

# (12) Indian Patent Application

(21) Application Number: 201741023034

(22) Filing Date: 30/06/2017 (43) Publication Date: 04/01/2019

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(51) International Classifications: B63H 25/42 B63H 5/20 B63H

(54) Title: PROPULSION SYSTEM FOR MARINE VESSEL

(57) Abstract: This disclosure relates generally to a propulsion system, and more particularly to a propulsion system (100) for a marine vessel. In one embodiment, the propulsion system (100) includes a propeller shaft (104) coupled to a propeller (108), and a pinion shaft (112) coupled to the propeller shaft (104), at a substantially vertical angle, via a gear assembly (114). The propulsion system (100) further includes at least one propeller shaft driving unit (118) to selectively engage with the propeller shaft (104), and at least one pinion shaft driving unit (120) to selectively engage with the pinion shaft (112).

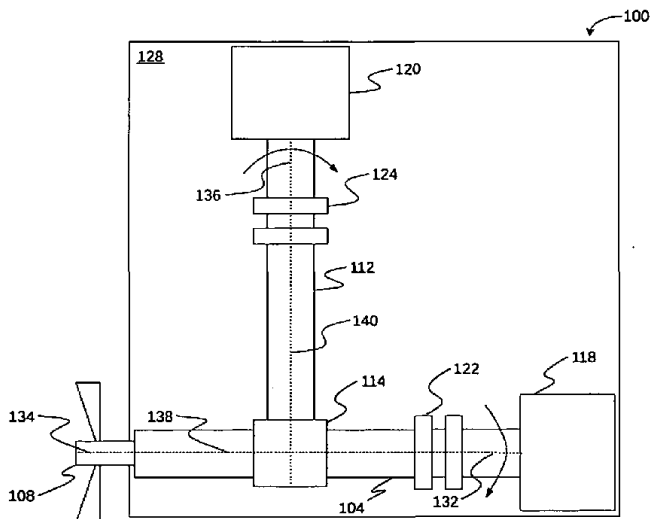


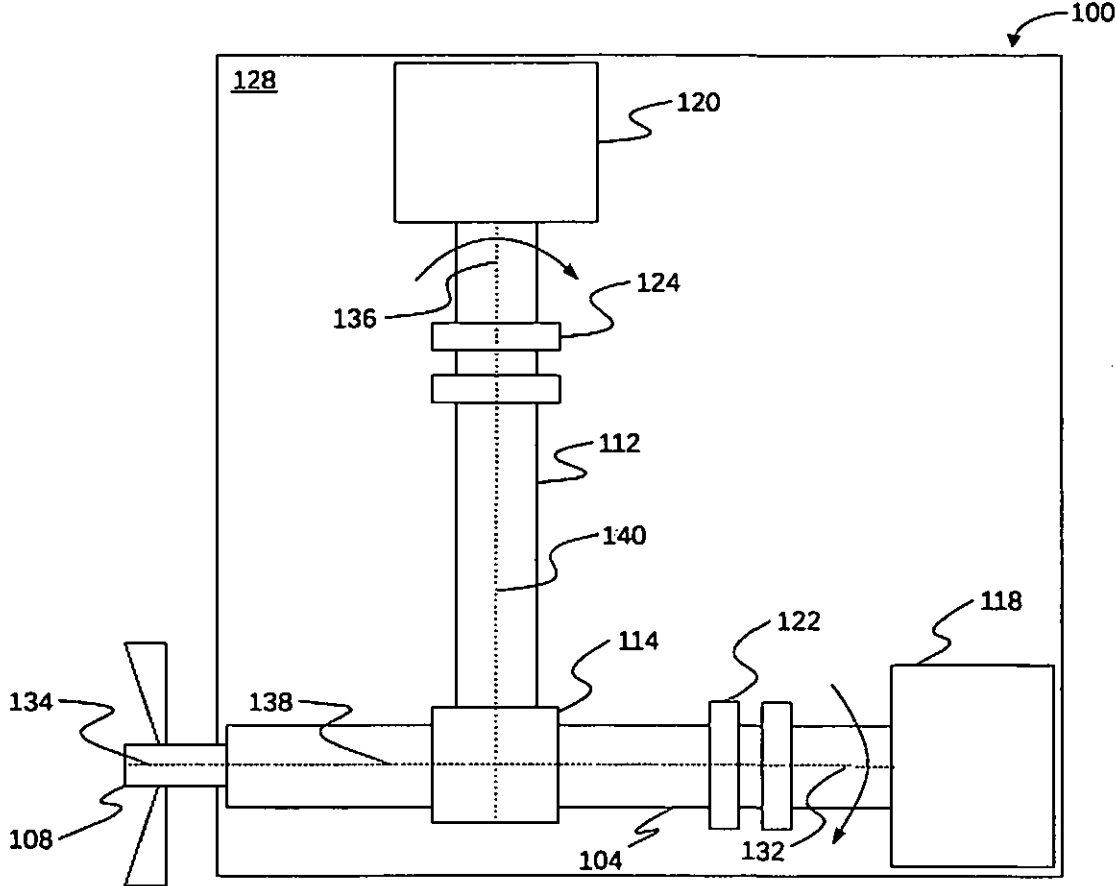
Figure 1

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**ABSTRACT**  
**PROPULSION SYSTEM FOR MARINE VESSEL**

This disclosure relates generally to a propulsion system, and more particularly to a propulsion system (100) for a marine vessel. In one embodiment, the propulsion system (100) includes a propeller shaft (104) coupled to a propeller (108), and a pinion shaft (112) coupled to the propeller shaft (104), at a substantially vertical angle, via a gear assembly (114). The propulsion system (100) further includes at least one propeller shaft driving unit (118) to selectively engage with the propeller shaft (104), and at least one pinion shaft driving unit (120) to selectively engage with the pinion shaft (112).



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We claim:

1. A propulsion system (100) for a marine vessel, the propulsion system (100) comprising:
  - a propeller shaft (104) coupled to a propeller (108);
  - a pinion shaft (112) coupled to the propeller shaft (104), at a substantially vertical angle, via a gear assembly (114);
  - at least one propeller shaft driving unit (118) to selectively engage with the propeller shaft (104); and
