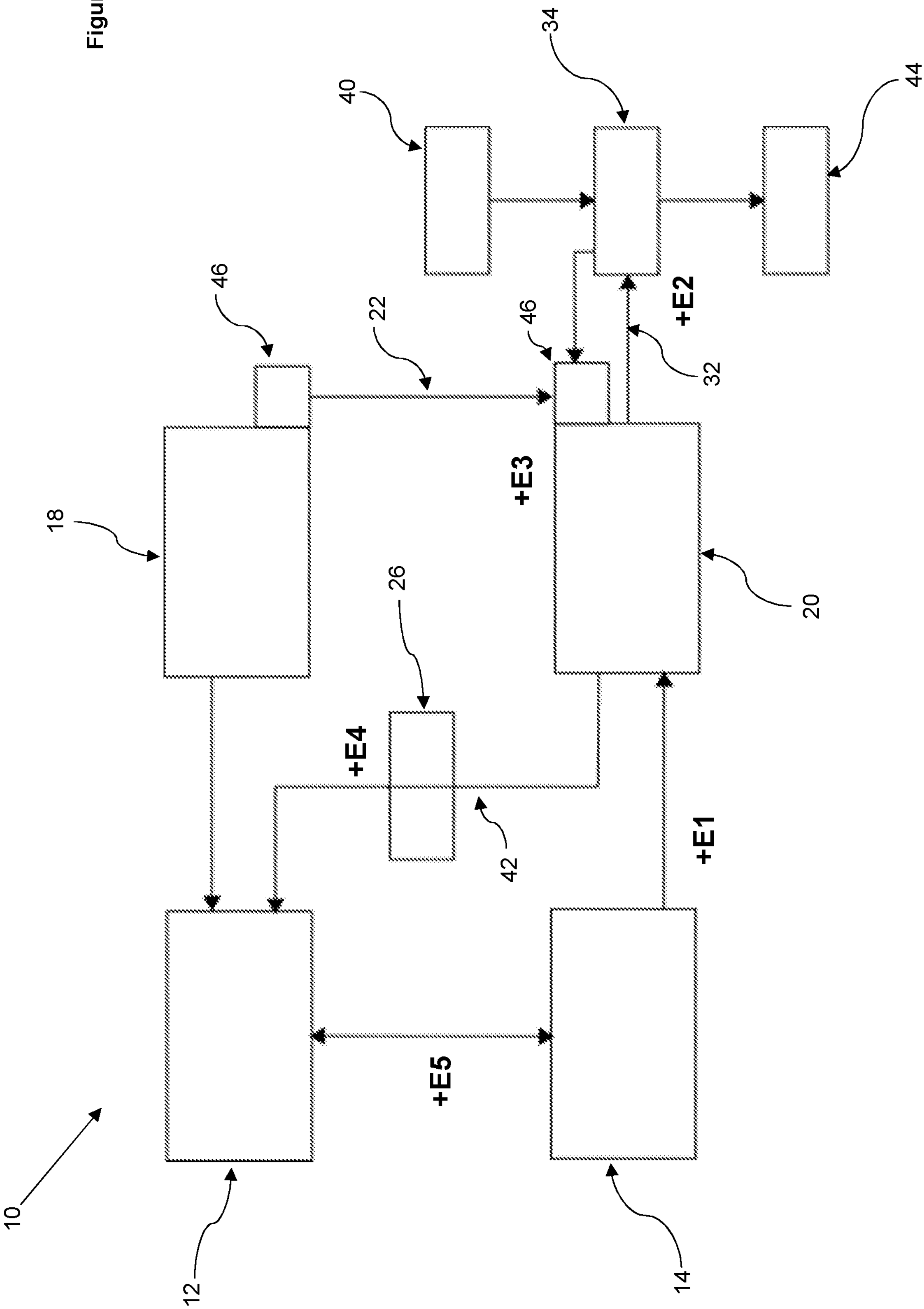


Figure 3

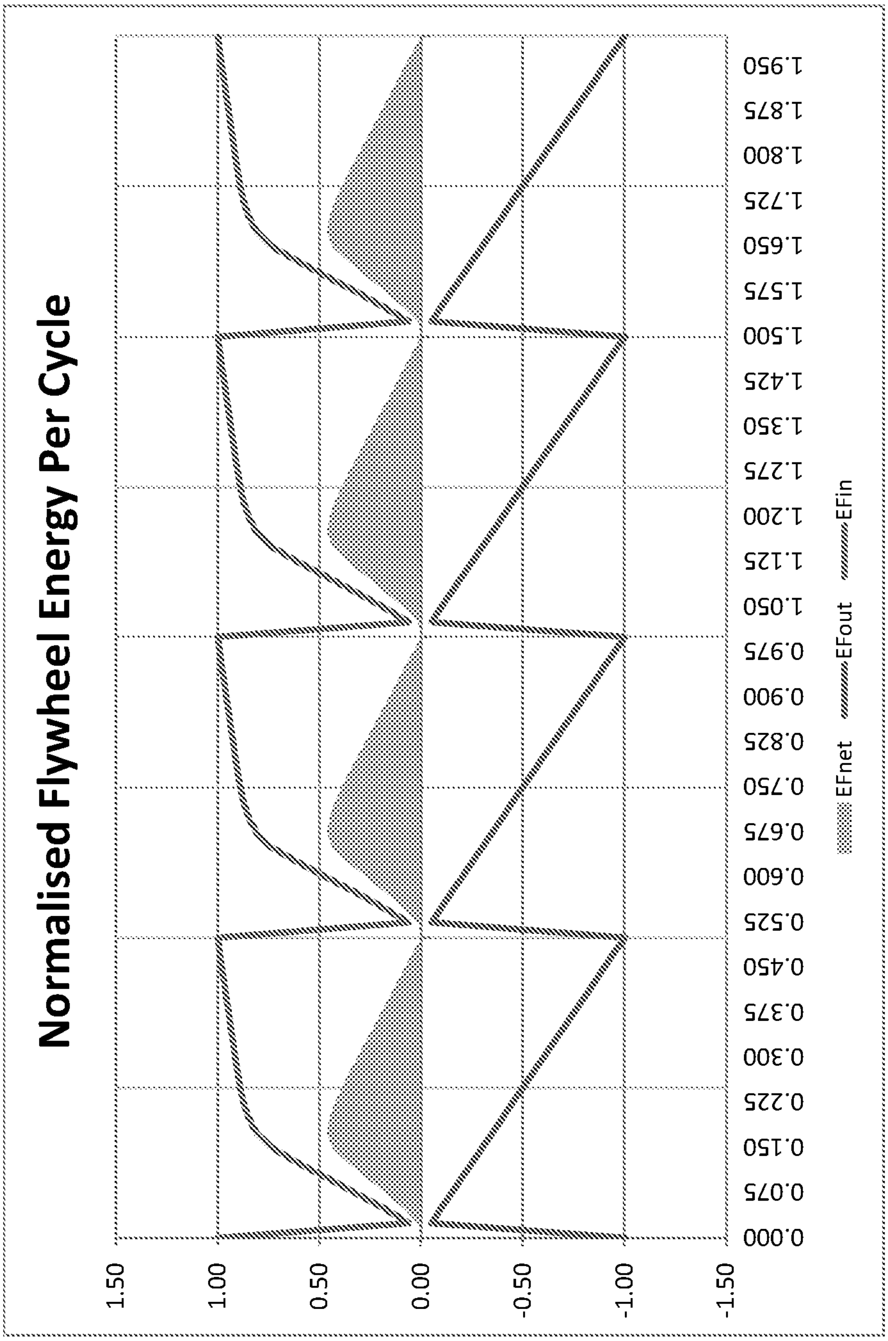

Normalised Flywheel Energy Per Cycle
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
0.000
0.075
0.150
0.225
0.300
0.375
0.450
0.525
0.600
0.675
0.750
0.825
0.900
0.975
1.050
1.125
1.200
1.275
1.350
1.425
1.500
1.575
1.650
1.725
1.800
1.875
1.950
EFnet
EFout
EFin

