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(71) Applicants:
- **ZF Friedrichshafen AG**
  88046 Friedrichshafen (DE)
- **ZF PADOVA S.r.l**
  35030 Caselle di Selvazzano (PD) (IT)

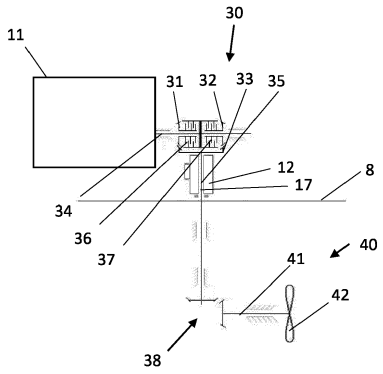
(72) Inventors:
- **Zottele, Michele**
  38123 Trento (IT)
- **Caracristi, Mattia**
  35030 Caselle di Selvazzano (PD) (IT)

(74) Representative: **ZF Friedrichshafen AG**
Gewerblicher Rechtsschutz
Löwentalerstraße 20
88046 Friedrichshafen (DE)

(54) HYBRID DRIVE APPARATUS FOR A WATER VEHICLE

(57) A hybrid drive apparatus for a water vehicle is provided. The hybrid drive apparatus comprises a combustion engine (11), a transmission output shaft (35), an electric motor (12) and motor pump device (17). The combustion engine (11) is configured for driving the transmission output shaft (35). The electric motor (12) is configured for driving the transmission output shaft (35) as well as for driving the motor pump device (17). The motor pump device (17) is mechanically linked to the drive shaft of the electric motor (12) in all operating states of the hybrid drive apparatus.

FIG. 1



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Description

Technical field

[0001] The present invention refers to a hybrid drive apparatus for a water vehicle, and to a water vehicle with such a hybrid drive apparatus.

Prior art

[0002] Hybrid drive apparatuses for water vehicles are known. The hybrid drive apparatuses may comprise a combustion engine and an electric motor for providing a propulsion of the water vehicle. The hybrid drive apparatus may comprise a pump device for lubricating and activating elements of the hybrid drive apparatus. The pump device may be driven by an additional lubrication motor. US 2022 289 355 relates to a marine propulsion apparatus with an internal combustion engine and a generator motor.

Description of the invention

[0003] It is an object of the present invention to provide an improved hybrid drive apparatus with which supply of a lubrication fluid to elements of the hybrid drive apparatus is ensured in all driving modes of the water vehicle. The object is solved by a hybrid drive apparatus comprising the features of claim 1. Advantageous further developments are subject-matter of the dependent claims.

[0004] In a first aspect, a hybrid drive apparatus is provided for a water vehicle. The water vehicle may be formed as a ship, e.g. a cargo ship or a sailing boat. The water vehicle may be configured for being used in water, for example a sea, a lake, or a river. The water vehicle may comprise a hull. The hull may form at least partially a boundary line between the water vehicle and the water. The hybrid drive apparatus comprises a combustion engine, a transmission output shaft, an electric motor and a motor pump device. The combustion engine is configured for driving the transmission output shaft. The electric motor is configured for driving the transmission output shaft as well as for driving the motor pump device. The motor pump device is mechanically linked to a drive shaft of the electric motor in all operating states of the hybrid drive apparatus. The drive shaft of the electric motor may be formed as a rotor.

[0005] When two elements are mechanically linked, the elements are directly or indirectly coupled to each other such that a movement of one element causes a reaction of the other element. For example, a mechanical link may be provided by a frictional engagement or a positive locking. The mechanical link may correspond to a meshing of corresponding gears of the two elements. Between the elements, further elements like one or more spur gear stages may be present. A permanent torque-proof connection is a connection for that the two elements are rigidly coupled with each other. The elements may be formed as separate elements connected torque-proofly with each other, e.g. by a spline connection, or may be formed integrally. The torque-proof connection between the two elements may be selectively provided and removed by a shift element, for example a sliding sleeve, a clutch, or a brake. The torque-proof connection may be provided if the shift element is engaged. The torque-proof connection may be removed if the shift element is disengaged.

[0006] The hybrid drive apparatus may comprise a transmission module. The transmission module may comprise a transmission input shaft and the transmission output shaft. The combustion engine may comprise a drive shaft. The drive shaft of the combustion engine may be mechanically linked, e.g. torque-proofly connected, to the transmission input shaft. The transmission module may comprise a shift element for providing and removing a mechanical link between the transmission input shaft and the transmission output shaft. The transmission module may provide a transmission ratio of 1, <1 or >1 between a rotational speed of the transmission input shaft and a rotational speed of the transmission output shaft.

[0007] The motor pump device may be formed as a fluid pump, e.g. as an oil pump. The motor pump device may be formed as a gear pump. The motor pump device may be configured for providing a fluid output, e.g. a fluid flow and a fluid pressure, e.g. at a fluid output element of the motor pump device. The motor pump device may be fluidly, e.g. indirectly, connected to a storage area, e.g. an oil sump, e.g. for sucking fluid. The motor pump device may be configured for lubricating elements, for example at least one of gears, bearings, shafts, and shift elements, as clutches, of the drive apparatus.

[0008] If two elements are fluidly connected, a fluid, e.g. oil, may be guided from one element to another element. The fluid connection may be formed for a low leakage, such that the fluid is guided substantially completely from one element to the other element. The fluid connection may be formed by a channel, a pipe, a tube, a sleeve, or the like. The fluid direction may be formed as a direct fluid connection without any additional elements fluidly between the fluidly connected elements. The fluid connection may be formed as an indirect fluid connection via additional elements in between. Under a fluid flow direction, a direction of the fluid is understood, in which it moves to reach elements to which the fluid is to be supplied.

[0009] The motor pump device may comprise an input shaft. The input shaft of the motor pump device may be mechanically linked, e.g. torque-proofly connected, to the drive shaft of the electric motor. The input shaft of the motor pump device may be formed by the drive shaft of the electric motor. The motor pump device may be integrally formed with the electric motor. The motor pump device may be configured for being driven, e.g. at the input shaft, by at least one of the drive shaft of the electric motor and a propulsion of a propulsion element of the

hybrid drive apparatus, for example during a movement of the water vehicle within the water. The motor pump device may be configured for being driven by a drag effect or hydrodynamic effect of the propulsion element being moved through the water. The motor pump device may be configured for being driven without the electric motor being driven, for example during sail cruising of the water vehicle, when the water vehicle is driven in a sailing mode. In the sailing mode, the combustion engine and the electric motor may not be driven. Then, the water vehicle may be moved through the water without a propulsion of one of the combustion engine and the electric motor.

[0010] In one embodiment of the hybrid drive apparatus, the input shaft of the pump device may be connected torque-proofly to and may be arranged coaxially to the drive shaft of the electric motor. This provides a hybrid drive apparatus with a small installation space.

[0011] In one embodiment of the hybrid drive apparatus, the hybrid drive apparatus may comprise a main pump device being configured for being driven by the combustion engine. The main pump device may be drivable by the electric motor in addition to the combustion engine. The main pump device may be formed as an oil pump. The main pump device may be formed as a gear pump. The main pump device may be configured for lubricating elements of the drive apparatus. The main pump device may be configured for lubricating as well as operating elements of the hybrid drive apparatus, e.g. one or more shift elements. The main pump device may comprise an input shaft. The input shaft of the main pump device may be mechanically linked, e.g. torque-proofly connected, to a drive shaft of the combustion engine. The main pump device may be configured for providing a fluid output, e.g. a fluid flow and a fluid pressure, e.g. at a fluid output element of the main pump device. The main pump device may be configured for providing a fluid output, e.g. oil pressure, for operating the at least one shift element, e.g. a clutch. The main pump device may be fluidly, e.g. indirectly, connected to the storage area, e.g. the oil sump, e.g. for sucking fluid.

[0012] In one embodiment of the hybrid drive apparatus, the hybrid drive apparatus may comprise a transmission module having a transmission input shaft. The transmission input shaft may be configured for being mechanically linkable to the drive shaft of the combustion engine. The transmission module may be configured for transmitting a driving force from the transmission input shaft to the transmission output shaft for driving the transmission output shaft in two different rotation directions. The transmission input shaft can be mechanically linked to the drive shaft of the combustion engine. The transmission input shaft can be torque-proofly connected to the drive shaft of the combustion engine. The transmission input shaft can be torque-proofly connectable to the drive shaft of the combustion engine via a shift element.

[0013] The transmission module may be formed as a reverse transmission. The rotation directions of the transmission output shaft may be constituted by a first rotation direction, e.g. a clockwise rotation direction, and a second rotation direction, e.g. a counterclockwise rotation direction. The transmission input shaft may be supported rotatably around a transmission input axis. The transmission input axis may be arranged in a longitudinal or an axial direction. The longitudinal direction may be constituted by a direction in which the water vehicle is moved during a propulsion by the hybrid drive apparatus or by wind. The transmission output shaft may be supported rotatably around a transmission output axis. The transmission output shaft and the transmission output axis may be arranged transversely, e.g. perpendicularly, to the transmission input shaft and the transmission input axis. The transmission output axis may be aligned in a vertical direction, e.g. a gravitational direction. The vertical direction may be perpendicular to the longitudinal direction. The vertical direction may be coincident with the gravitational direction when the hybrid drive apparatus is installed in the water vehicle and the water vehicle is placed on the water.

[0014] In one embodiment of the hybrid drive apparatus, the transmission module may have a first input gear, a second input gear and an output gear. The output gear may be torque-proofly connected to the transmission output shaft. The first input gear may be torque-proofly connectable to the transmission input shaft via a first shift element. The second input gear may be torque-proofly connectable to the transmission input shaft via a second shift element. The first input gear and the second input gear may be arranged coaxially to each other and may be in engagement with the output gear such that the output gear is drivable by the first input gear in the first rotational direction and is drivable by the second input gear in the second rotational direction opposite to the first rotation direction. The first rotational direction may be constituted by the clockwise rotation direction. The second rotational direction may be constituted by the counterclockwise rotation direction.

[0015] The first input gear and the second input gear may be arranged at opposing sides of the transmission output shaft in the axial direction. The first input gear and the second input gear may be arranged coaxially to the transmission input shaft. At least one of the first input gear and the second input gear may be formed as a pinion. At least one of the first input gear and the second input gear may be formed as a bevel gear. The output gear may be formed as a bevel gear or a crown gear. The number of teeth of the output gear may be larger than the number of teeth of one of the first input gear and the second input gear. The first input gear and the second input gear may comprise the same pitch diameter. The first input gear and the second input gear may comprise the same number of teeth. The pitch diameter of the first input gear may be larger or smaller than the pitch diameter of the second input gear. In this case, the transmission output shaft may be inclined with respect to the vertical direction.

[0016] At least one of the first shift element and the

second shift element may be operable by pressurized fluid, e.g. hydraulic pressure such as oil pressure. At least one of the first shift element and the second shift element may be formed as a friction clutch. At least one of the first shift element that the second shift element may be formed as a multi-disc clutch. At least one of the motor pump device and the main pump device may be configured for lubricating discs, e.g. friction discs or plates, of at least one of the first shift element at the second shift element. At least one of the first shift element and the second shift element may be a positive locking shift element, e.g. a positive locking clutch.

[0017] At least one of the first shift element and the second shift element may provide an engaged state, in which the respective shift element provides a torque-proof connection between two elements. At least one of the first shift element and the second shift element may provide a disengaged state, in which the respective shift element removes the torque-proof connection between the two elements. The first shift element and the second shift element may be arranged in the axial direction between the first input gear and the second input gear. The first shift element and the second shift element may be arranged coaxially with respect to each other. The first shift element and the second shift element may be arranged coaxially to the transmission input shaft.

[0018] The motor pump device may be configured for lubricating the first shift element and the second shift element. The motor pump device may be configured for operating a further shift element, e.g. at least one of a hybrid shift element and an output shift element. The motor pump device may be indirectly fluidly connected to the fluid storage area, e.g. for sucking fluid. A filter device may be interposed between the pump device and the fluid storage area. The filter device may be formed as an oil filter. The pump device may be fluidly connected to a non-return valve. The non-return valve may be fluidly connected to at least one of the first shift element and the second shift element for providing lubrication of at least one of the first shift element and the second shift element.

[0019] The main pump device may be configured for lubricating as well as operating the first shift element and the second shift element. The main pump device may be indirectly fluidly connected to the fluid storage area, e.g. for sucking fluid. A filter device may be interposed between the main pump device and the fluid storage area. The filter device may be formed as an oil filter. The main pump device may be fluidly connected to a pressure relief valve. The pressure relief valve may be configured for providing a fluid flow output when the fluid comprises a minimum fluid pressure, e.g. 2 bar, or higher. The pressure relief valve may be fluidly connected to a heat exchanger. The heat exchanger may be formed as a cooling unit, e.g. an oil cooling unit. The heat exchanger may be fluidly connected to at least one of the first shift element and the second shift element for providing lubrication of at least one of the first shift element and the second shift element.

[0020] The main pump device may be fluidly connected to a shift valve. The shift valve may be configured for providing pressurized fluid to at least one of the first shift element and the second shift element for operating the at least one of the first shift element and the second shift element. The main pump device may be configured for operating a further shift element, e.g. at least one of the hybrid shift element and the output shift element. The shift valve may comprise a first solenoid and a second solenoid. The first solenoid may be configured for providing pressurized fluid to the first shift element. The second solenoid may be configured for providing pressurized fluid to the second shift element. At least one of the first solenoid and the second solenoid may be configured for being electrically operated. At least one of the shift valve, the first shift element and the second shift element may be fluidly connected to the fluid storage area, e.g. for outputting pressurized fluid, e.g. after engaging at least one of the first shift element and the second shift element. By outputting pressurized fluid from one of the first shift element and the second shift element, the respective shift element may be disengageable.

[0021] The hybrid drive apparatus may be configured for increasing a total fluid output, e.g. a total fluid flow rate. The total fluid flow rate may be constituted by a fluid output of the main pump device and a fluid output of the motor pump device.

[0022] In one embodiment of the hybrid drive apparatus, the hybrid drive apparatus may comprise a propulsion module having a propulsion shaft and a propulsion element. The propulsion element may be connected torque-proofly to the propulsion shaft. The propulsion shaft may be mechanically linked to the transmission output shaft. The propulsion shaft may be rotatably supported at a stationary element. The stationary element may be formed by the hull of the water vehicle or a housing of the drive apparatus. This has the advantage that the propulsion element may be supported rotatably, e.g. by a bearing unit, in a stable manner by the propulsion shaft. The propulsion shaft may extend from an inner side of the water vehicle through the hull to an outside of the water vehicle into the water. This has the advantage that the bearing unit may be positioned within the water vehicle and separated from the water. This leads to a high lifetime of the drive apparatus. The propulsion element may be formed as a propeller, for example as a non foldable propeller, a fixed propeller, a fixed pitch propeller or a feathering propeller.

[0023] In one embodiment of the hybrid drive apparatus, the drive apparatus may comprise an output transmission having an input bevel gear and an output bevel gear. The input bevel gear may be configured for being mechanically linkable to the transmission output shaft. The output bevel gear may be configured for being mechanically linkable to the propulsion shaft. The input bevel gear may be mechanically linkable to the transmission output shaft via a shift element. The input bevel gear may be mechanically linked to the transmission output

shaft. The input bevel gear may be connectable torque-proofly to the transmission output shaft via a shift element. The input bevel gear may be connected torque-proofly to the transmission output shaft. The output bevel gear may be mechanically linkable the propulsion shaft via a shift element. The output bevel gear may be mechanically linked the propulsion shaft. The output bevel gear may be connectable torque-proofly to the propulsion shaft via a shift element. The output bevel gear may be connected torque-proofly to the propulsion shaft. The transmission output shaft and the propulsion shaft may be arranged transversely, for example perpendicularly, with respect to each other. The output transmission may provide a transmission ratio from the input bevel gear to the output bevel gear of 1, >1 or <1.

[0024] In one embodiment of the hybrid drive apparatus, the transmission output shaft, the output transmission and the propulsion module may be formed as a POD drive. A POD drive or an azimuth thruster may comprise a housing called POD. The transmission output shaft, the output transmission and the propulsion module may be housed at least partially by the housing. The housing may be fluidly sealed. The housing may be attached to the hull, e.g. downward of the hull in the vertical direction. The transmission output shaft may extend from an inside of the hull to an inside of the housing. The propulsion shaft may extend from an inside of the housing to an outside, e.g. water. The propulsion element may be arranged at the outside of the housing, e.g. within the water. The POD drive may be pivotable around the transmission output axis.

[0025] In one embodiment of the hybrid drive apparatus, the hybrid drive apparatus is configured for providing a driving mode which may be at least one of a combustion mode, a hydrogeneration mode, a zero noise mode, a boost mode, a generator mode and an ECO mode. The drive modes can be categorized into three modes: combustion mode, electric mode and hybrid mode. In the combustion mode, the combustion engine may be driven and the electric motor may not be driven. In the electric mode, the electric motor may be driven and the combustion engine may not be driven. In the hybrid mode, the electric motor as well as the combustion engine may be driven.

[0026] The electric mode may comprise one of the hydrogeneration mode and the zero noise mode. In the hydrogeneration mode, the hybrid drive apparatus may be configured for generating electric energy by driving the electric motor by the propulsion element being driven by a drag effect or hydrodynamic effect due to the propulsion element being moved through the water. Thereby, electric energy may be generatable and storable, e.g. in an energy storage like a battery. The hydrogeneration mode may be applicable during a sailing mode of the water vehicle, e.g. when the water vehicle is moved through the water without a propulsion by one of the combustion engine and the electric motor. In the zero noise mode, the hybrid drive apparatus may be configured for being driven by the electric motor and without the combustion engine. In the zero noise mode, no pollution is generated by the combustion engine. The zero noise mode may be applicable during docking maneuvers or during no wake cruising.

[0027] The hybrid mode may comprise one of the boost mode, the generator mode and the ECO mode. In the boost mode, the hybrid drive apparatus may be configured for adding power of the electric motor to the power of the combustion engine for a propulsion of the water vehicle. The boost mode may be applicable in a full power and intermediate power operating condition of the water vehicle. The electric motor may be used for small accelerations or small changes in speed of the water vehicle. Thereby, it is possible to drive the combustion engine with a high efficiency, a low fuel consumption and also with reduced emissions. In the generator mode, the hybrid drive apparatus may be configured for driving the electric motor by the combustion engine. Thereby, electric energy may be generatable and storable e.g. in an energy storage like a battery. In the ECO mode, the hybrid drive apparatus may be configured for running the combustion engine only when power requirements exceed a power amount providable by renewable resources, as from the electric motor, from the energy storage, from wind or the like.