  - at least one pinion shaft driving unit (120) to selectively engage with the pinion shaft (112).
2. The propulsion system (100) of claim 1, wherein the substantially vertical angle comprises an angle of about 90 degrees.
3. The propulsion system (100) of claim 1, wherein the gear assembly (114) couples an intermediary shaft (216) to the pinion shaft (112) via a bevel gear assembly, and further couples the intermediary shaft (216) to the propeller shaft (104) via a parallel gear assembly.
4. The propulsion system (100) of claim 1, wherein:
  - the at least one propeller shaft driving unit (118) selectively engages with the propeller shaft (104) via at least one first coupling assembly (122); or
  - the at least one pinion shaft driving unit (120) selectively engages with the pinion shaft (112) via at least one second coupling assembly (124).
5. The propulsion system (100) of claim 6, wherein each of the at least one first (122) and the at least one second (124) coupling assembly comprises one of a clutch assembly or a spline assembly.
6. The propulsion system (100) of claim 1, wherein each of the at least one propeller shaft driving unit (118) and the at least one pinion shaft driving unit (120) comprises an electric motor.
7. The propulsion system (100) of claim 1, wherein the propeller (108) is operated by operating at least one of the at least one propeller shaft driving unit (118) or the at least one pinion shaft driving unit (120).

8. A propulsion system (100) for a marine vessel, the propulsion system (100) housed in an enclosure (128) and comprising:

a first driving unit (118) couplable to a propeller (108) via a first coupling assembly (122), wherein axis (132) of the first driving unit (118) is aligned at a substantially horizontal angle to axis (134) of the propeller (108); and

a second driving unit (120) couplable to the propeller (108) via a second coupling assembly (124) and a gear assembly (114), wherein axis (136) of the second driving unit (120) is aligned at a substantially vertical angle to the axis (134) of the propeller (108).