Figure 4B

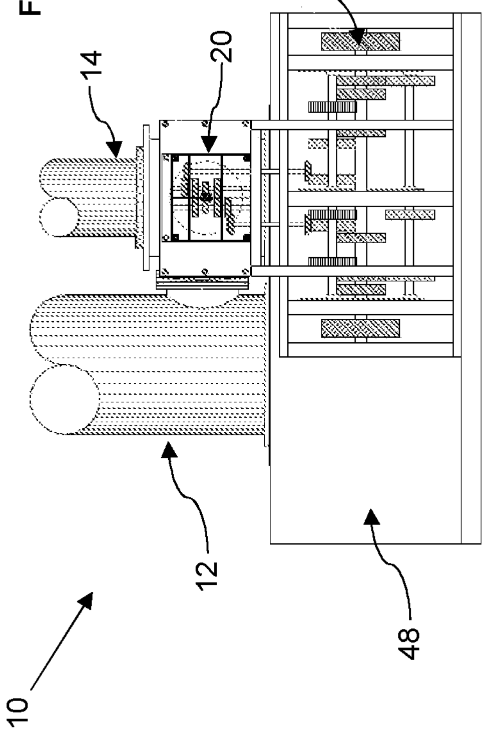


Figure 4C

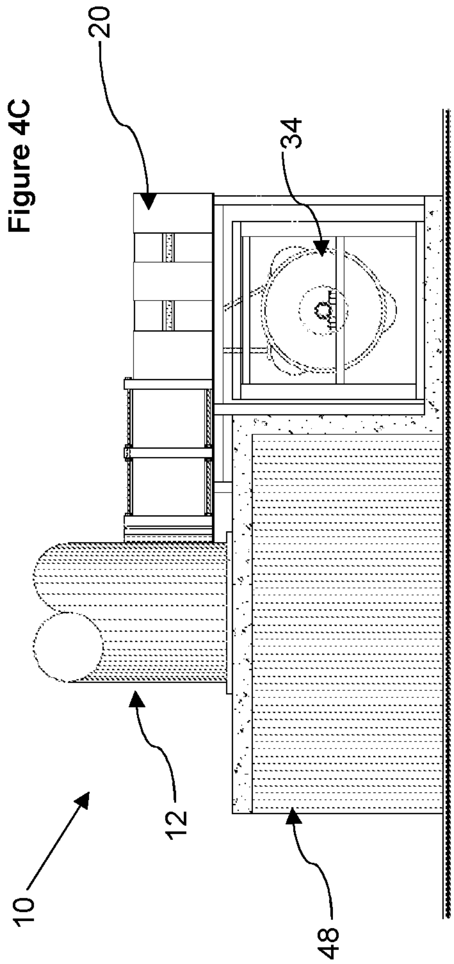
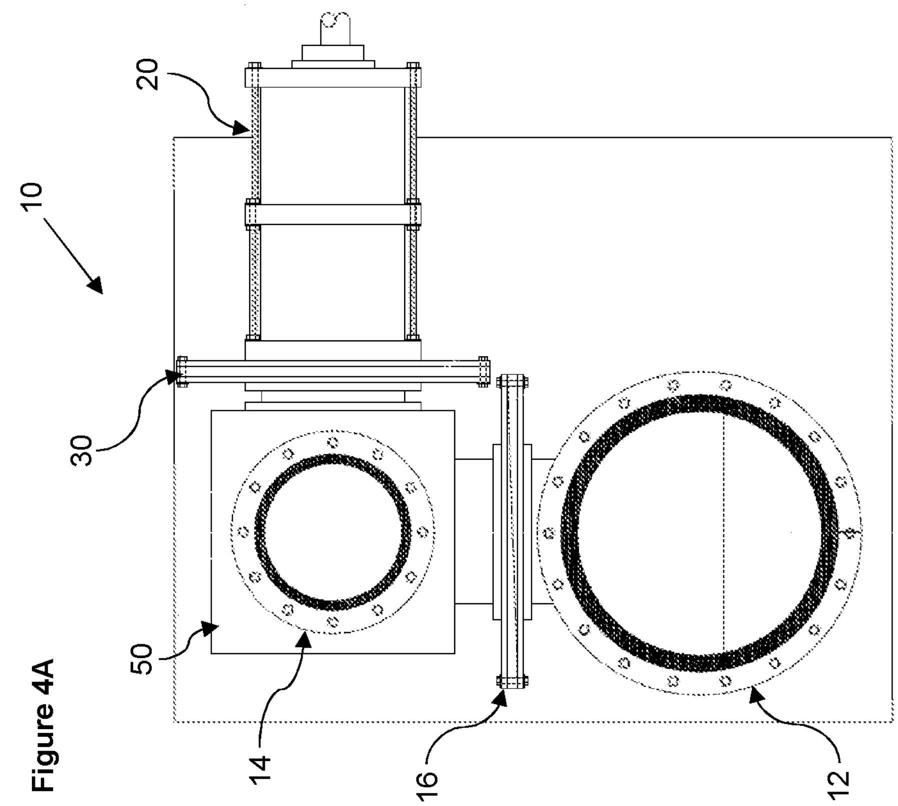


Figure 4A



INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2023/050091

A. CLASSIFICATION OF SUBJECT MATTER
INV. F03B17/02
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015/330356 A1 (GNANI OTELLO [IT]) 19 November 2015 (2015-11-19) paragraphs [0001], [0017] - [0019], [0023], [0041] - [0048]; figures 1,2	1-20
A	US 2015/362124 A1 (FAVY CLAUDE [FR] ET AL) 17 December 2015 (2015-12-17) paragraphs [0001], [0049], [0050], [0103] - [0105]	1-20
A	US 2017/082123 A1 (MOMEN AYYOUB MEHDIZADEH [US] ET AL) 23 March 2017 (2017-03-23) abstract; figures 1,2	1-20
A	CN 101 260 857 A (FENG QI [CN]) 10 September 2008 (2008-09-10) abstract; figure 1	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 July 2023	14/07/2023

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Lux, Ralph

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2023/050091

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 2015330356	A1	19-11-2015	CN 104884788	A	02-09-2015
			EP 2941561	A1	11-11-2015
			US 2015330356	A1	19-11-2015
			WO 2014106550	A1	10-07-2014
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			ES 2897557	T3	01-03-2022
			FR 3001025	A1	18-07-2014
			US 2015362124	A1	17-12-2015
			WO 2014111649	A1	24-07-2014
US 2017082123	A1	23-03-2017	NONE		
CN 101260857	A	10-09-2008	NONE		