[0028] In one embodiment of the hybrid drive apparatus, the hybrid drive apparatus may comprise a drive cooling unit fluidly connected to the motor pump device and configured for cooling the electric motor. The motor pump device may be configured for cooling the electric motor. The motor pump device may be configured for providing a base fluid output sufficient for cooling the electric motor. The motor pump device may be fluidly connected to the drive cooling unit. The motor pump device may be fluidly connected to a heat exchanger. The drive cooling unit may be fluidly connected to the heat exchanger. The heat exchanger may be configured for cooling fluid output from the motor pump device or the drive cooling unit. The drive cooling unit may be configured for guiding fluid through elements, e.g. a stator or a rotor, of the electric motor. The heat exchanger may be formed as a thermal cooler, a water/oil cooler, water-glycol/oil cooler, or an oil/oil cooler. At least one of the heat exchanger and the drive cooling unit may be fluidly connected to the fluid storage area, e.g. for outputting fluid into the fluid storage area.

[0029] In one embodiment of the hybrid drive apparatus, the motor pump device may be configured for being driven at its input shaft into two different rotation directions and for providing a single flow direction of a fluid output. The rotation directions may be constituted by the clockwise rotation direction and the counterclockwise rotation direction. The single flow direction may be constituted by a unidirectional flow.

[0030] The motor pump device may comprise a reversible pump creating the unidirectional flow having a single flow direction independent of a rotation direction of its

input shaft. The reversible pump may provide the single flow direction for the case that its input shaft is driven in the first rotational direction, e.g. the clockwise direction, as well as for the case that its input shaft is driven in the second rotational direction, e.g. the counterclockwise direction.

[0031] The motor pump device may comprise a bidirectional pump and a flow direction control unit being configured for providing the unidirectional flow. A bidirectional pump may be configured for providing a first flow direction of the fluid output and a second flow direction of the fluid output opposite to the first flow direction depending on a rotational direction of its input shaft. The bidirectional pump may be configured for providing the first flow direction for the case that its input shaft is driven in the first rotational direction, e.g. the clockwise direction. The bidirectional pump may be configured for providing the second flow direction for the case that its input shaft is driven in the second rotational direction, e.g. the counterclockwise direction. The flow direction control unit may be configured for providing the single flow direction out of the first flow direction and the second flow direction. The flow direction control unit may comprise a first flow direction valve, a second flow direction valve and two non-return valves. At least one of the first flow direction valve and the second flow direction valve may be configured for preventing a fluid flow when a closing condition is present. For the first flow direction valve, the closing condition may be present if the input shaft of the motor pump device is driven in the second rotational direction. For the second flow direction valve, the closing condition may be present if the input shaft of the motor pump device is driven in the first rotational direction.

[0032] At least one of the first flow direction valve and second flow direction valve may be formed as a non-return valve. At least one of the first flow direction valve and the second flow direction valve may be formed as a solenoid valve. The first flow direction valve may be fluidly connected to a first output element of the motor pump device. The first output element of the motor pump device may be indirectly fluidly connected to the fluid storage area via one of the non-return valves and a filter device for sucking fluid, e.g. when the input shaft of the motor pump device is driven in the second rotation direction and e.g. when the closing condition for the first flow direction valve is fulfilled. The second flow direction valve may be fluidly connected to a second output element of the motor pump device. The second output element of the motor pump device may be indirectly fluidly connected to the fluid storage area via one of the non-return valves and a filter device for sucking fluid, e.g. when the input shaft of the motor pump device is driven in the first rotation direction and e.g. when the closing condition for the second flow direction valve is fulfilled. Each of the first flow direction valve and second flow direction valve may be fluidly connected to a common fluid flow path. The common fluid flow path may constitute a fluid connection between the motor pump device and the non-return valve or the at least one of the first shift element and the second shift element.

[0033] The motor pump device may comprise two unidirectional pumps. The hybrid drive apparatus may comprise a non-return valve for each of the unidirectional pumps for creating the unidirectional flow. Each unidirectional pump may be configured for providing a flow direction only for a distinct rotational direction of its input shaft. A first unidirectional pump may be configured for providing the first flow direction if its input shaft is driven in the first rotational direction. A second unidirectional pump may be configured for providing the second flow direction if its input shaft is driven in the second rotational direction. The respective unidirectional pump may be configured for not providing any fluid flow if the respective input shaft is driven in any other rotational direction. The first unidirectional pump and the second unidirectional pump may be arranged coaxially. The input shaft of the first unidirectional pump and the input shaft of the second unidirectional pump maybe torque-proofly connected. The first unidirectional pump and the second unidirectional pump may comprise one common input shaft. The first unidirectional pump may be fluidly connected to a first non-return valve. The second unidirectional pump may be fluidly connected to a second non-return valve. The first non-return valve and the second non-return valve may be fluidly connected to the common fluid flow path. The common fluid flow path may constitute a fluid connection between the non-return valves and the at least one of the first shift element and the second shift element.

[0034] In one embodiment of the hybrid drive apparatus, the hybrid drive apparatus may comprise a fluid storage device for storing pressurized fluid for actuating a shift element.

[0035] The shift element may be constituted by an output shift element. The shift element may be constituted by a hybrid shift element. The shift element may be constituted by at least one of the first shift element and the second shift element. The fluid storage device may comprise an expansion tank for storing pressurized fluid. The storage device may be configured for providing pressurized fluid in an operating state of the hybrid drive apparatus, in which none of the main pump device in the motor pump device may be driven, e.g. during a transitory change of rotation of the electric motor.

[0036] In one embodiment of the hybrid drive apparatus, constituting a first basic concept, the motor pump device may be formed as a screw pump having a pump tube and a spiral element for rotating relative to the pump tube for pumping a fluid to a fluid receiving area. The motor pump device may be formed as a helical screw pump. The fluid receiving area may be formed as a ring. The fluid receiving area may extend along the transmission output shaft in a circumferential direction. The fluid receiving area may be arranged coaxially to the transmission output shaft. The fluid receiving area may be formed by the drive shaft of the electric motor, the trans-

mission output shaft and the pump tube at an end side in an axial direction, e.g. in the direction of the transmission output axis.

[0037] The pump tube may comprise a cylindrical form. The pump tube may be hollow. The wall thickness in a radial direction of the pump tube may be small compared to a wall thickness in the radial direction of the drive shaft of the electric motor. The pump tube may be fixed to the stationary element. The pump tube may be formed of an anti-friction material. The pump tube may be formed of thermoplastic, e.g. PEEK. The pump tube and the spiral element may be configured to extend in the vertical direction from above a fluid level, e.g. of the fluid storage area, downwards into the fluid.

[0038] In one embodiment of the hybrid drive apparatus, the drive shaft of the electric motor may be formed as a hollow shaft and may be torque-proofly connected to the transmission output shaft. The transmission output shaft may extend through the hollow drive shaft. The pump tube may be arranged between and coaxially to the hollow shaft and the transmission output shaft. One of the drive shaft of the electric motor and the transmission output shaft may form the spiral element. The drive shaft of the electric motor may be torque-proofly connected to the transmission output shaft by a spline connection.

[0039] The spiral element may be formed like a thread or a screw. The spiral element may be formed at an outer circumference of the transmission output shaft. The spiral element may be formed at an inner circumference of the hollow drive shaft. The spiral element may be configured to be rotatable relative to the pump tube. The spiral element may be configured for pumping fluid along the pump tube, e.g. in the gravitational direction upwards. The spiral element may be in sliding contact with an inner circumference or an outer circumference of the pump tube.

[0040] This embodiment is applicable for a hydrogeneration, e.g. in which the transmission output shaft is aligned with the vertical direction, e.g. the gravitational direction. By the electric motor being torque-proofly connected to the transmission output shaft and thereby to the propulsion element, the hybrid drive apparatus may provide the hydrogeneration mode as long as the propulsion element is driven, e.g. by the combustion engine or by the water due to the drag effect. An electric motor control system may be configured independent from a control system of the combustion engine. Moreover, it may be possible to maneuver the work vehicle forward and reverse merely by the electric motor without any interaction with the transmission module, in particular without any operation of a shift element, e.g. of the first shift element and the second shift element.

[0041] In one embodiment of the hybrid drive apparatus, the drive shaft of the electric motor may comprise an opening extending from the fluid receiving area radially outward through the drive shaft for supplying fluid to at least one of a stator and a rotor of the electric motor. The drive shaft of the electric motor may comprise at least one, e.g. 2 or more openings.

[0042] The motor pump device may comprise a fluid channel configured for conveying fluid from the fluid receiving area in the radial direction outward, e.g. via the at least one opening of the drive shaft of the electric motor. Thereby, a centrifugal force caused by a rotation of at least one of the transmission output shaft and the drive shaft of the electric motor may be utilized for conveying fluid from the fluid receiving area radially outward.

[0043] The fluid channel may comprise a number of, e.g. 1, 2, 3, or more, axial channel openings extending in the axial direction. The fluid channel may comprise a number of, e.g. 1, radial channel openings extending in the radial direction. The radial channel openings may be arranged at an inside of the fluid channel in the radial direction. A channel opening may be configured for conveying the fluid to an element of the electric motor, for example one of the stator and the rotor of the electric motor.

[0044] At least one of the stator and the rotor of the electric motor may be configured for guiding fluid in the axial direction of the drive shaft of the electric motor through the stator and the rotor. The electric motor may be configured for guiding fluid through rotor windings. The electric motor may be configured for guiding fluid through a gap between the stator and the rotor. Thereby, the hybrid drive apparatus may provide an auto cooling system for the electric motor.

[0045] In one embodiment of the hybrid drive apparatus, constituting a second basic concept, the hybrid drive apparatus may comprise a hybrid shift element configured for mechanically linking the drive shaft of the combustion engine with an input shaft of the main pump. The drive shaft of the electric motor is configured for being mechanically linked to the input shaft of the main pump device. The drive shaft of the electric motor may be mechanically linked to the input shaft of the main pump device in all operating states of the hybrid drive apparatus. The hybrid shift element may be positioned in the longitudinal direction between the combustion engine and electric motor.

[0046] The hybrid shift element may comprise a clutch, for example a multi-disc clutch. The hybrid shift element may be formed as a normal open shift element. The hybrid shift element may be operable by pressurized fluid, e.g. a hydraulic pressure. An output element of the hybrid shift element may comprise a clutch basket. The hybrid shift element may comprise discs, e.g. friction discs or plates. The hybrid shift element may comprise an input element. The input element may be formed as an input shaft.

[0047] The hybrid drive apparatus may be configured for increasing a total fluid output, e.g. a total fluid flow rate, especially during low speed of the water vehicle, e.g. a low rotational speed of the transmission input shaft. The total fluid flow rate may be constituted by a fluid output of the main pump device and a fluid output of the motor pump device. Moreover, the hybrid drive apparatus may

be configured for increasing a total fluid pressure for operating the hybrid shift element. The motor pump device may be configured for providing a minimum fluid pressure sufficient for operating the hybrid shift element, e.g. in all operating states of the hybrid drive apparatus, in particular in the electric mode, or during an operation condition of the combustion engine with a low and very low rotational speed. The hybrid drive apparatus may be configured for providing a minimum total fluid flow rate that is sufficient for operating the hybrid shift element and for lubricating elements of the hybrid drive apparatus.

[0048] In one embodiment of the hybrid drive apparatus, the drive shaft of the electric motor may be arranged parallel to the drive shaft of the combustion engine. The drive shaft of the electric motor may be offset in the vertical direction upward with respect to the drive shaft of the combustion engine. The electric motor may be offset in the vertical direction upward with respect to the transmission module. With respect to the hybrid shift element and in the longitudinal direction, the electric motor may be positioned opposed to the combustion engine.

[0049] In one embodiment of the hybrid drive apparatus, the hybrid shift element may have the input element and the output element. The output element may be configured for being mechanically linkable to the input shaft of the main pump device as well as to the drive shaft of the electric motor. The output element may be torque-proofly connected to the input shaft of the main pump device. The output element may be mechanically linked to the drive shaft of the electric motor via a hybrid transmission. Thus, the drive shaft of the electric motor may be mechanically linked to the input shaft of the main pump device as well as to the input shaft of the motor pump device. Thereby, a fluid output of the main pump device and a fluid output of the motor pump device may be increased by driving the electric motor.

[0050] The hybrid drive apparatus may comprise the hybrid transmission having an input element and an output element. The input element of the hybrid transmission and the output element of the hybrid transmission may be arranged parallel to each other. The input element of the hybrid transmission and the output element of the hybrid transmission may be aligned in the axial direction, respectively. The input element of the hybrid transmission may be connected torque-proofly to the input shaft of the motor pump device. The output element of the hybrid transmission may be connected torque-proofly to the output element of the hybrid shift element. The output element of the hybrid drive transmission may be formed by the output element of the hybrid shift element. The hybrid transmission may comprise one of a belt transmission, a chain transmission, a spur gear transmission, and a multistep transmission, e.g. comprising two or more meshing gears. The input element of the hybrid transmission and the output element of the hybrid transmission may be formed as a spur gear, a belt pulley, or a chain gear, respectively. The input element of the hybrid shift element may be formed as a spur gear, a belt pulley, or a chain gear.

[0051] In one embodiment of the hybrid drive apparatus, the hybrid drive apparatus may comprise a fluid summarizing module configured for summarizing a fluid output of the main pump device and a fluid output of the motor pump device. The fluid summarizing module may be formed as a T-connection. The fluid summarizing module may be configured for summarizing a fluid pressure output from the main pump device and a fluid pressure output from the motor pump device. The fluid summarizing module may be configured for summarizing a fluid flow output from the main pump device and a fluid flow output from the motor pump device. The summarized fluid output, e.g. the total fluid output, may be configured such that the fluid pressure of the summarized fluid output is sufficient for operating and/or lubricating the hybrid shift element.

[0052] In one embodiment of the hybrid drive apparatus, constituting a third basic concept, the input shaft of the motor pump device may be mechanically linked to the transmission output shaft in all operating states of the hybrid drive apparatus. The hybrid drive apparatus may provide the electric mode. The motor pump device may be configured for providing a base fluid output sufficient for lubricating elements, e.g. at least one of the bearings, gears, the first shift element, and the second shift element, of the hybrid drive apparatus e.g. during the electric mode of the hybrid drive apparatus. The motor pump device may be configured for providing a base fluid output sufficient for lubricating elements of the hybrid drive apparatus as well as for cooling the electric motor. The output shaft of the electric motor may be mechanically linked to the propulsion element in all operating states of the hybrid drive apparatus. Thereby, the hybrid drive apparatus may provide the hydrogeneration mode. When at least one of the first shift element and the second shift element is engaged, the hybrid drive apparatus may provide the hybrid mode, in particular the generator mode.

[0053] In one embodiment of the hybrid drive apparatus, the drive shaft of the electric motor may be torque-proofly connected to the second input gear. The drive shaft of the electric motor may be arranged coaxially to the drive shaft of the combustion engine. The drive shaft of the electric motor may be aligned in the longitudinal direction. The drive shaft of the electric motor may be connected torque-proofly to the second input gear, e.g. via a spline connection. The drive shaft of the electric motor may be connectable torque-proofly to the second input gear by a shift element. With the drive shaft of the electric motor, also the input shaft of the motor pump device may be connected or connectable torque-proofly to the second input gear. In the longitudinal direction and with respect to the transmission module, the electric motor may be arranged at an opposing side of the combustion engine. The combustion engine may be arranged at a front side in the longitudinal direction. The electric

motor may be arranged at a rear side in the longitudinal direction. The front side may be a side to which the work vehicle is moved during a forward propulsion via the hybrid drive apparatus.

[0054] In one embodiment of the hybrid drive apparatus, the drive shaft of the electric motor may be mechanically linked to the transmission output shaft. The drive shaft of the electric motor may be arranged transversely to the drive shaft of the combustion engine. The drive shaft of the electric motor may be aligned in the vertical direction. The drive shaft of the combustion engine may be aligned perpendicularly to the drive shaft of the electric motor. The drive shaft of the electric motor may be mechanically linkable to the transmission output shaft, e.g. via a shift element. The drive shaft of the electric motor may be mechanically linked to the transmission output shaft, e.g. by a hybrid transmission. The hybrid transmission may comprise an input element and an output element. The input element of the hybrid transmission and the output element of the hybrid transmission may be arranged parallel to each other. The input element of the hybrid transmission and the output element of the hybrid transmission may be aligned in the vertical direction, respectively. The input element of the hybrid transmission may be connected torque-proofly to the input shaft of the motor pump device. The output element of the hybrid transmission may be connected torque-proofly to the output element of the hybrid shift element. The hybrid transmission may comprise one of a belt transmission, a chain transmission, a spur gear transmission, and a multistep transmission, e.g. comprising two or more meshing gears. The input element of the hybrid transmission and the output element of the hybrid transmission may be formed as a spur gear, a belt pulley, or a chain gear. The input element of the hybrid shift element may be engaged with or torque-proofly connected with the output element of the hybrid transmission. The input element of the hybrid shift element may form the output element of the hybrid transmission. The input element of the hybrid shift element may be formed as a spur gear, a belt pulley, or a chain gear.

[0055] In one embodiment of the hybrid drive apparatus, constituting a fourth basic concept, the hybrid drive apparatus may comprise an output shift element by which the transmission output shaft may be mechanically linkable to the propulsion shaft. The motor pump device may be configured for providing a base fluid output sufficient for operating the output shift element, in particular during the electric mode. In addition, the main pump device may be configured for providing a base fluid output sufficient for operating the output shift element, in particular when the combustion engine is driven. The hybrid drive apparatus may provide the generator mode, in particular without the propulsion element being driven, when at least one of the first shift element and the second shift element is engaged. The hybrid drive apparatus may provide the generator mode when the output shift element is disengaged. Then, the generator mode may be providable without the propulsion element being driven by one of the combustion engine and the electric motor.

[0056] The hybrid drive apparatus may provide the hydrogeneration mode when the output shift element is engaged. The hybrid drive apparatus may comprise a control unit. The control unit may be configured for performing a method for providing the hydrogeneration mode. The method may comprise a first step of verifying that a hydrogeneration condition is fulfilled. The hydrogeneration condition may be fulfilled if the speed of the water vehicle is lower than a predetermined threshold value. The hydrogeneration condition may be fulfilled if the speed of the water vehicle is lower than 5 knots. The hydrogeneration condition may be fulfilled when the combustion engine is not driven. The hydrogeneration condition may be fulfilled when the electric motor is not driven. The method may comprise a second step of switching on the electric motor. The step of switching on the electric motor may comprise regulating a rotational speed of the electric motor such that a difference of a rotational speed of the input element of the output shift element and a rotational speed of the output element of the output shift element is reduced. The step of switching on the electric motor may comprise verifying that the input element of the output shift element and the output element of the output shift element rotate in the same rotational direction. The method may comprise a further step of engaging the output clutch. The method may comprise a further step of driving the electric motor in the hydrogeneration mode.