9. The propulsion system (100) of claim 11, wherein the first driving unit (118) is couplable to a first shaft (104) via the first coupling assembly (122) and the first shaft (104) is coupled to the propeller (108), and wherein axis (138) of the first shaft (104) is aligned at a substantially horizontal angle to the axis (132) of the first driving unit (118) and to the axis (134) of the propeller (108).

10. The propulsion system (100) of claim 11, wherein the second driving unit (120) is couplable to a second shaft (112) via the second coupling assembly (124) and the second shaft (112) is coupled to the propeller (108) via the gear assembly (114), and wherein axis (140) of the second shaft (112) is aligned at a substantially horizontal angle to the axis (136) of the second driving unit (120) and is aligned at the substantially vertical angle to the axis (134) of the propeller (108).

11. The propulsion system (100) of claim 11, wherein each of the first (122) and the second (124) coupling assembly comprises one of a clutch assembly or a spline assembly, and wherein each of the first (118) and the second (120) driving unit comprises an electric motor.

Dated this 30<sup>th</sup> day of June 2017



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### Technical Field

[001] This disclosure relates generally to a propulsion system, and more particularly to a propulsion system for a marine vessel.

### Background

[002] Propulsion systems play an important role in marine vessels like ships, boats, yachts, etc. A propulsion system for a marine vessel may include a driving unit (i.e., power generation source) for driving a propeller, which may then generate thrust to impart to movement of the marine vessel across water. The propulsion system may further include a power transmission assembly that may couple the driving unit to the propeller. The driving unit may include an electric motor, a combustion engine, or a combination of the electric motor and the combustion engine. Generally, the driving unit may be selected based on a maximum power requirement of the marine vessel. It should be noted that the maximum power requirement may include a backup power requirement. For example, in some scenarios, 10% of the maximum continuous power rating of the driving unit may be provided for the backup power requirement.

[003] Existing propulsion systems employing single driving unit (i.e., electric motor, or combustion engine) may typically require higher power rating driving unit so as to meet the power requirement of the marine vessel. As will be appreciated, such high-power rating driving unit are not only costly but also inefficient. For example, when the marine vessel is required to run at slow speed, the propulsion system has to run at slower speed which may decrease the overall efficiency of the driving unit. Existing propulsion systems employing hybrid driving unit (i.e., combination of electric motor and combustion engine) may overcome some of the above limitations. However, even with the hybrid driving unit running at optimum efficiency, there may be losses due to conversion of energy from one source to another source. Further, such propulsion systems may occupy significant space in the marine vessel as batteries for the electric motor of the required rating need a large amount of space.

[004] Some of the existing propulsion systems may employ a mechanical drive shaft that extends through a hull of the marine vessel to an external body. The mechanical drive shaft may be driven by either a driving unit (e.g., prime mover) located within the marine vessel or another driving unit (e.g., electric motor) located in the external body through which the

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mechanical drive shaft extends. Again, such propulsion systems may occupy space in the marine vessel as the prime mover is located in the hull of the marine vessel.

### SUMMARY

[005] In one embodiment, a propulsion system for a marine vessel is disclosed. The propulsion system may include a propeller shaft coupled to a propeller. The propulsion system may further include a pinion shaft coupled to the propeller shaft at a substantially vertical angle, via a gear assembly. The propulsion system may further include at least one propeller shaft driving unit to selectively engage with the propeller shaft. The propulsion system may further include at least one pinion shaft driving unit to selectively engage with the pinion shaft.

[006] In another embodiment, a propulsion system for a marine vessel is disclosed. The propulsion system may be housed in an enclosure and may include a first driving unit couplable to the propeller via a first coupling assembly, such that axis of the first driving unit is aligned at a substantially horizontal angle to axis of the propeller. The propulsion system may further include a second driving unit couplable to the propeller via a second coupling assembly and a gear assembly, such that axis of the second driving unit is aligned at a substantially vertical angle to the axis of the propeller.