[0057] In a second aspect, a water vehicle comprising a drive apparatus according to one of the preceding embodiments and aspects is provided. Further features, advantages, and effects of the second aspect may arise from the first aspect. Features, advantages, and effects of the second aspect may also constitute features, advantages, and effects for the first aspect. The drive apparatus is configured for a propulsion of the water vehicle. The drive apparatus may be mounted or installed to a stationary element, e.g. a hull, of the water vehicle. The water vehicle may be formed as a ship, for example as cargo ship or as a sailing boat.

Brief description of the drawings

[0058]

Figure 1 shows a schematic sketch of a sectional view of an embodiment of a hybrid drive apparatus according to a first concept.

Figure 2 shows a detail of the sectional view of the embodiment of the hybrid drive apparatus of Figure 1.

Figure 3 shows a further detail of the view of Figure 2 with indication of the oil flow.

Figure 4 shows a schematic sketch of a sectional view of an embodiment of a hybrid drive apparatus according to a second concept.

Figure 5 shows a schematic sketch of a sectional view of the embodiment of the hybrid drive apparatus of Figure 4.

Figure 6 shows an oil flow diagram of the embodiment of the hybrid drive apparatus of Figures 4 and 5.

Figure 7 shows a schematic sketch of a sectional view of an embodiment of a hybrid drive apparatus according to a third concept.

Figure 8 shows a schematic sketch of a sectional view of a further embodiment of the hybrid drive apparatus according to a further concept.

Figure 9 shows an oil flow diagram of an embodiment of the hybrid drive apparatus of the third concept.

Figure 10 shows an oil flow diagram of a further embodiment of the hybrid drive apparatus of the third concept.

Figure 11 shows a detail of the oil flow diagram of the embodiment of the hybrid drive apparatus of Figure 10.

Figure 12 shows a schematic sketch of a sectional view of a further embodiment of the hybrid drive apparatus of the third concept.

Figure 13 shows an oil flow diagram of the embodiment of Figure 12.

Figure 14 shows a schematic sketch of a sectional view of a further embodiment of the hybrid drive apparatus of the third concept.

Figure 15 shows an oil flow diagram of a further embodiment of the hybrid drive apparatus of the third concept.

Figure 16 shows a detail of the oil flow diagram of the embodiment of the hybrid drive apparatus of Figure 15.

Figure 17 shows a schematic sketch of a sectional view of a further embodiment of the hybrid drive apparatus according to a fourth concept.

Figure 18 shows a schematic sketch of a sectional view of a further embodiment of the hybrid drive apparatus of the fourth concept.

Figure 19 shows a sectional view of an embodiment of the hybrid drive apparatus of the fourth concept.

Figure 20 shows a detail of the sectional view of the embodiment of the hybrid drive apparatus of Figure 19.

Figure 21 shows an oil flow diagram of an embodiment of the hybrid drive apparatus of the fourth concept.

Figure 22 shows an oil flow diagram of a further embodiment of the hybrid drive apparatus of the fourth concept.

Figure 23 shows a detail of the oil flow diagram of the embodiment of the hybrid drive apparatus of Figure 22.

Figure 24 shows a principal sketch of a sectional view of a further embodiment of the hybrid drive apparatus of the fourth concept.

Figure 25 shows an oil flow diagram of the embodiment of the hybrid drive apparatus of Figure 24.

Figure 26 shows a schematic sketch of an embodiment of a water vehicle with a hybrid drive apparatus.

Detailed description of embodiments

[0059] In a general embodiment, which is shown for example in Figures 1, 4, 7, 8 and 17, the hybrid drive apparatus is configured for being used in a water vehicle and comprises a combustion engine 11, an electric motor 12, a motor pump device 17 and a transmission output shaft 35. The combustion engine 11 is configured for driving the transmission output shaft 35. The electric motor 12 is configured for driving the transmission output shaft 35 as well as for driving the motor pump device 17. The motor pump device 17 is mechanically linked to the drive shaft of the electric motor 12 in all operating states of the hybrid drive apparatus. The water vehicle provides at least three driving modes: a combustion mode in which the water vehicle is driven by the combustion engine 11 and without the electric motor 12, an electric mode in which the water vehicle is driven by the electric motor 12 and without the combustion engine 11, and a hybrid mode in which the water vehicle is driven by the combustion engine 11 as well as by the electric motor 12. The hybrid drive apparatus may be operated in each of the driving modes. By the configuration of the hybrid drive apparatus of the present embodiments, a sufficient oil output for supplying elements of the hybrid drive apparatus in all operating states of the hybrid drive apparatus is provided.

[0060] Figure 1 shows a schematic sketch of a sectional view of an embodiment of a first basic concept of the hybrid drive apparatus. The embodiment of Figure 1 comprises all features of the general embodiment. The

hybrid drive apparatus further comprises a transmission module 30, an output transmission 38 and a propulsion module 40. The transmission module 30 comprises a transmission input shaft 34, a first input gear 31, a second input gear 32, an output gear 33, a first shift element 36, a second shift element 37 and the transmission output shaft 35. The propulsion module 40 comprises a propulsion shaft 41 and a propulsion element 42, which is configured as a fixed propeller in the present embodiment.

[0061] The first input gear 31 is formed as a bevel gear. The second input gear 32 is formed as a bevel gear. The output gear 33 is formed as a crown gear. The first shift element 36 and the second shift element 37 are formed as multi-disc clutches. The transmission input shaft 34 is configured for being driven by the combustion engine 11. The transmission output shaft 35 is configured for being mechanically linked to the propulsion element 42 for a propulsion of the water vehicle. The first shift element 36 and the second shift element 37 are configured for providing and removing a mechanical link between the transmission input shaft 34 and the transmission output shaft 35 for transmitting a torque from the combustion engine 11 to the propulsion element 42.

[0062] The first input gear 31 and the second input gear 32 are arranged at opposing sides of the transmission output shaft 35 and perpendicular to a rotation axis of the transmission output shaft 35. The transmission input shaft 34 is arranged perpendicularly to the transmission output shaft 35. The transmission output shaft 35 extends vertically from an inside of a hull 8 of the water vehicle to an outside of the hull 8 of said water vehicle. The transmission output shaft 35 extends through the electric motor 12. The first input gear 31 and the second input gear 32 are arranged coaxially to the transmission input shaft 34. The output gear 33 is torque-proofly connected to the transmission output shaft 35. The first input gear 31 is torque-proofly connectable to the transmission input shaft 34 via the first shift element 36. The second input gear 32 is torque-proofly connectable to the transmission input shaft 34 via the second shift element 37. The first input gear 31 and the second input gear 32 are in engagement with the output gear 33 in all operating states of the device. Thereby, the output gear 33 is drivable by the first input gear 31 in a first rotational direction, e.g. a clockwise direction, and is drivable by the second input gear 32 in a second rotational direction, e.g. a counterclockwise direction, opposite to the first rotation direction. The transmission module 30 is formed as a reverse transmission.

[0063] The motor pump device 17 is formed as a screw pump. The drive shaft of the electric motor 12 is torque-proofly connected to an input shaft of the motor pump device 17 via a splined connection. The electric motor 12 is arranged coaxially to the transmission output shaft 35. The electric motor 12 is arranged perpendicularly to the transmission input shaft 34. The motor pump device 17 is configured for cooling the electric motor 12. The electric motor 12 and the motor pump device 17 are mechanically linked to the propulsion element 42 in all operating states of the hybrid drive apparatus. Thereby, cooling of the electric motor 12 is ensured as long as the drive shaft of the electric motor 12 rotates. If the water vehicle is moved through water, the propulsion element 42 is driven by a drag effect. Cooling of the electric motor 12 is ensured as long as the water vehicle is moved through the water, due to the drag effect of the propulsion element 42. Moreover, the hybrid drive apparatus is able to provide a hydrogeneration mode as long as the water vehicle is moved through the water.

[0064] The output transmission 38 comprises an input bevel gear and an output bevel gear. The input bevel gear is torque-proofly connected to the transmission output shaft 35. The output bevel gear is torque-proofly connected to the propulsion shaft 41. The transmission output shaft 35 and the propulsion shaft 41 are arranged perpendicular with respect to each other. The propulsion element 42 is torque-proofly connected to the propulsion shaft 41. The transmission output shaft 35 and the propulsion shaft 41 are rotatably supported by a stationary element of the water vehicle. Thereby, the propulsion element 42 is rotatably supported via the propulsion shaft 41.

[0065] Figure 2 shows a detail of the sectional view of the embodiment of the hybrid drive apparatus of Figure 1. As shown in Figure 2, the motor pump device 17 comprises a spiral element 71 and a pump tube 72. The spiral element 71 is configured for rotating relative to the pump tube 72 for pumping a fluid, oil at present, to a fluid receiving area. The fluid receiving area is formed as a ring and extends along the transmission output shaft 35 in a circumferential direction. The fluid receiving area is arranged coaxially to the transmission output shaft 35 at an upper end of the pump tube 72 in the vertical direction.

[0066] The drive shaft, a rotor at present, of the electric motor 12 is formed as a hollow shaft. The transmission output shaft 35 extends through said hollow shaft. The pump tube 72 is formed cylindrically. The pump tube 72 is arranged between and coaxially to the hollow shaft and the transmission output shaft 35. The wall thickness in a radial direction of the pump tube 72 is small compared to a wall thickness of the drive shaft of the electric motor 12 in the radial direction. The transmission output shaft 35 forms the spiral element 71 on an outer circumference. The spiral element 71 is formed like a thread. The spiral element 71 is in sliding contact with an inner circumference of the pump tube 72. The spiral element 71 is configured for pumping fluid along the pump tube 72, e.g. in a gravitational direction or vertical direction upwards to the fluid receiving area.

[0067] A broken line arranged in the horizontal direction indicates a fluid level of fluid being stored in a fluid storage area. The electric motor 12 is arranged in the vertical direction above the fluid level. The transmission output shaft 35, the spiral element 71 and the pump tube

72 extent from a side above the fluid level in the vertical direction downward into the fluid.

[0068] Figure 3 shows a further detail of Figure 2. As shown in Figure 3, the drive shaft of the electric motor 12 comprises a number of openings extending from the fluid receiving area radially outward through the drive shaft of the electric motor 12 for supplying fluid to a stator and the rotor of the electric motor 12. The openings open out into fluid channels 73. The fluid channels 73 are configured for conveying fluid from the fluid receiving area in the radial direction outward to the stator and the rotor of the electric motor 12. Thereby, a centrifugal force caused by a rotation of the rotor of the electric motor 12 is utilized for conveying the fluid. The fluid channels 73 may comprise a number of axial channel openings extending in the axial direction downward through the wall of the fluid channels 73. The fluid channels 73 comprise a radial channel opening at an outward end of the fluid channels 73 in the radial direction. The fluid is conveyed in the axial direction through the rotor of the electric motor 12 and in the vertical direction downward by a gravitational force. In addition, fluid is conveyed through a gap between the stator and the rotor of the electric motor 12 by the centrifugal force and the gravitational force. Thereby, the hybrid drive apparatus provides an auto cooling system for the electric motor 12.

[0069] Figure 3 shows further a principal sketch of an oil flow diagram in the embodiment of the hybrid drive apparatus of Figures 1 and 2. The fluid is conveyed by the spiral element 71 in the vertical direction upward to the fluid receiving area. The fluid is then conveyed through the openings of the drive shaft of the electric motor 12 and through the fluid channels 73 in the radial direction outward. The fluid is then conveyed through the axial channel openings to the rotor of the electric motor 12 and is conveyed through the radial channel openings to the stator of the electric motor 12. Then, the fluid is conveyed through the rotor of the electric motor 12 and through a gap between the rotor and the stator of the electric motor 12 in the vertical direction downward by the gravitational force.

[0070] Figure 4 shows a schematic sketch of a sectional view of an embodiment of a second basic concept of the hybrid drive apparatus. The present embodiment comprises all features of the general embodiment described above. The hybrid drive apparatus further comprises a hybrid transmission 13, a main pump device 16, a transmission module 30, a propulsion module 40 and a hybrid shift element 83. The transmission module 30 comprises a transmission input shaft 34. The propulsion module 40 comprises a propulsion shaft 41 and a propulsion element, which corresponds to the fixed propeller 42 of the embodiment of Figure 1.

[0071] The input shaft of the main pump device 16 is mechanically linkable to the drive shaft of the combustion engine 11 via the hybrid shift element 83. Thereby, the main pump device 16 is configured for being driven by the combustion engine 11. The hybrid drive apparatus is configured for increasing a total fluid output of the motor pump device and the main pump device, especially during low speed of the water vehicle and during a low rotational speed of the transmission input shaft 34. The motor pump device 17 is configured for increasing a total fluid pressure sufficient for operating the hybrid shift element 83.

[0072] The hybrid shift element 83 is configured for torque-proofly connecting the drive shaft of the combustion engine 11 to the input shaft of the main pump 16. The hybrid shift element 83 is formed as a multi-disc clutch. The hybrid shift element 83 has an input element and an output element, a clutch basket at present. The output element of the hybrid shift element 83 is torque-proofly connected to the input shaft of the main pump device 16. Besides, the output element of the hybrid shift element 83 is mechanically linked to the drive shaft of the electric motor 12 via the hybrid transmission 13. The drive shaft of the electric motor 12 is arranged parallel to the drive shaft of the combustion engine 11.

[0073] The hybrid transmission 13 has an input element and an output element. The input element of the hybrid transmission 13 and the output element of the hybrid transmission 13 are arranged parallel to each other. The input element of the hybrid transmission 13 is torque-proofly connected to a shaft of the motor pump device 17. The output element of the hybrid transmission 13 is connected torque-proofly to the output element of the hybrid shift element 83. The hybrid transmission 13 is configured as a multistep transmission comprising three meshing gears, one of which is formed by the output element of the hybrid shift element 83. The meshing gears are formed as spur gears.

[0074] In one embodiment not shown in Figure 4, the transmission module 30 is formed as the transmission module 30 of the embodiment of Figure 1. It is referred to the corresponding description above. The transmission module 30 is arranged in the vertical direction under the electric motor 12. Furthermore, in one embodiment not shown in Figure 6, the hybrid drive apparatus comprises an output transmission, which is formed as the output transmission 38 of the embodiment of Figure 1. It is referred to the corresponding description above.

[0075] Figure 5 shows a further schematic sketch of a sectional view of the embodiment of the hybrid drive apparatus of Figure 4. The hybrid drive apparatus further comprises a drive cooling unit 70 fluidly connected to the motor pump device 17 and configured for cooling the electric motor 12. The motor pump device 17 provides a base fluid output sufficient for cooling the electric motor 12. The motor pump device 17 is fluidly connected to the drive cooling unit 70. The drive cooling 70 is configured for guiding fluid through the stator and the rotor of the electric motor 12. The drive cooling unit 70 is fluidly connected to a heat exchanger 54. The heat exchanger 54 is configured for cooling fluid output from the drive cooling unit 70. The heat exchanger 54 is formed as a thermal water/oil cooler. The drive cooling unit 70 is fluidly

connected to a fluid storage area 59, an oil sump at present.

[0076] Figure 6 shows an oil flow diagram of the embodiment of the hybrid drive apparatus of Figures 4 and 5. The hybrid drive apparatus comprises a fluid summarizing module 58 configured for summarizing a fluid output of the main pump device 16 and a fluid output of the motor pump device 17. The motor pump device 17 is indirectly fluidly connected to the fluid storage area 59. A filter device 57, an oil filter at present, is interposed between the motor pump device 17 and the fluid storage area 59. The motor pump device 17 is fluidly connected to a non-return valve 55. The non-return valve 55 is fluidly connected to the fluid summarizing module 58. The main pump device 16 is indirectly fluidly connected to the fluid storage area 59. A filter device 57 is interposed between the main pump device 16 and the fluid storage area 59. The main pump device 16 is fluidly connected to the fluid summarizing module 58 via a non-return valve 55. When viewed from the oil sump, in the fluid pathway, the filter devices 57 are provided before the respective pump devices 16, 17, which are provided before the non-return valves 55. After the non-return valves 55, in the fluid pathway, the fluid summarizing module 58 is provided.

[0077] Thus, the motor pump device 17 and the main pump device 16 are indirectly fluidly connected to the fluid summarizing module 58 via a non-return valve 55, respectively. The fluid summarizing module 58 is fluidly connected to a pressure relief valve 56. The pressure relief valve 56 provides a fluid flow when the fluid comprises a minimum fluid pressure or higher. The pressure relief valve 56 is fluidly connected to a heat exchanger 53 for cooling the fluid. After passing the heat exchanger 53, fluid reaches the first shift element 36 and the second shift element 37 for providing lubrication for discs, e.g. friction discs, of the first shift element 36 and the second shift element 37.

[0078] In addition, the fluid summarizing module 58 is fluidly connected to a shift valve. The shift valve provides pressurized fluid to the first shift element 36 and the second shift element 37 for operating the first shift element 36 and the second shift element 37. The shift valve comprises a first solenoid 51 and a second solenoid 52. The first solenoid 51 provides pressurized fluid to the first shift element 36. The second solenoid 52 provides pressurized fluid to the second shift element 37. The shift valve, the first shift element 36 and the second shift element 37 are fluidly connected to the fluid storage area 59.

[0079] Figure 7 shows a schematic sketch of a sectional view of an embodiment of a third basic concept of the hybrid drive apparatus. The embodiment of Figure 7 comprises all features of the general embodiment. The hybrid drive apparatus further comprises a main pump device 16, a transmission module 30, an output transmission 38 and a propulsion module 40. The transmission module 30 is configured as the transmission module 30 of the embodiment of Figure 1. It is referred to the corresponding description above. Likewise, the propulsion module 40 is configured as the propulsion module 40 of the embodiment of Figure 1. It is referred to the corresponding description above.

[0080] The drive shaft of the combustion engine 11 and the drive shaft of the electric motor 12 are arranged coaxially to the transmission input shaft 34. The drive shaft of the electric motor 12 is torque-proofly connected to the second input gear 32 of the transmission module 30. The input shaft of the motor pump device 17 is mechanically linked to the transmission output shaft 35 of the transmission module 30 in all operating states of the hybrid drive apparatus.

[0081] The transmission module 30 is arranged in an axial direction between the main pump device 16 and the motor pump device 17. The transmission input shaft 34 is configured for being driven by the combustion engine 11. The transmission output shaft 35 is configured for being mechanically linked to a propulsion element 42 for a propulsion of the water vehicle. The first shift element 36 and the second shift element 37 of the transmission module 30 are configured for providing and removing a mechanical link between the transmission input shaft 34 and the transmission output shaft 35. Just as in the embodiment of Figure 1, the transmission output shaft 35 extends from an inside of the hull 8 to an outside of the hull 8 in the vertical direction.