[007] In yet another embodiment, a marine vessel is disclosed. The marine vehicle may include a propeller and a propulsion system for driving the propeller. The propulsion system may include a propeller shaft coupled to the propeller. The propulsion system may further include a pinion shaft coupled to the propeller shaft at a substantially vertical angle, via a gear assembly. The propulsion system may further include at least one propeller shaft driving unit to selectively engage with the propeller shaft. The propulsion system may further include at least one pinion shaft driving unit to selectively engage with the pinion shaft.

[008] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

## BRIEF DESCRIPTION OF THE DRAWINGS

[009] The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate exemplary embodiments and, together with the description, serve to explain the disclosed principles.

[010] FIG. 1 illustrates a schematic of an exemplary propulsion system for a marine vessel, in accordance with some embodiments; and

[011] FIG. 2 illustrates a cross-section view of another exemplary propulsion system for a marine vessel, in accordance with some embodiments; and

[012] FIG. 3 illustrates an isometric section view of the exemplary propulsion system of FIG. 2, in accordance with some embodiments.

## DETAILED DESCRIPTION

[013] Exemplary embodiments are described with reference to the accompanying drawings. Wherever convenient, the same reference numbers are used throughout the drawings to refer to the same or like parts. While examples and features of disclosed principles are described herein, modifications, adaptations, and other implementations are possible without departing from the spirit and scope of the disclosed embodiments. It is intended that the following detailed description be considered as exemplary only, with the true scope and spirit being indicated by the following claims.

[014] Referring now to FIG. 1, a schematic of an exemplary propulsion system 100 is illustrated, in accordance with some embodiments. The propulsion system 100 may be employed in a marine vessel such as a ship, a yacht, a boat, a submarine, etc. for imparting movement to the marine vessel across water. In some embodiments, the propulsion system 100 may be attached to a hull of the marine vessel. It should be noted that the attachment between the propulsion system 100 and the hull of the marine vessel may be in such a way that the propulsion system 100 may be steerable from the surface of the marine vessel. The propulsion system 100 may be coupled to a propeller 108. As will be appreciated by those skilled in the art, the propulsion system 100 may drive the propeller 108 to rotate at a speed so as to create thrust and to impart movement to the marine vessel across water.

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[015] In some embodiments, the propulsion system 100 may be implemented as a pod. In other words, the propulsion system 100 may be substantially housed in a specifically designed enclosure 128. As will be appreciated, the design of the enclosure 128 may be streamlined for better hydrodynamics. For example, in some embodiments, the shape of the enclosure 128 (and therefore the shape of the pod) may be similar to the shape of a gondola. The propulsion system 100 may include a propeller shaft (also referred to as first shaft) 104, a pinion shaft (also referred to as second shaft) 112, a gear assembly 114, at least one propeller shaft driving unit (also referred to as first driving unit) 118, at least one pinion shaft driving unit (also referred to as second driving unit) 120, at least one first coupling assembly 122, at least one second coupling assembly 124. In some embodiments, the enclosure 128 may house the propeller shaft 104, the pinion shaft 112, the at least one propeller shaft driving unit 118, and the at least one pinion shaft driving unit 120.

[016] The propeller shaft 104 may be coupled to one or more propellers 108 at one or more ends of the propeller shaft 104. In some embodiments, the propeller shaft 104 may be coupled to at least two propellers 108 at one end of the propeller shaft 104. In alternate embodiments, the propeller shaft 104 may be coupled to one or more propellers 108 at each end of the propeller shaft 104. The propeller shaft 104 may be further coupled to at least one propeller shaft driving unit 118 at one or more ends of the propeller shaft 104. It should be noted that each of the at least one propeller shaft driving unit 118 may selectively engage or disengage with the propeller shaft 104. In some embodiments, the propeller shaft 104 may be coupled to the at least one propeller shaft driving unit 118 via the at least one first coupling assembly 122. Thus, each of the at least one propeller shaft driving unit 118 may selectively engage or disengage with the propeller shaft 104 through each of the at least one first coupling assembly 122. As will be appreciated, when engaged, the at least one propeller shaft driving unit 118 may drive (i.e., rotate) the propeller shaft 104, which in turn may drive (i.e., rotate) the propeller 108.