[0082] The main pump device 16 is configured for lubricating the first shift element 36 and the second shift element 37 as well as operating the first shift element 36 and the second shift element 37. The input shaft of the main pump device 16 is mechanically linked to the drive shaft of the combustion engine 11. Thereby, the main pump device 16 is configured for being driven by the combustion engine 11.

[0083] Figure 8 shows a schematic sketch of a sectional view of a further embodiment of the hybrid drive apparatus according to the third concept. The present embodiment comprises all features of the preceding embodiment of Figure 7. The present embodiment differs from the preceding embodiment of Figure 7 in that the drive shaft of the electric motor 12 is mechanically linked to the transmission output shaft 35 and that the drive shaft of the combustion engine 11 is arranged transversely to the drive shaft of the electric motor 12. The drive shaft of the electric motor 12 is mechanically linked to the transmission output shaft 35 via a hybrid transmission 13.

[0084] The hybrid transmission 13 has an input element and an output element. The input element of the hybrid transmission 13 and the output element of the hybrid transmission 13 are arranged parallel to each other. The input element of the hybrid transmission 13 is connected torque-proofly to a shaft of the motor pump device 17 and the drive shaft of the electric motor 12. The output element of the hybrid transmission 13 is connected torque-proofly to the transmission output shaft 35. The hybrid transmission 13 is configured as a multi-step transmission comprising three meshing gears. The

meshing gears are formed as spur gears.

[0085] Figure 9 shows an oil flow diagram of the embodiment of the hybrid drive apparatus of Figures 7 and 8. In the present embodiment, the motor pump device 17 is configured for providing a fluid output sufficient for lubricating the first shift element 36 and second shift element 37. The motor pump device 17 is formed as a reversible pump creating an unidirectional flow of the fluid output independent of a rotation direction of the input shaft of the motor pump device 17.

[0086] The motor pump device 17 is indirectly fluidly connected to a fluid storage area 59 as described with reference to Figure 6. A filter device 57, an oil filter at present, is fluidly interposed between the motor pump device 17 and the fluid storage area 59. The motor pump device 17 is fluidly connected to a non-return valve 55. The non-return valve 55 is fluidly connected to the first shift element 36 and the second shift element 37 for providing lubrication for discs, e.g. friction discs, of the first shift element 36 and the second shift element 37.

[0087] The main pump device 16 is indirectly fluidly connected to the fluid storage area 59. A filter device 57, an oil filter at present, is fluidly interposed between the main pump device 16 and the fluid storage area 59. The main pump device 16 is fluidly connected to a pressure relief valve 56. The pressure relief valve 56 provides a fluid flow when the fluid comprises a minimum fluid pressure or higher. The pressure relief valve 56 is fluidly connected to a heat exchanger 53 for cooling of the fluid. Fluid that has passed the heat exchanger 53 flows to the first shift element 36 and the second shift element 37 for providing lubrication for discs, e.g. friction discs, of the first shift element 36 and the second shift element 37. Accordingly, said lubrication is providable by both the main pump device and the motor pump device 17.

[0088] In addition, the main pump device 16 is fluidly connected to a shift valve. The shift valve provides pressurized fluid to the first shift element 36 and the second shift element 37 for operating the first shift element 36 and the second shift element 37. The shift valve comprises a first solenoid 51 and a second solenoid 52. The first solenoid 51 provides pressurized fluid to the first shift element 36. The second solenoid 52 provides pressurized fluid to the second shift element 37. The shift valve, the first shift element 36 and the second shift element 37 are fluidly connected to the fluid storage area 59.

[0089] Figure 10 shows an oil flow diagram of a further embodiment of the hybrid drive apparatus of the third concept. The embodiment of Figure 10 differs from the embodiment of Figure 9 in that the motor pump device 17 is formed as a bidirectional pump and in that the hybrid drive apparatus comprises a flow direction control unit 60 for generating the unidirectional flow of the fluid output of the motor pump device 17.

[0090] Figure 11 shows the flow direction control unit 60 of Figure 10 in more detail. The flow direction control unit 60 is formed by a first flow direction valve 61, a second flow direction valve 62 and two non-return valves 55. The first flow direction valve 61 and the second flow direction valve 62 are formed by a solenoid valve at present, respectively.

[0091] The first flow direction valve 61 is fluidly connected to a first output element of the motor pump device 17. The first output element of the motor pump device 17 is indirectly fluidly connected to the fluid storage area 59 via a non-return valve 55 and a filter device 57 for sucking fluid when the input shaft of the motor pump device 17 is driven in the second rotation direction. The second flow direction valve 62 is fluidly connected to a second output element of the motor pump device 17. The second output element of the motor pump device 17 is indirectly fluidly connected to the fluid storage area 59 via a non-return valve 55 and a filter device 57 for sucking fluid when the input shaft of the motor pump device 17 is driven in the first rotation direction opposite to the first rotation direction. Each of the first flow direction valve 61 and second flow direction valve 62 is fluidly connected to a common fluid flow path. The common fluid flow path constitutes the fluid connection between the motor pump device 17 and the non-return valve 55 shown in Figure 10.

[0092] Figure 12 shows a schematic sketch of a sectional view of a further embodiment of the hybrid drive apparatus according to the third aspect. The embodiment of Figure 12 differs from the embodiment of Figure 11 in that the motor pump device 17 comprises two unidirectional pumps and a non-return valve 55 for each of said unidirectional pumps for creating the unidirectional flow. In this embodiment, a flow direction control unit 60 is not provided. The first unidirectional pump and the second unidirectional pump are arranged coaxially in series and comprise one common input shaft.

[0093] Figure 13 shows an oil flow diagram of the embodiment of Figure 12. In the present embodiment, the first unidirectional pump is fluidly connected to a non-return valve 55. The second unidirectional pump is fluidly connected to a further non-return valve 55. Both non-return valves 55 are fluidly connected to the common fluid flow path. The fluid flow path constitutes a fluid connection between the non-return valves 55 and the first shift element 36 and the second shift element 37. Moreover, the first unidirectional pump and the second unidirectional pump are indirectly fluidly connected to the fluid storage area 59 via a filter device 57 for sucking fluid, respectively.

[0094] Figure 14 shows a schematic sketch of a sectional view of a further embodiment of the hybrid drive apparatus of the third concept. The present embodiment comprises all features of at least one of the preceding embodiments of Figures 7 to 13. The hybrid drive apparatus comprises a drive cooling unit 70 fluidly connected to the motor pump device 17 and configured for cooling the electric motor 12. The drive cooling unit is configured as the driving cooling unit 70 of the embodiment of Figure 5. It is referred to the corresponding description above.

[0095] Figure 15 shows an oil flow diagram of a further embodiment of the hybrid drive apparatus of the third

concept. The present embodiment comprises all features of at least one of the preceding embodiments of the third concept. In particular, the motor pump device 17 is formed as a bidirectional pump, the hybrid drive apparatus comprises a flow direction control unit 60 and a drive cooling unit 70. The flow direction control unit 60 is fluidly connected to the drive cooling unit 70. The drive cooling unit 70 is fluidly connected to the heat exchanger 54. The heat exchanger 54 is fluidly connected to the fluid storage area 59.

[0096] Figure 16 shows a detail of the oil flow diagram of the embodiment of Figure 15. The fluid direction control unit 60 is indirectly fluidly connected to the fluid storage area 59 via a filter device 57 for providing the motor pump device 17 with fluid. The fluid direction control unit 60 is fluidly connected to the drive cooling unit 70. The drive cooling unit 70 is fluidly connected to the heat exchanger 54. The heat exchanger 54 is fluidly connected to the fluid storage area 59.

[0097] Figure 17 shows a schematic sketch of a sectional view of a further embodiment of a fourth basic concept of the hybrid drive apparatus. The present embodiment comprises all features of the embodiment of Figure 7. The fourth basic concept differs from the embodiment of Figure 7 in that the hybrid drive apparatus further comprises an output shift element 84. By the output shift element 84, the transmission output shaft 35 is mechanically linkable to the propulsion shaft 41. The output shift element 84 is formed as a multi-disc clutch operable by fluid pressure.

[0098] Figure 18 shows a schematic sketch of a sectional view of an embodiment of the hybrid drive apparatus according to the fourth concept. The present embodiment comprises all features of the embodiment shown in Figure 8. The present embodiment differs from the embodiment shown in Figure 8 in that the hybrid drive apparatus further comprises an output shift element 84. By the output shift element 84, the transmission output shaft 35 is mechanically linkable to the propulsion shaft 41. An input element of the output shift element 84 forms the output element of the hybrid transmission 13.

[0099] Figure 19 shows a sectional view of an embodiment of the hybrid drive apparatus of the fourth concept. The present embodiment comprises all features of the embodiment of Figure 18. The present embodiment differs from the embodiment of Figure 18 in that the propulsion element 42 and the output gear of the output transmission 38 are arranged on a side with respect to the rotation axis of the transmission output shaft 35 opposite the electric motor 12. The propulsion shaft 41 extends away from the rotation axis of the transmission output shaft 35. In the embodiment of Figure 19, the propulsion element 42 and the output gear of the output transmission 38 are arranged on the same side as the electric motor 12 with respect to the rotation axis of the transmission output shaft 35.

[0100] Figure 20 shows a detail of the sectional view of the embodiment of the hybrid drive apparatus of Figure 19. The electric motor 12, the hybrid transmission 13, the motor pump device 17, the transition module 30 and the output shift element 84 are illustrated enlarged.

[0101] Figure 21 shows an oil flow diagram of a further embodiment of the hybrid drive apparatus of the fourth concept. The motor pump device 17 is formed as a reversible pump creating the unidirectional flow of the fluid output independent of a rotation direction of the input shaft of the motor pump device 17. The hybrid drive apparatus of the present embodiment comprises all features of the embodiment described with reference to Figure 9. A difference to the embodiment of Figure 9 is that the motor pump device 17 is not configured for lubricating the first shift element 36 and the second shift element 37 and that the hybrid drive apparatus comprises the output shift element 84.

[0102] The motor pump device 17 is indirectly fluidly connected to the output shift element 84 via the non-return valve 55 for operating the output shift element 84. In addition to the embodiment described in Figure 9, the main pump device 16 is fluidly connected to a non-return valve 55. The non-return valve 55 is fluidly connected to the output shift element 84 for operating the output shift element 84. The output shift element 84 is fluidly connected to the fluid storage area 59. In one embodiment, the two non-return valves 55 are fluidly connected to an actuation valve, a solenoid valve at present. The actuation valve is fluidly connected to the output shift element 84 for operating the output shift element 84.

[0103] Figure 22 shows an oil flow diagram of a further embodiment of the hybrid drive apparatus of the fourth concept. The motor pump device 17 is formed as a bidirectional pump and the hybrid drive apparatus comprises the flow direction control unit 60 for generating the unidirectional flow of the fluid output of the motor pump device 17. The present embodiment comprises all features of the embodiment described with reference to Figure 10. A difference to the embodiment of Figure 10 is that the motor pump device 17 is not configured for lubricating the first shift element 36 and the second shift element 37, and that the hybrid drive apparatus comprises the output shift element 84.

[0104] The motor pump device 17 is fluidly connected to the output shift element 84 via the non-return valve 55 and via the flow direction control unit 60 for operating the output shift element 84. In addition to the embodiment described in Figure 10, the main pump device 16 is fluidly connected to a non-return valve 55. The non-return valve 55 is fluidly connected to the output shift element 84 for operating the output shift element 84. The output shift element 84 is fluidly connected to the fluid storage area 59.

[0105] Figure 23 shows a detail of the oil flow diagram of the embodiment of the hybrid drive apparatus of Figure 22. In Figure 23, the flow direction control and 60 is shown comprising all features as described in the embodiment of Figure 11. It is referred to the corresponding description above.

[0106] Figure 24 shows a principal sketch of a sectional view of a further embodiment of the hybrid drive apparatus of the fourth aspect. In the present embodiment, the motor pump device 17 comprises two unidirectional pumps and a non-return valve 55 for each of the unidirectional pumps for creating the unidirectional flow. The present embodiment comprises all features of the embodiment described with reference to Figure 12. In addition, the hybrid drive apparatus further comprises the output shift element 84. By the output shift element 84, the transmission output shaft 35 is mechanically linkable to the propulsion shaft 41. The output shift element 84 is formed as a multi-disc clutch operable by fluid pressure.

[0107] Figure 25 shows an oil flow diagram of the embodiment of the hybrid drive apparatus of Figure 24. The present embodiment comprises all features of the embodiment described with reference to Figure 13. A difference to the embodiment of Figure 13 is that the motor pump device 17 is not configured for lubricating the first shift element 36 and the second shift element 37, and that the hybrid drive apparatus of the present embodiment comprises the output shift element 84.

[0108] Both unidirectional pumps are indirectly fluidly connected to the output shift element 84 via the non-return valve 55, respectively, for operating the output shift element 84. In addition to the embodiment described in Figure 13, the main pump device 16 is fluidly connected to a non-return valve 55. The non-return valves 55 are fluidly connected to the output shift element 84 for operating the output shift element 84. The output shift element 84 is fluidly connected to the fluid storage area 59.

[0109] Figure 26 shows a schematic sketch of an embodiment of a water vehicle with the hybrid drive apparatus. The present embodiment comprises all features of at least one of the preceding embodiments. The water vehicle is formed as a ship and comprises a hull 8. The drive apparatus is mounted inside of the hull 8. The propulsion module 40 with the propulsion shaft 41 and the propulsion element 42 extends through the hull 8 to the outside.

[0110] The invention is further described by the following items:

Item 1. A hybrid drive apparatus for a water vehicle, wherein the hybrid drive apparatus comprises a combustion engine (11) and a transmission output shaft (35), wherein the combustion engine (11) is configured for driving the transmission output shaft (35), an electric motor (12) with a drive shaft and a motor pump device (17), wherein the electric motor (12) is configured for driving the transmission output shaft (35) as well as for driving the motor pump device (17), the motor pump device (17) being mechanically linked to the drive shaft of the electric motor (12) in all operating states of the hybrid drive apparatus.

Item 2. The hybrid drive apparatus according to item 1, characterized in that the input shaft of the motor pump device (17) is connected torque-proofly to and is arranged coaxially to the drive shaft of the electric motor (12).

Item 3. The hybrid drive apparatus according to one of the preceding items, characterized in that the hybrid drive apparatus comprises a main pump device (16) being configured for being driven by the combustion engine (11).

Item 4. The hybrid drive apparatus according to one of the preceding items, characterized in that the hybrid drive apparatus comprises a transmission module (30) having a transmission input shaft (34), wherein the transmission input shaft (34) is configured for being mechanically linkable to a drive shaft of the combustion engine (11), and the transmission module (30) is configured for transmitting a driving force from the transmission input shaft (34) to the transmission output shaft (35) for driving the transmission output shaft (35) in two different rotation directions.

Item 5. The hybrid drive apparatus according to item 4, characterized in that the transmission module (30) has a first input gear (31), a second input gear (32) and an output gear (33), wherein the output gear (33) is torque-proofly connected to the transmission output shaft (35), the first input gear (31) is torque-proofly connectable to the transmission input shaft (34) via a first shift element (36) and the second input gear (32) is torque-proofly connectable to the transmission input shaft (34) via a second shift element (37), and the first input gear (31) and the second input gear (32) are arranged coaxially to each other and are in engagement with the output gear (33) such that the output gear (33) is drivable by the first input gear (31) in a first rotational direction and is drivable by the second input gear (32) in a second rotational direction opposite to the first rotation direction.

Item 6. The hybrid drive apparatus according to one of the preceding items, characterized in that the hybrid drive apparatus comprises a propulsion module (40) having a propulsion shaft (41) and a propulsion element (42), wherein the propulsion element (42) is connected torque-proofly to the propulsion shaft (41) and the propulsion shaft (41) is mechanically linked to the transmission output shaft (35).

Item 7. The hybrid drive apparatus according to item 6, characterized in that the drive apparatus comprises an output transmission (38) having an input bevel gear and an output bevel gear, the input bevel gear being configured for being mechanically linkable to the transmission output shaft (35) and the

output bevel gear being configured for being mechanically linkable to the propulsion shaft (41).

Item 8. The hybrid drive apparatus according to item 7, characterized in that the transmission output shaft (35), the output transmission (38) and the propulsion module (40) are formed as a POD drive.

Item 9. The hybrid drive apparatus according to one of the preceding items, characterized in that the hybrid drive apparatus is configured for providing a driving mode which is at least one of a combustion mode, a hydrogeneration mode, a zero noise mode, a boost mode, a generator mode and an ECO mode.

Item 10. The hybrid drive apparatus according to one of the preceding items, characterized in that the hybrid drive apparatus comprises a drive cooling unit (70) fluidly connected to the motor pump device (17) and configured for cooling the electric motor (12).

Item 11. The hybrid drive apparatus according to one of the preceding items, characterized in that the motor pump device (17) is configured for being driven at its input shaft into two different rotation directions and for providing a single flow direction of a fluid output.

Item 12. The hybrid drive apparatus according to one of the preceding items, characterized in that the hybrid drive apparatus comprises a fluid storage device for storing pressurized fluid for actuating a shift element (36, 37, 83, 84).

Item 13. The hybrid drive apparatus according to one of the preceding items, characterized in that the hybrid drive apparatus comprises a hybrid shift element (83) configured for mechanically linking the drive shaft of the combustion engine (11) with an input shaft of the main pump device (16), the drive shaft of the electric motor (12) being configured for being mechanically linked to an input shaft of the main pump device (16).

Item 14. The hybrid drive apparatus according item 13, characterized in that the drive shaft of the electric motor (12) is arranged parallel to the drive shaft of the combustion engine (11).

Item 15. The hybrid drive apparatus according to item 13 or 14, characterized in that the hybrid shift element (83) has an input element and an output element, wherein the output element is configured for being mechanically linkable to the input shaft of the main pump device (16) as well as to the drive shaft of the electric motor (12).

Item 16. The hybrid drive apparatus according to one of the preceding items, characterized in that the hybrid drive apparatus comprises a fluid summarizing module (58) configured for summarizing a fluid output of the main pump device (16) and a fluid output of the motor pump device (17).

Item 17. A water vehicle comprising a hybrid drive apparatus according to one of the preceding items being configured for a propulsion of the water vehicle

[0111] The invention is further described by the following clauses:

Clause 1. A hybrid drive apparatus for a water vehicle, wherein the hybrid drive apparatus comprises a combustion engine (11) and a transmission output shaft (35), wherein the combustion engine (11) is configured for driving the transmission output shaft (35), an electric motor (12) with a drive shaft and a motor pump device (17), wherein the electric motor (12) is configured for driving the transmission output shaft (35) as well as for driving the motor pump device (17), the motor pump device (17) being mechanically linked to the drive shaft of the electric motor (12) in all operating states of the hybrid drive apparatus.

Clause 2. The hybrid drive apparatus according to clause 1, characterized in that the input shaft of the motor pump device (17) is connected torque-proofly to and is arranged coaxially to the drive shaft of the electric motor (12).

Clause 3. The hybrid drive apparatus according to one of the preceding clauses, characterized in that the hybrid drive apparatus comprises a main pump device (16) being configured for being driven by the combustion engine (11).

Clause 4. The hybrid drive apparatus according to one of the preceding clauses, characterized in that the hybrid drive apparatus comprises a transmission module (30) having a transmission input shaft (34), wherein the transmission input shaft (34) is configured for being mechanically linkable to a drive shaft of the combustion engine (11), and the transmission module (30) is configured for transmitting a driving force from the transmission input shaft (34) to the transmission output shaft (35) for driving the transmission output shaft (35) in two different rotation directions.

Clause 5. The hybrid drive apparatus according to clause 4, characterized in that the transmission module (30) has a first input gear (31), a second input gear (32) and an output gear (33), wherein the output gear (33) is torque-proofly connected to the transmission output shaft (35), the first input gear (31) is

torque-proofly connectable to the transmission input shaft (34) via a first shift element (36) and the second input gear (32) is torque-proofly connectable to the transmission input shaft (34) via a second shift element (37), and the first input gear (31) and the second input gear (32) are arranged coaxially to each other and are in engagement with the output gear (33) such that the output gear (33) is drivable by the first input gear (31) in a first rotational direction and is drivable by the second input gear (32) in a second rotational direction opposite to the first rotation direction.

Clause 6. The hybrid drive apparatus according to one of the preceding clauses, characterized in that the hybrid drive apparatus comprises a propulsion module (40) having a propulsion shaft (41) and a propulsion element (42), wherein the propulsion element (42) is connected torque-proofly to the propulsion shaft (41) and the propulsion shaft (41) is mechanically linked to the transmission output shaft (35).

Clause 7. The hybrid drive apparatus according to clause 6, characterized in that the drive apparatus comprises an output transmission (38) having an input bevel gear and an output bevel gear, the input bevel gear being configured for being mechanically linkable to the transmission output shaft (35) and the output bevel gear being configured for being mechanically linkable to the propulsion shaft (41).

Clause 8. The hybrid drive apparatus according to clause 7, characterized in that the transmission output shaft (35), the output transmission (38) and the propulsion module (40) are formed as a POD drive.

Clause 9. The hybrid drive apparatus according to one of the preceding clauses, characterized in that the hybrid drive apparatus is configured for providing a driving mode which is at least one of a combustion mode, a hydrogeneration mode, a zero noise mode, a boost mode, a generator mode and an ECO mode.

Clause 10. The hybrid drive apparatus according to one of the preceding clauses, characterized in that the hybrid drive apparatus comprises a drive cooling unit (70) fluidly connected to the motor pump device (17) and configured for cooling the electric motor (12).

Clause 11. The hybrid drive apparatus according to one of the preceding clauses, characterized in that the motor pump device (17) is configured for being driven at its input shaft into two different rotation directions and for providing a single flow direction of a fluid output.

Clause 12. The hybrid drive apparatus according to one of the preceding clauses, characterized in that the hybrid drive apparatus comprises a fluid storage device for storing pressurized fluid for actuating a shift element (36, 37, 83, 84).

Clause 13. The hybrid drive apparatus according to one of the preceding clauses, characterized in that the input shaft of the motor pump device (17) is mechanically linked to the transmission output shaft (35) in all operating states of the hybrid drive apparatus.

Clause 14. The hybrid drive apparatus according to clauses 5 and 13, characterized in that the drive shaft of the electric motor (12) is torque-proofly connected to the second input gear (32) and the drive shaft of the electric motor (12) is arranged coaxially to the drive shaft of the combustion engine (11).

Clause 15. The hybrid drive apparatus according to clause 13, characterized in that the drive shaft of the electric motor (12) is mechanically linked to the transmission output shaft (35) and the drive shaft of the electric motor (12) is arranged transversely to the drive shaft of the combustion engine (11).

Clause 16. The hybrid drive apparatus according to clause 6 and one of clauses 13 to 15, characterized in that the hybrid drive apparatus comprises an output shift element (84) by which the transmission output shaft (35) is mechanically linkable to the propulsion shaft (41).

Clause 17. A water vehicle comprising a hybrid drive apparatus according to one of the preceding clauses being configured for a propulsion of the water vehicle.

List of reference signs

[0112]

8	Hull
11	Combustion engine
12	Electric motor
13	Hybrid transmission
16	Main pump device
17	Motor pump device
30	Transmission module
31	First input gear
32	Second input gear
33	Output gear
34	Transmission input shaft
35	Transmission output shaft
36	First shift element
37	Second shift element
38	Output transmission

40 Propulsion module
41 Propulsion shaft
42 Propulsion element
51 First solenoid
52 Second solenoid
53 Heat exchanger
54 Heat exchanger
55 Non-return valve
56 Pressure relief valve
57 Filter device
58 Summarizing module
59 Fluid storage area
60 Flow direction control unit
61 First flow direction valve
62 Second flow direction valve
70 Drive cooling unit
71 Spiral element
72 Pump tube
73 Fluid channel
83 Hybrid shift element
84 Output shift element

Claims

1. A hybrid drive apparatus for a water vehicle, wherein the hybrid drive apparatus comprises a combustion engine (11) and a transmission output shaft (35), wherein the combustion engine (11) is configured for driving the transmission output shaft (35), an electric motor (12) with a drive shaft and a motor pump device (17), wherein the electric motor (12) is configured for driving the transmission output shaft (35) as well as for driving the motor pump device (17), the motor pump device (17) being mechanically linked to the drive shaft of the electric motor (12) in all operating states of the hybrid drive apparatus.

2. The hybrid drive apparatus according to claim 1, **characterized in that** the input shaft of the motor pump device (17) is connected torque-proofly to and is arranged coaxially to the drive shaft of the electric motor (12).

3. The hybrid drive apparatus according to one of the preceding claims, **characterized in that** the hybrid drive apparatus comprises a main pump device (16) being configured for being driven by the combustion engine (11).

4. The hybrid drive apparatus according to one of the preceding claims, **characterized in that** the hybrid drive apparatus comprises a transmission module (30) having a transmission input shaft (34), wherein the transmission input shaft (34) is configured for being mechanically linkable to a drive shaft of the combustion engine (11), and the transmission module (30) is configured for transmitting a driving force from the transmission input shaft (34) to the transmission output shaft (35) for driving the transmission output shaft (35) in two different rotation directions.

5. The hybrid drive apparatus according to claim 4, **characterized in that** the transmission module (30) has a first input gear (31), a second input gear (32) and an output gear (33), wherein the output gear (33) is torque-proofly connected to the transmission output shaft (35), the first input gear (31) is torque-proofly connectable to the transmission input shaft (34) via a first shift element (36) and the second input gear (32) is torque-proofly connectable to the transmission input shaft (34) via a second shift element (37), and the first input gear (31) and the second input gear (32) are arranged coaxially to each other and are in engagement with the output gear (33) such that the output gear (33) is drivable by the first input gear (31) in a first rotational direction and is drivable by the second input gear (32) in a second rotational direction opposite to the first rotation direction.

6. The hybrid drive apparatus according to one of the preceding claims, **characterized in that** the hybrid drive apparatus comprises a propulsion module (40) having a propulsion shaft (41) and a propulsion element (42), wherein the propulsion element (42) is connected torque-proofly to the propulsion shaft (41) and the propulsion shaft (41) is mechanically linked to the transmission output shaft (35).

7. The hybrid drive apparatus according to claim 6, **characterized in that** the drive apparatus comprises an output transmission (38) having an input bevel gear and an output bevel gear, the input bevel gear being configured for being mechanically linkable to the transmission output shaft (35) and the output bevel gear being configured for being mechanically linkable to the propulsion shaft (41).

8. The hybrid drive apparatus according to claim 7, **characterized in that** the transmission output shaft (35), the output transmission (38) and the propulsion module (40) are formed as a POD drive.

9. The hybrid drive apparatus according to one of the preceding claims, **characterized in that** the hybrid drive apparatus is configured for providing a driving mode which is at least one of a combustion mode, a hydrogeneration mode, a zero noise mode, a boost mode, a generator mode and an ECO mode.

10. The hybrid drive apparatus according to one of the preceding claims, **characterized in that** the hybrid drive apparatus comprises a drive cooling unit (70) fluidly connected to the motor pump device (17) and configured for cooling the electric motor (12).

11. The hybrid drive apparatus according to one of the preceding claims, **characterized in that** the motor pump device (17) is configured for being driven at its input shaft into two different rotation directions and for providing a single flow direction of a fluid output.

12. The hybrid drive apparatus according to one of the preceding claims, **characterized in that** the hybrid drive apparatus comprises a fluid storage device for storing pressurized fluid for actuating a shift element (36, 37, 83, 84).

13. The hybrid drive apparatus according to one of the preceding claims, **characterized in that** the motor pump device (17) is formed as a screw pump having a pump tube (72) and a spiral element (71) for rotating relative to the pump tube (72) for pumping a fluid to a fluid receiving area.

14. The hybrid drive apparatus according to claim 13, **characterized in that** the drive shaft of the electric motor (12) is formed as a hollow shaft and is torque-proofly connected to the transmission output shaft (35), the transmission output shaft (35) extends through the hollow shaft, the pump tube (72) is arranged between and coaxially to the hollow shaft and the transmission output shaft (35), and one of the drive shaft of the electric motor (12) and the transmission output shaft (35) forms the spiral element (71).

15. The hybrid drive apparatus according to claim 13 or 14, **characterized in that** the drive shaft of the electric motor (12) comprises an opening extending from the fluid receiving area radially outward through the drive shaft for supplying fluid to at least to one of a stator and a rotor of the electric motor (12).

16. A water vehicle comprising a hybrid drive apparatus according to one of the preceding claims being configured for a propulsion of the water vehicle.