[017] In some embodiments, axis 132 of the propeller shaft driving unit 118 may be aligned at a substantially horizontal angle to axis 138 of the propeller shaft 104. Further, in some embodiments, the axis 132 of the propeller shaft driving unit 118 as well as the axis 138 of the propeller shaft 104 may be aligned at a substantially horizontal angle to axis 134 of the propeller 108. It should be noted that each of the propeller shaft driving unit 118, the propeller shaft 104,

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and the propeller 104 may be configured to freely rotate along their respective axis 132, 138, and 134.

[018] In some embodiments, the pinion shaft 112 may be coupled to the one or more propellers 108, at a substantially vertical angle, via the gear assembly 114. It should be noted that, in such embodiments, the one or more propellers 108 may also be coupled the propeller shaft 104, at a substantially horizontal angle, at one end of the propeller shaft 104. Further, in some of such embodiments, the pinion shaft 104 may be coupled to the one or more propellers 108 at one end of the pinion shaft 104. In alternate embodiments, the pinion shaft 112 may be coupled to the propeller shaft 104, which in turn may be coupled to the one or more propellers 108. The pinion shaft 112 may be coupled to the propeller shaft 104, at the substantially vertical angle, via the gear assembly. As will be appreciated, the gear assembly 114 may transmit the motion of the pinion shaft 112 to the propeller 108, either directly or via the propeller shaft 104. Further, in some embodiments, the gear assembly 114 may amplify or reduce the speed or torque while transmitting the motion of the pinion shaft 112 to the propeller 108.

[019] The gear assembly 114 may include a bevel gear assembly. As will be appreciated, the bevel gear assembly may include, but may not be limited to, a straight bevel gear assembly, a spiral bevel gear assembly, a zero bevel gear assembly, and a hypoid bevel gear assembly. The gear assembly 114 may further include a parallel gear assembly. As will be appreciated, the parallel gear assembly may include, but may not be limited to, a spur gear assembly, a helical gear assembly, and a planetary gear assembly. In some embodiments, the gear assembly 114 may couple an intermediary shaft (not shown) to the pinion shaft 112 via the bevel gear assembly (e.g., spiral bevel gear assembly), and may further couple the intermediary shaft (not shown) to propeller shaft 104 via the parallel gear assembly (e.g., helical gear assembly).

[020] The pinion shaft 112 may be further coupled to at least one pinion shaft driving unit 120 at one or more ends of the pinion shaft 112. It should be noted that each of the at least one pinion shaft driving unit 120 may selectively engage or disengage with the pinion shaft 104. In some embodiments, the pinion shaft 112 may be coupled to the at least one pinion shaft driving unit 120 via the at least one second coupling assembly 124. Thus, each of the at least one pinion shaft driving unit 120 may selectively engage or disengage with the pinion shaft 112 through each of the at least one second coupling assembly 124. As will be appreciated, when

engaged, the at least one pinion shaft driving unit 120 may drive (i.e., rotate) the pinion shaft 112, which in turn may drive (i.e., rotate) the propeller 108, either through the gear assembly 114 or through the gear assembly 114 and the propeller shaft 104. As stated above, in some embodiments, the gear assembly 114 may be configured to amplify or reduce the power transmission from each of the at least one pinion shaft driving unit 120 to the propeller 108. The gear assembly 114 may, therefore, reduce the power rating requirement for each of the at least one pinion shaft driving unit 120. Further, the gear assembly 114 may enable the use of high speed driving units for each of the at least one pinion shaft driving unit 120.

[021] In some embodiments, axis 136 of the pinion shaft driving unit 120 may be aligned at a substantially horizontal angle to axis 140 of the pinion shaft 112. Further, in some embodiments, the axis 136 of the pinion shaft driving unit 120 as well as the axis 140 of the pinion shaft 112 may be aligned at a substantially vertical angle to the axis 134 of the propeller 108 as well as to the axis 138 of the propeller shaft 104. It should be noted that each of the pinion shaft driving unit 120 and the pinion shaft 112 may be configured to freely rotate along their respective axis 136 and 140.