FIG. 1

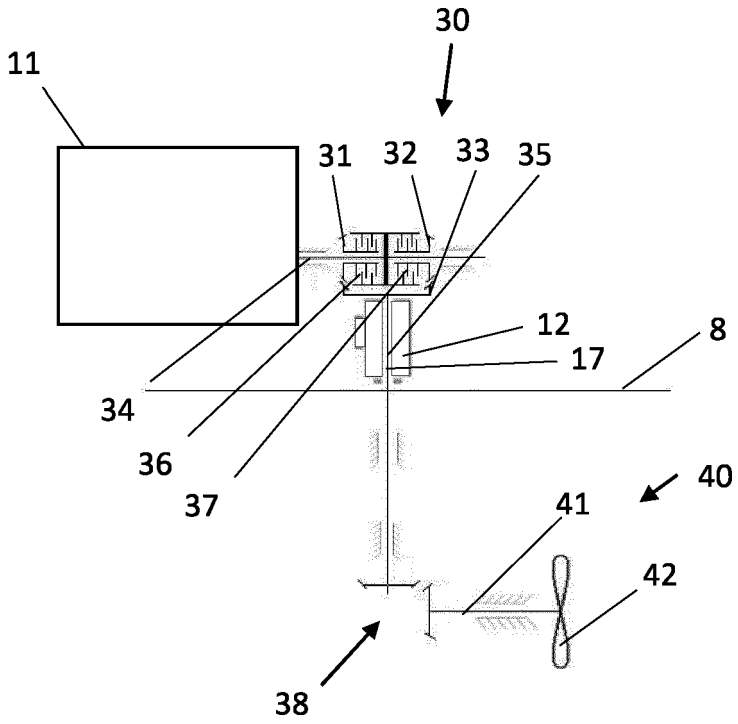


FIG. 2

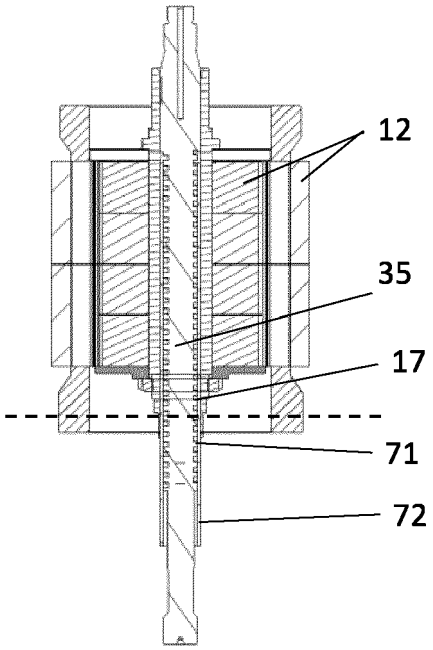


FIG. 3

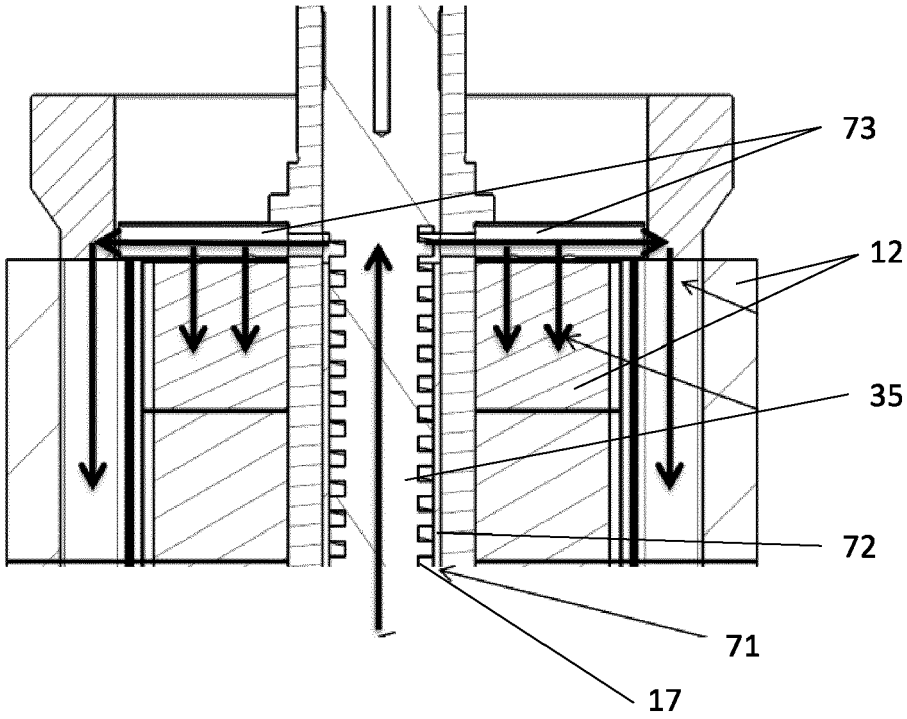


FIG. 4

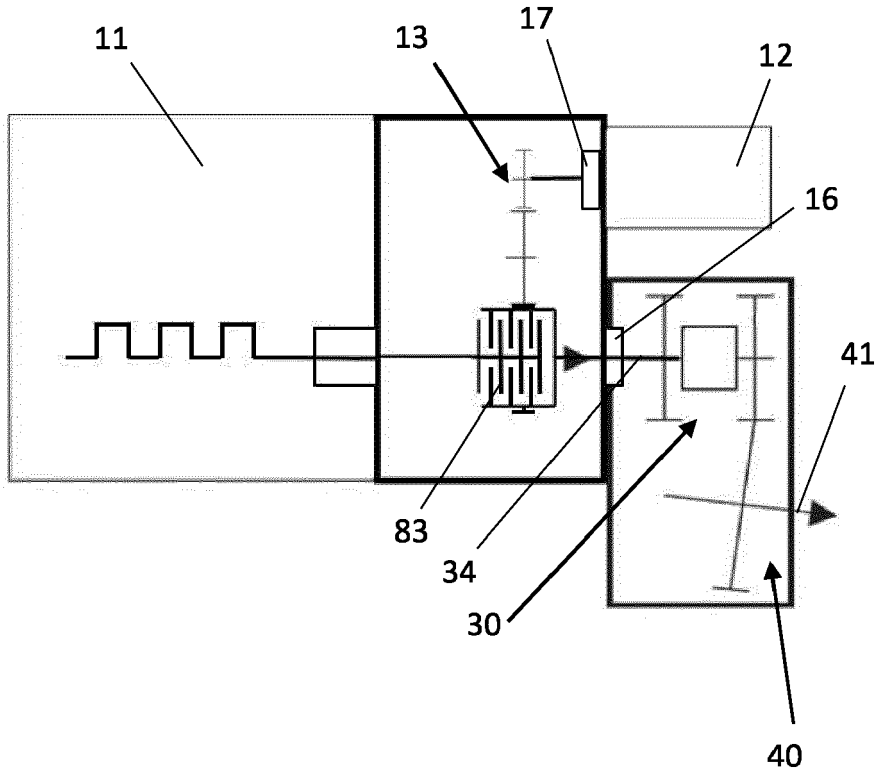


FIG. 5

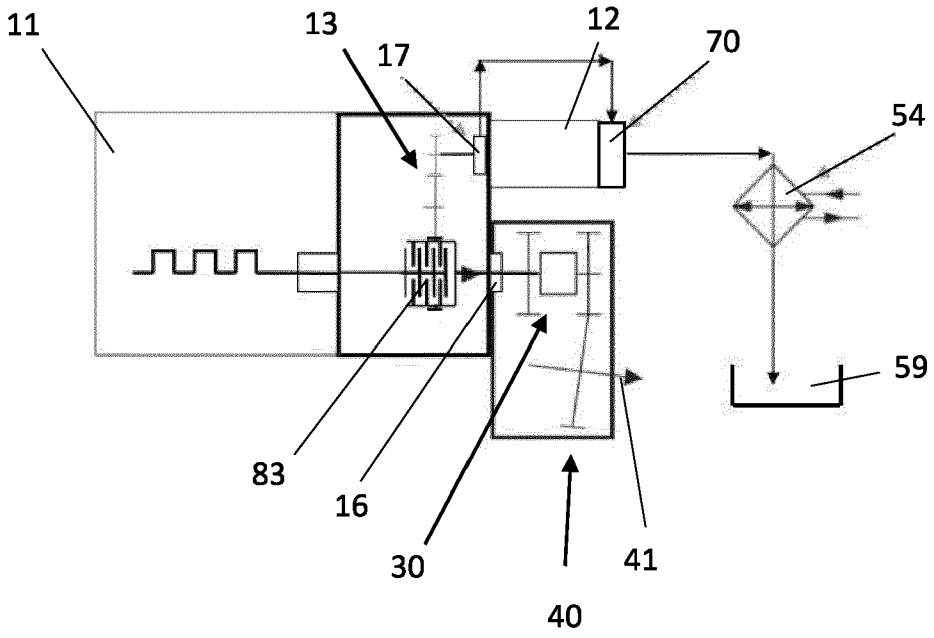


FIG. 6

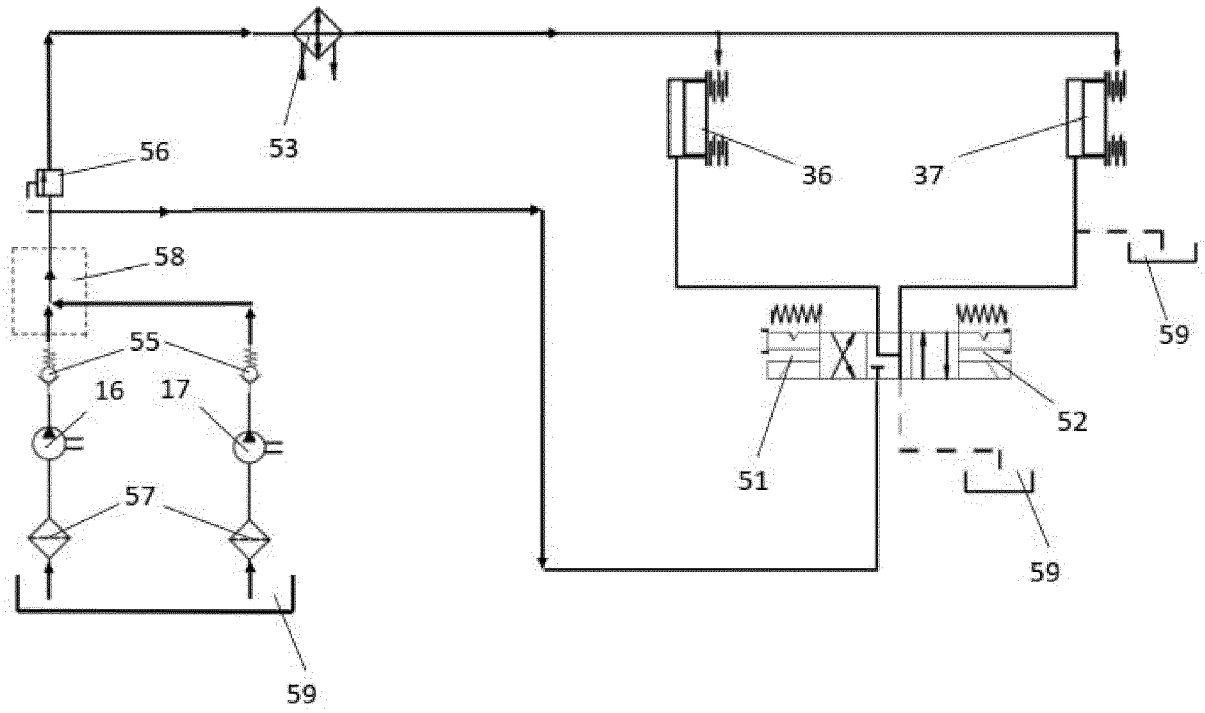


FIG. 7

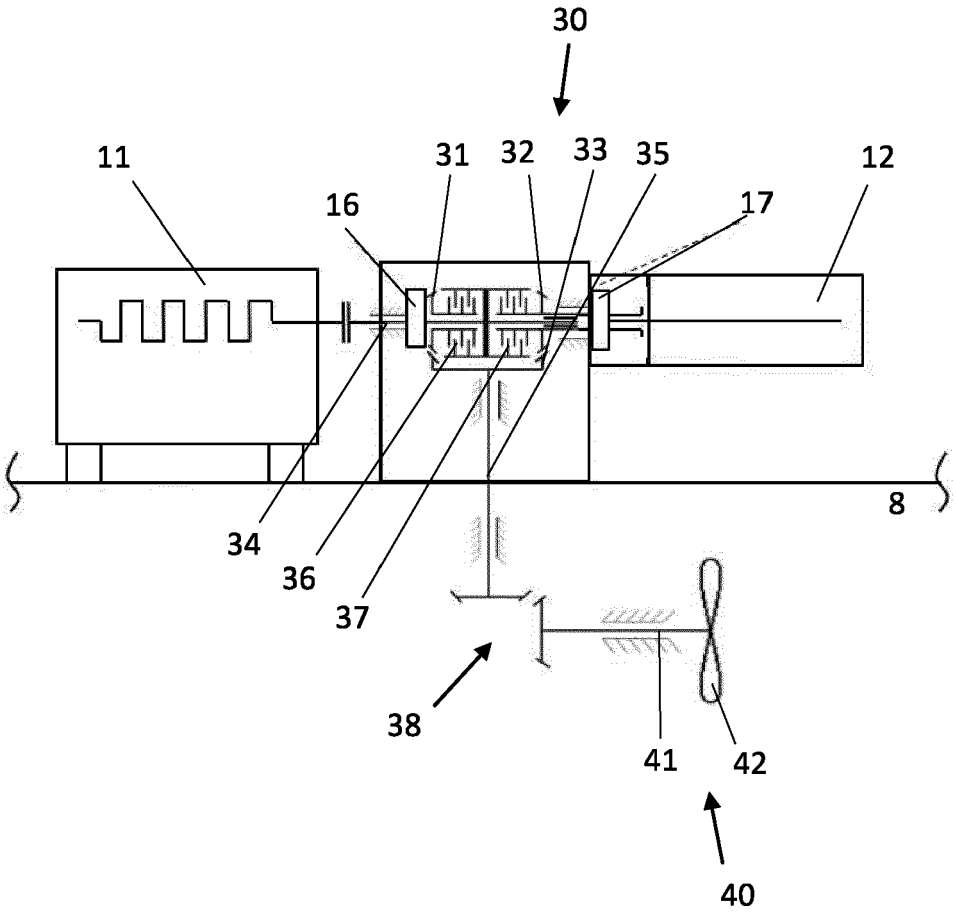


FIG. 8

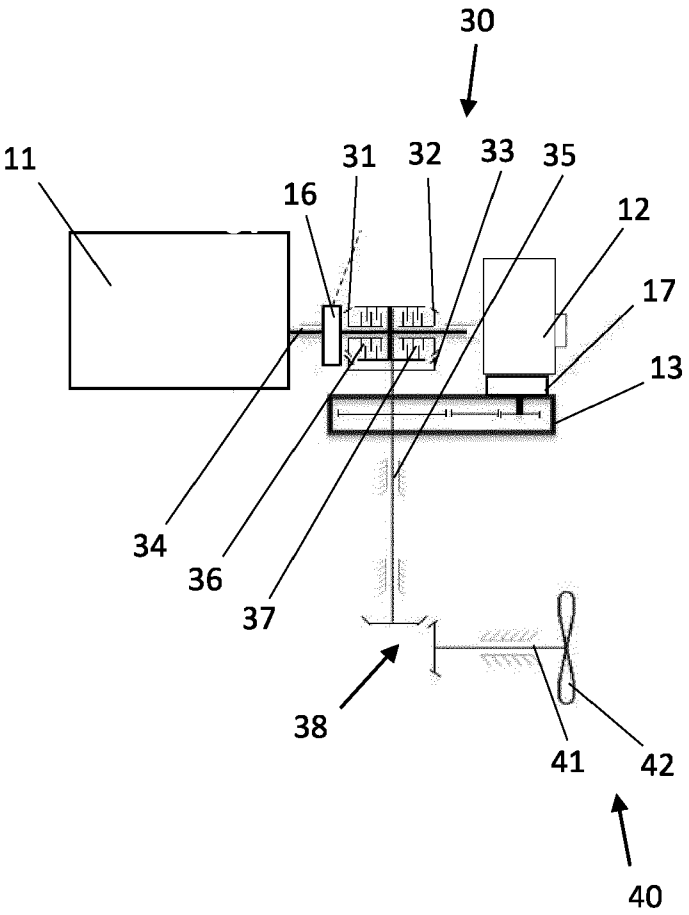


FIG. 9

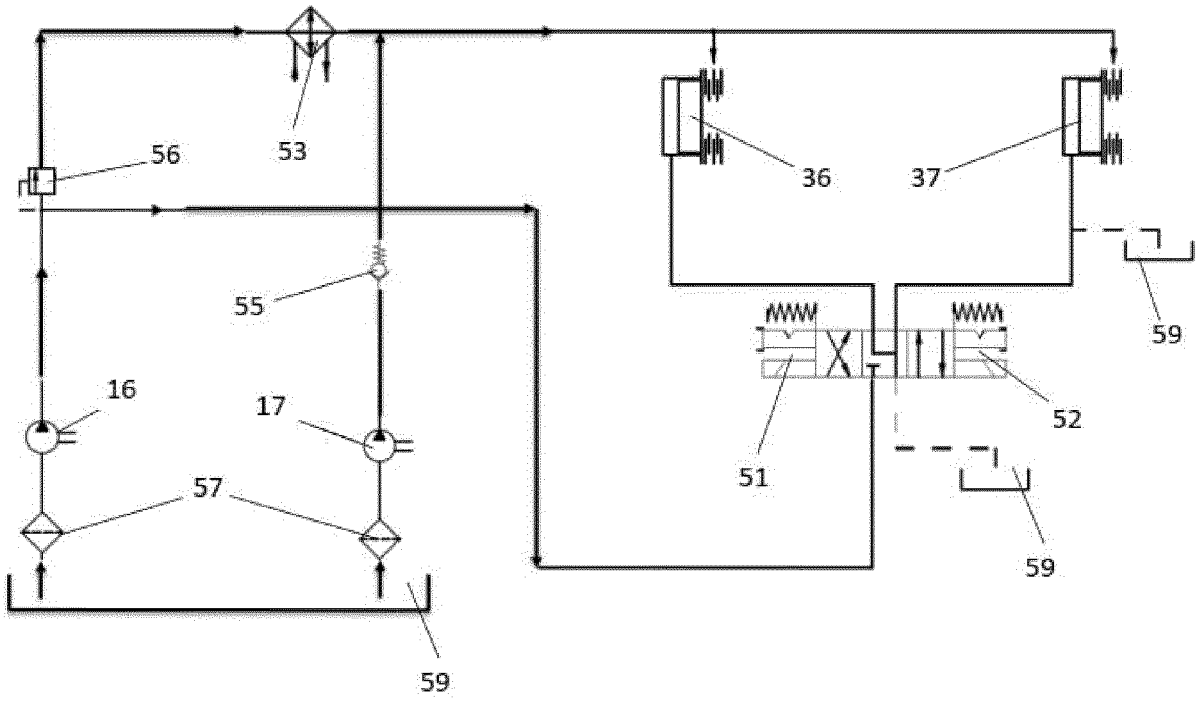


FIG. 10

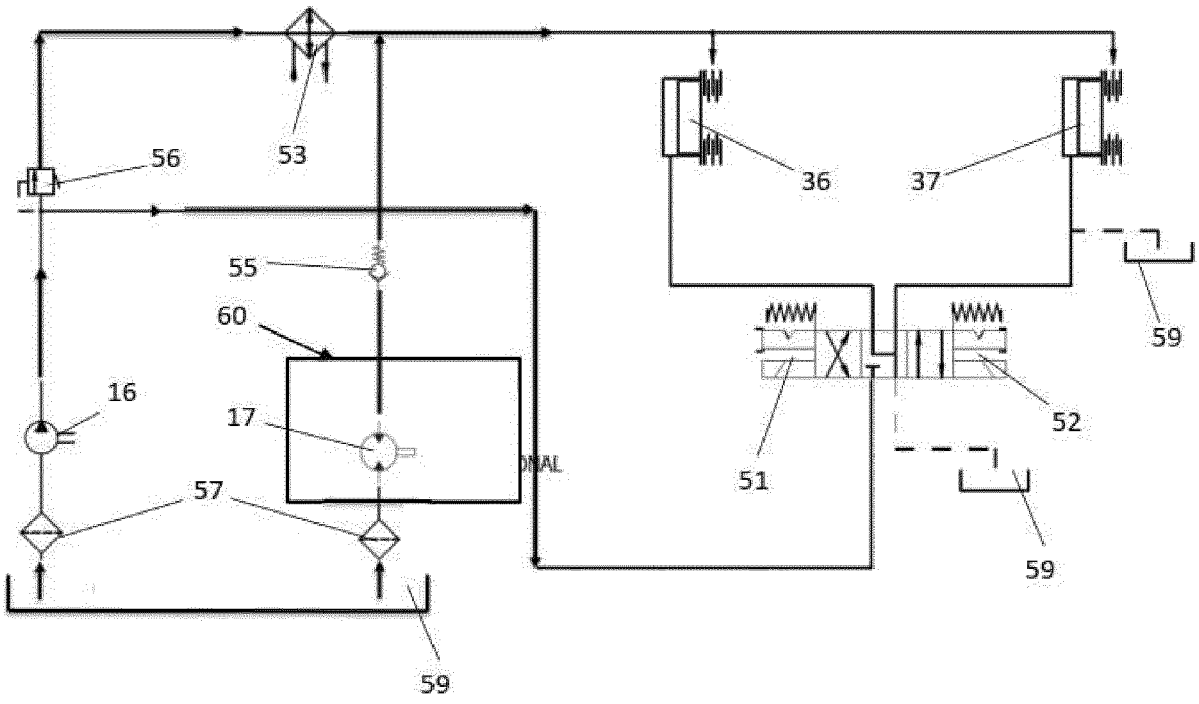


FIG. 11

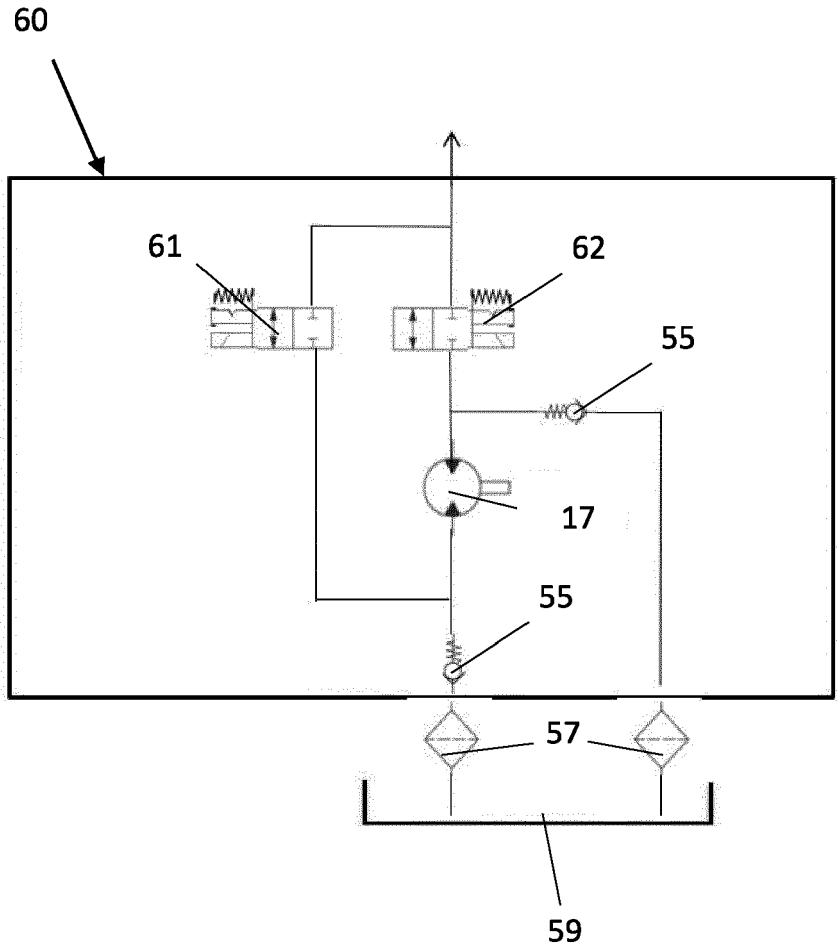


FIG. 12

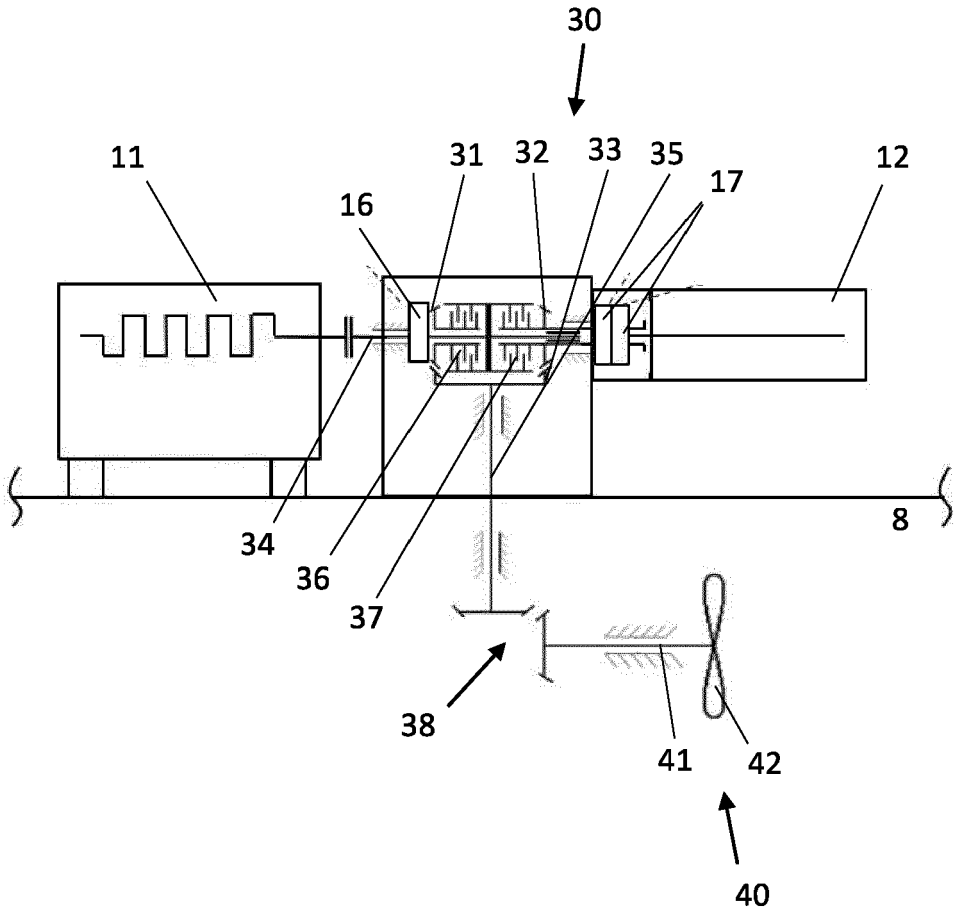


FIG. 13

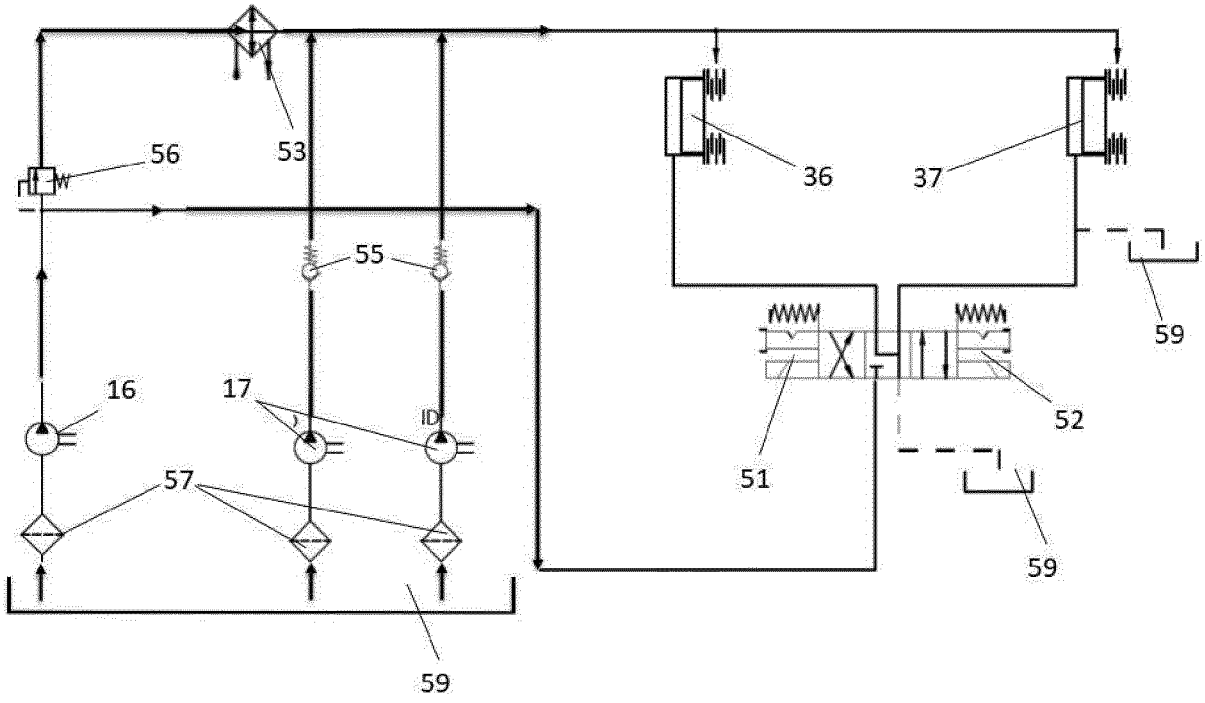


FIG. 14

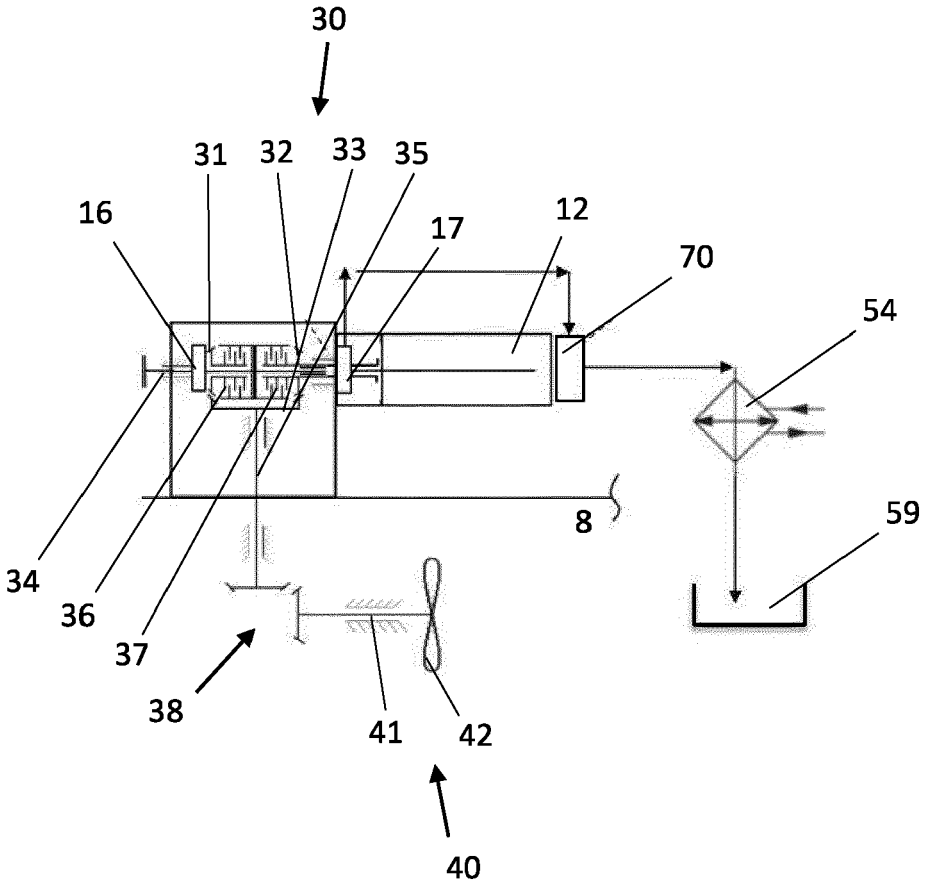


FIG. 15

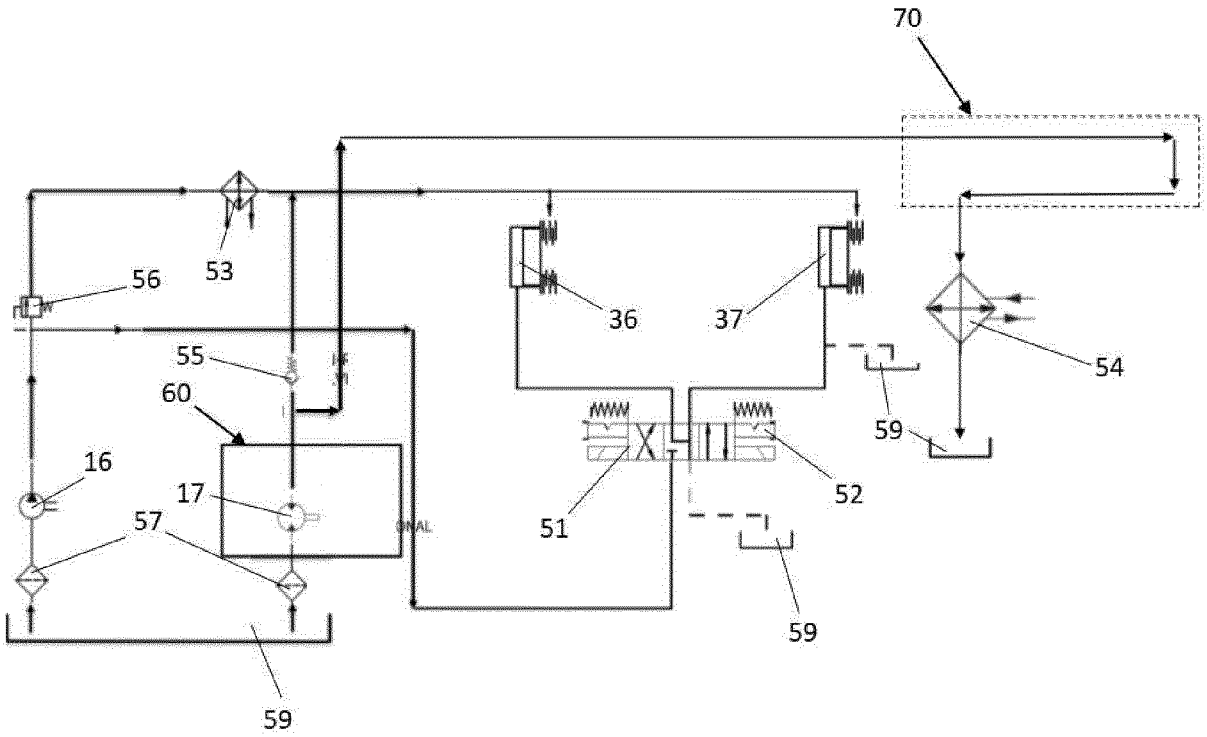


FIG. 16

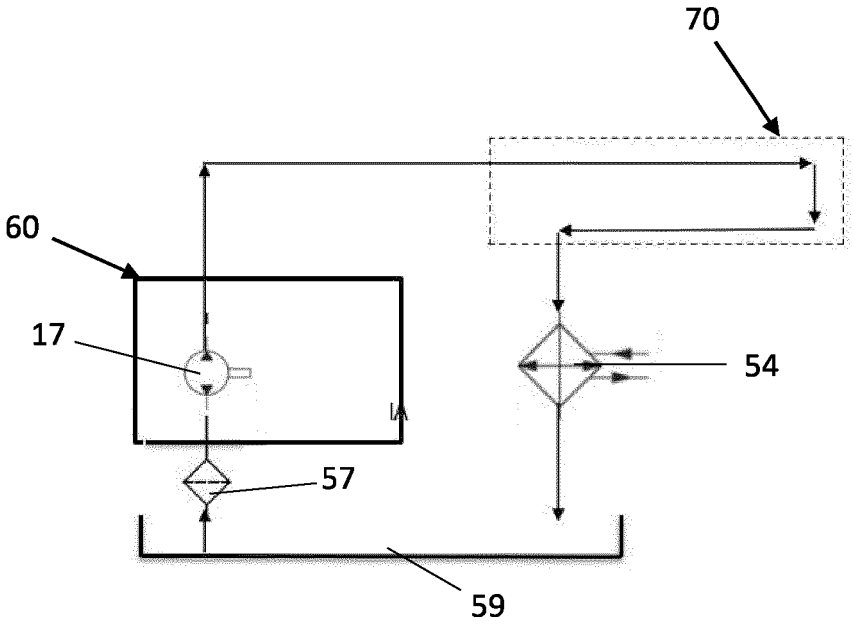


FIG. 17

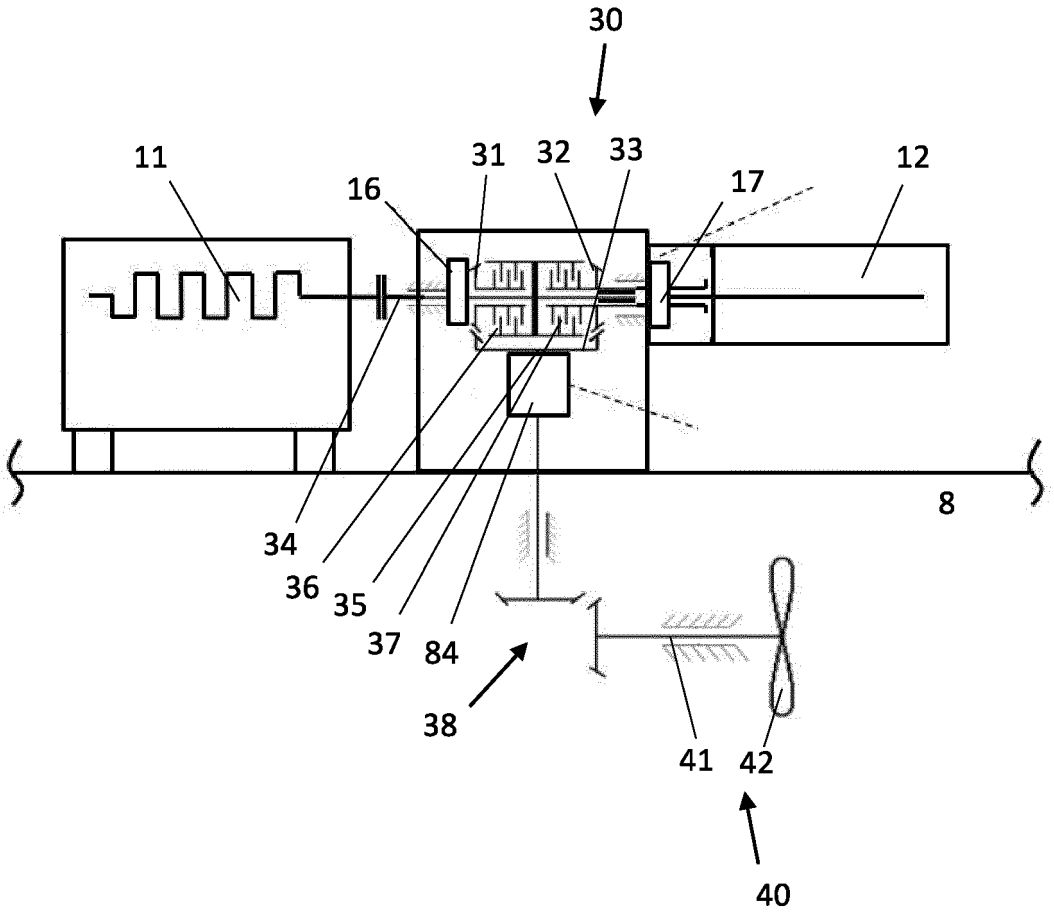


FIG. 18

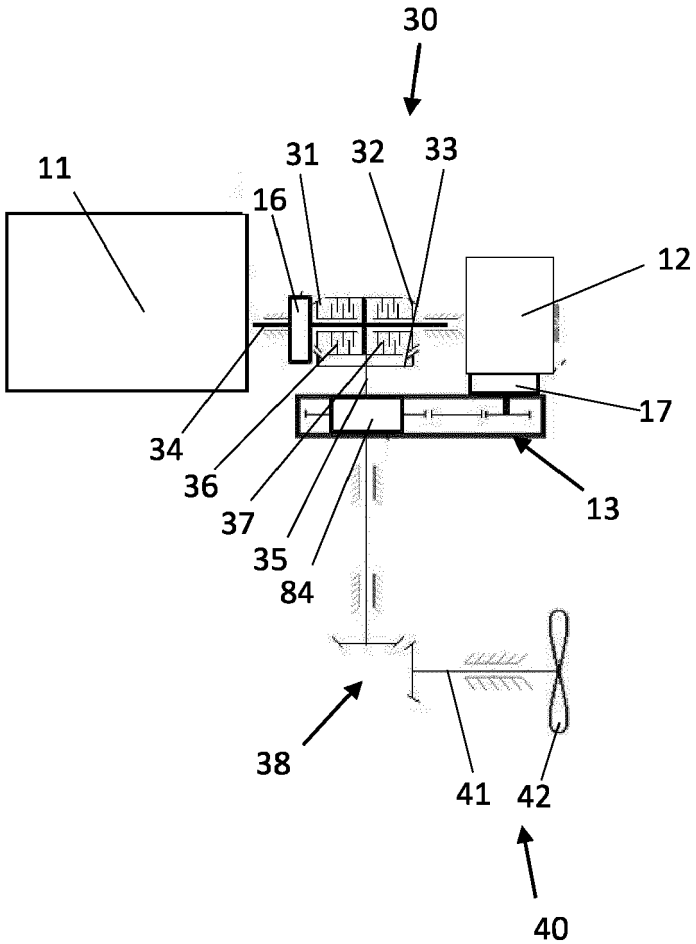


FIG. 19

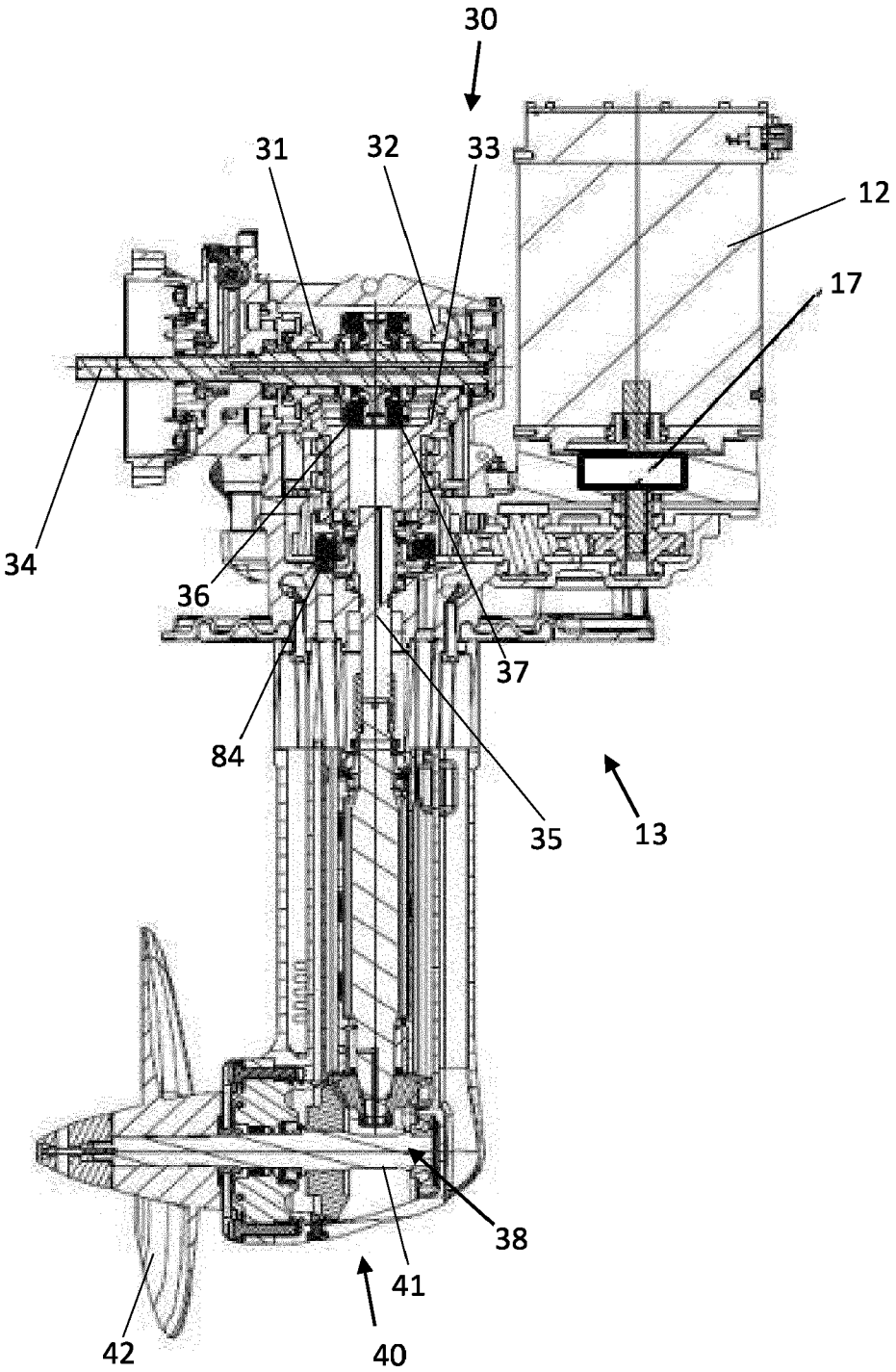


FIG. 20

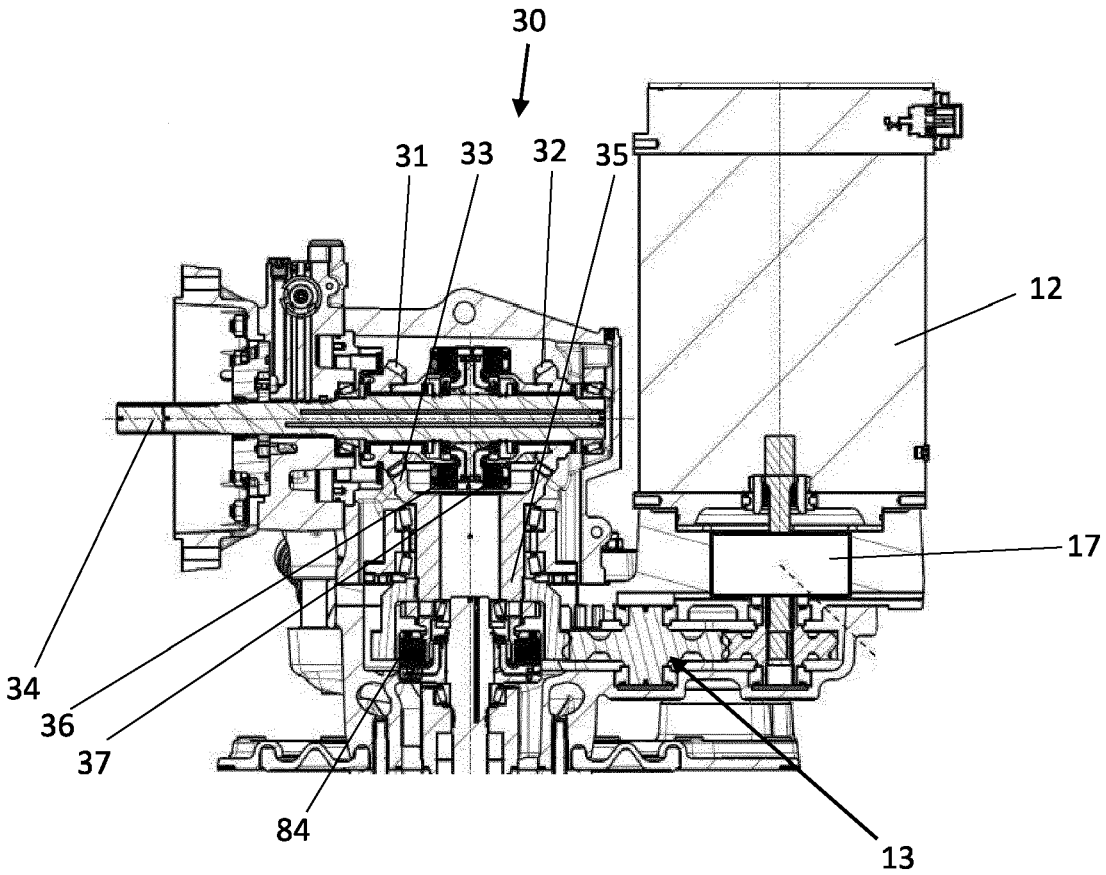


FIG. 21

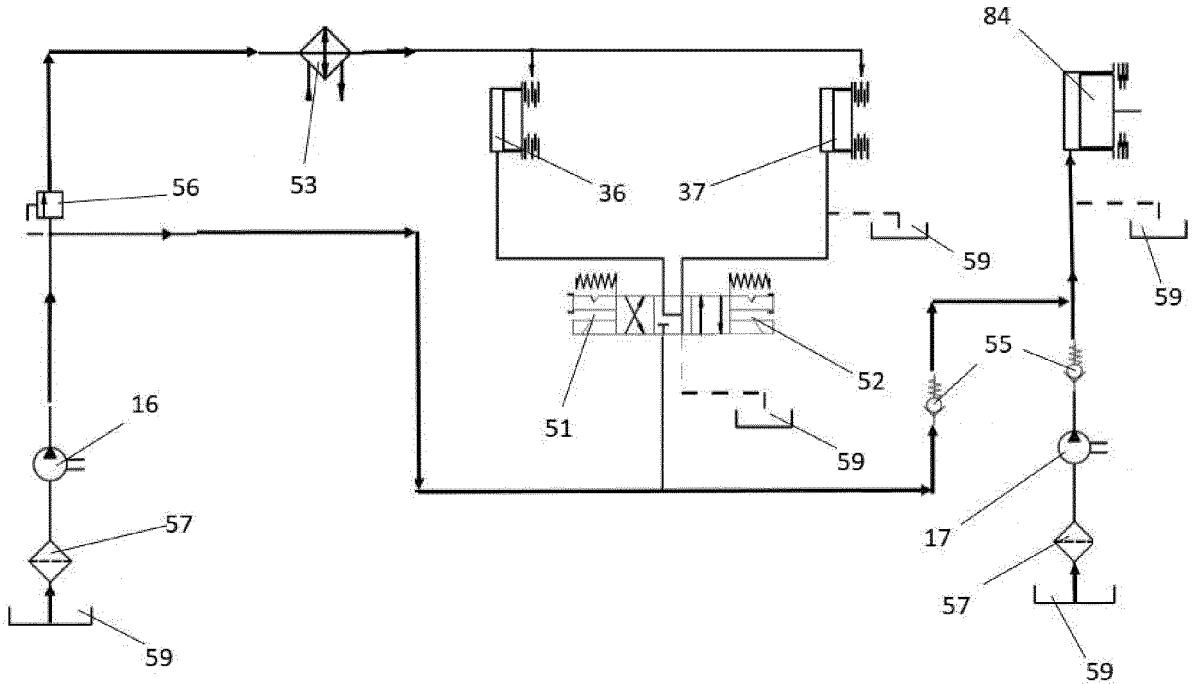


FIG. 22

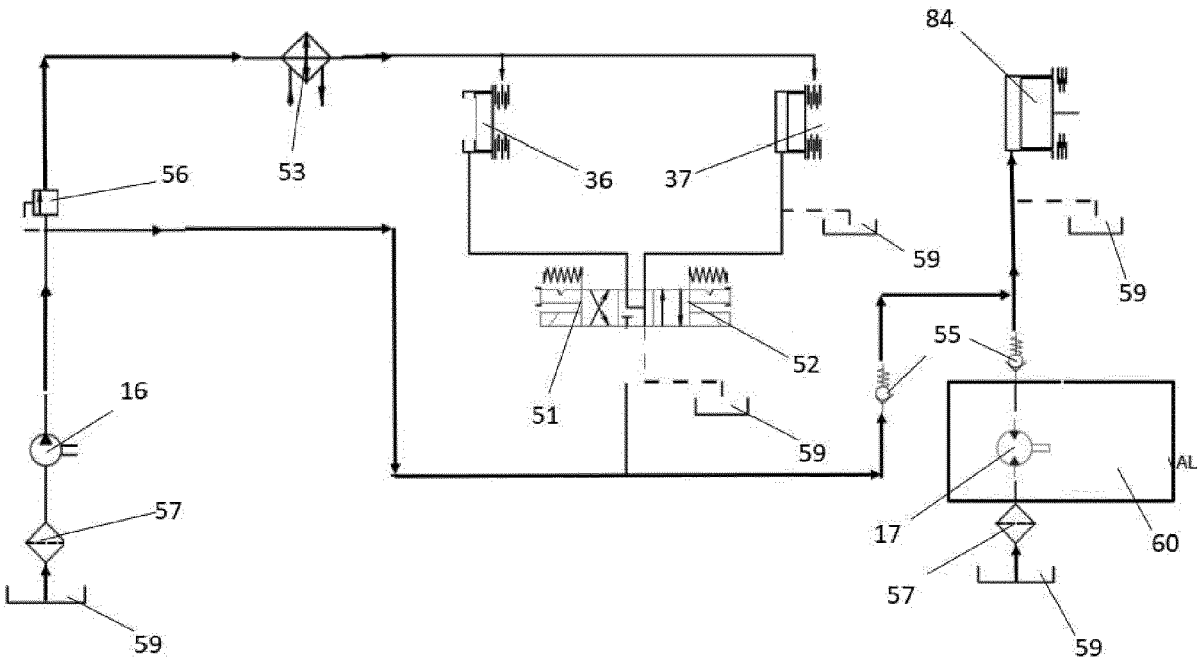


FIG. 23

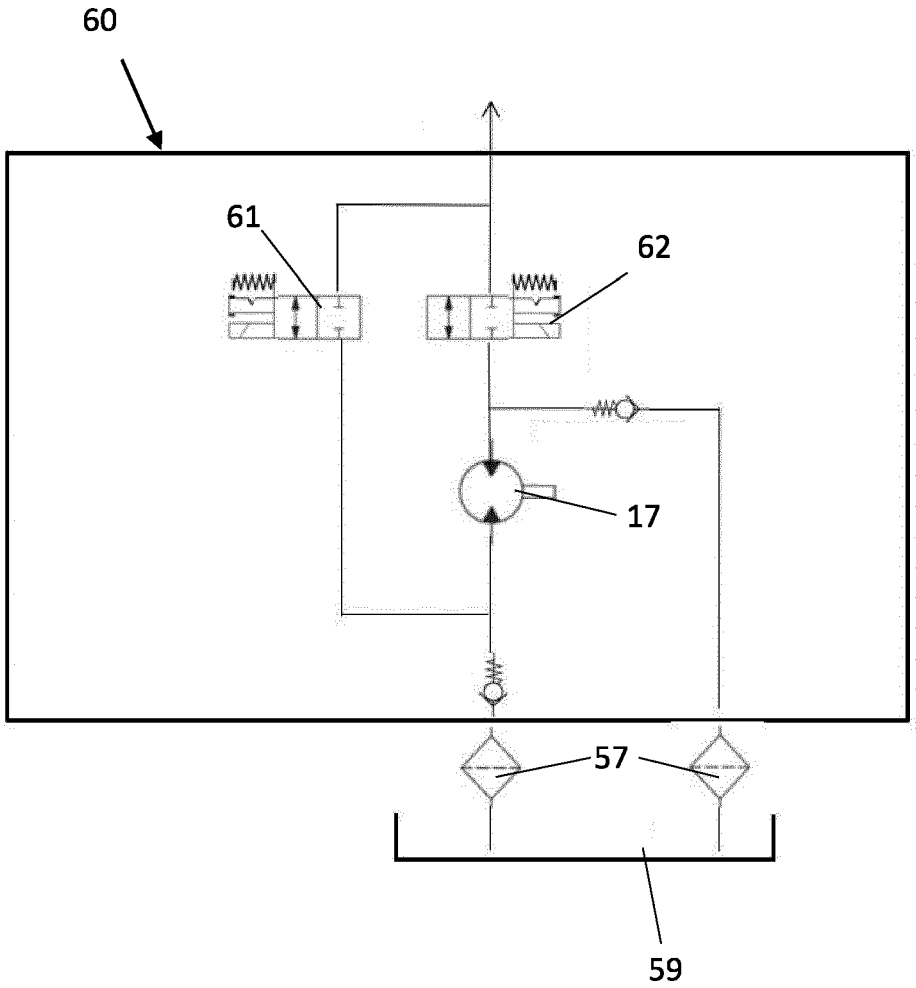


FIG. 24

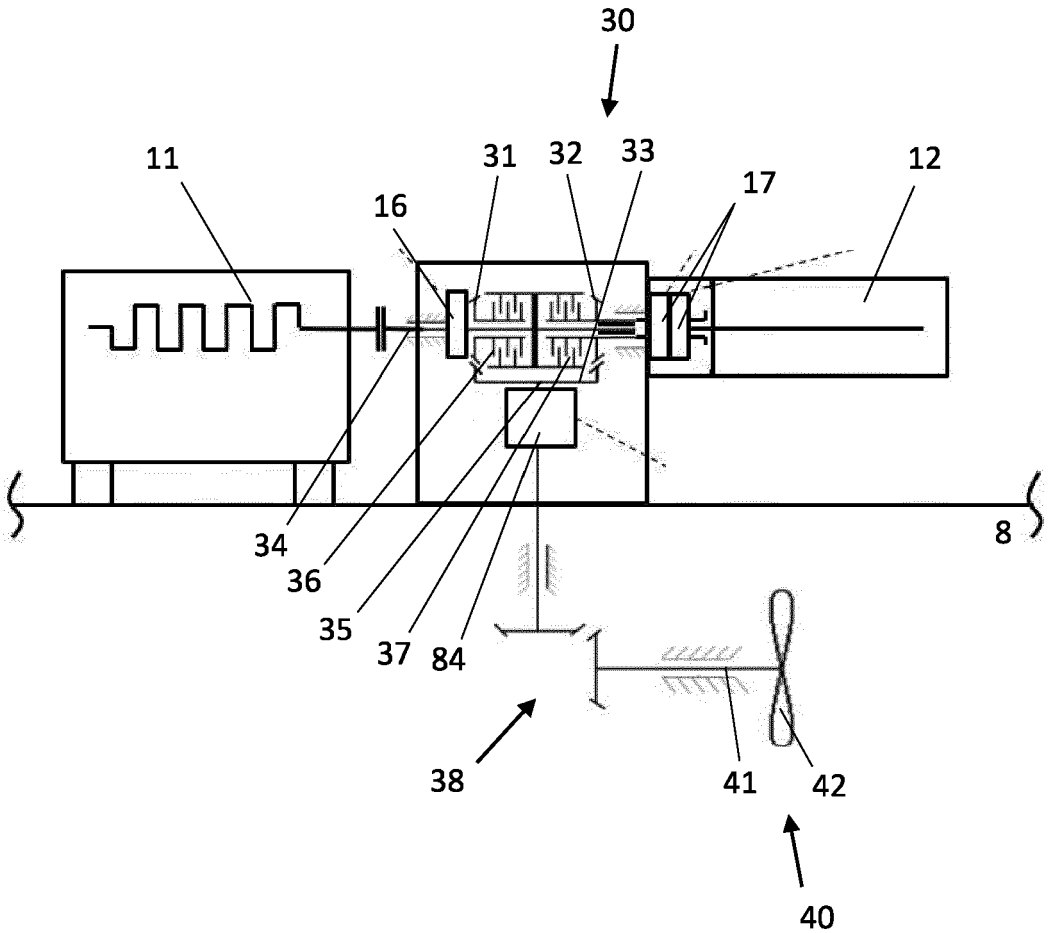


FIG.25

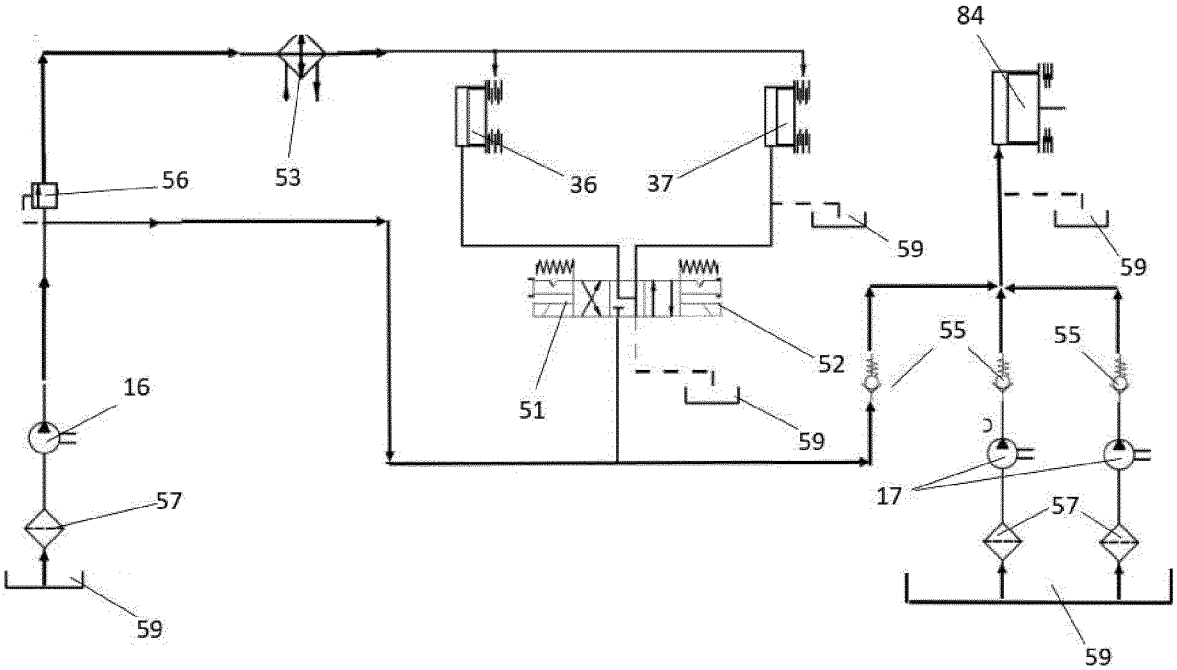
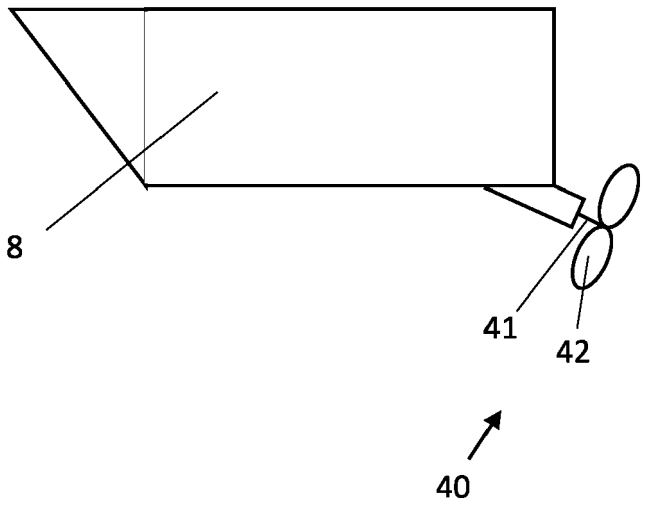


FIG. 26



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Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	29 January 2025	Freire Gomez, Jon

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