[022] In some embodiments, each of the at least one propeller shaft driving unit 118 and the at least one pinion shaft driving unit 120 may include an electric motor. In other words, in some embodiments, each of the prime movers for the propeller system 100 (i.e., the at least one propeller shaft driving unit 118 or the at least one pinion shaft driving unit 120) may be electrical motors. The electric motor may include, but may not be limited to, an induction motor, a permanent magnet induction motor, synchronous motor, and permanent magnet synchronous motor. It should be noted that the electric motors may be supplied electrical power through an external power source on the marine vessel. The external power source may include batteries, combustion engine, ultracapacitors, and fuel cells.

[023] In some embodiments, each of the at least one first coupling assembly 122 and the at least one second coupling assembly 124 may include one of a clutch assembly or a spline assembly. It should be noted that each of the at least one first coupling assembly 122 and the at least one second coupling assembly 124 may be operated manually or automatically, based on power requirement or the mode of the operation. Further, it should be noted that, the selective engagement between the driving units 118 and 120 and the corresponding shafts 104 and 112

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may enable each driving unit to drive the propulsion system 100 independently and simultaneously to the other driving unit.

[024] It should be noted that, in some embodiments, the substantially horizontal angle may be an angle ranging from about -15 degrees to about 15 degrees. In some embodiments, the substantially horizontal angle may be an angle of about 0 degrees. However, in alternate embodiments, the substantially horizontal angle may be an angle of about 10 degrees, without deviating from the scope of the present subject matter. Similarly, it should be noted that, in some embodiments, the substantially vertical angle may be an angle ranging from about 75 degrees to about 105 degrees. In some embodiments, the substantially vertical angle may be an angle of about 90 degrees. Alternatively, in some embodiments, the substantially vertical angle may be an angle of about 82 degrees, without deviating from the scope of the present subject matter.

[025] As stated above, the one or more propellers 108 may be operated so as to impart movement to the marine vessel. As will be appreciated, the propeller 108 may be operated by operating at least one of the at least one propeller shaft driving unit 118 or the at least one pinion shaft driving unit 120. In other words, the one or more propellers 108 may be powered to rotate by the at least one propeller shaft driving unit 118, or by the at least one pinion shaft driving unit 120, or by the at least one propeller shaft driving unit 118 as well as the at least one pinion shaft driving unit 120. In some embodiments, the at least one pinion shaft driving unit 120 may be of higher power rating as compared to the at least one propeller shaft driving unit 118. In such embodiments, the one or more propeller 108 may be powered by the at least one pinion shaft driving unit 120 during a standard mode of operation (i.e., having a standard power requirement). Thus, the power from the at least one pinion shaft driving unit 120 may be transferred to the pinion shaft 112 and then to the one or more propeller 108 either through the gear assembly 114 or through the gear assembly 114 and the propeller shaft 104. Additionally, in such embodiments, the one or more propeller 108 may be powered by the at least one propeller shaft driving unit 118 during a low power mode of operation (i.e., having a low power requirement). Thus, the power from the at least one propeller shaft driving unit 118 may be transferred to the propeller shaft 104 and then to the one or more propeller 108. Alternatively, in some embodiments, the at least one propeller shaft driving unit 118 may be of higher power rating as compared to the at least one pinion shaft driving unit 120. In such embodiments, the at least one pinion shaft driving unit 120 may drive the low power mode of operation while the at least one

propeller shaft driving unit 118 may drive the standard mode of operation. Further, in either of the above discussed embodiments, the one or more propeller 108 may be powered by both of the at least one pinion shaft driving unit 120 and the at least one propeller shaft driving unit 118 during a high power mode of operation (i.e., having a high power requirement). Thus, the power from the at least one pinion shaft driving unit 120 as well as the at least one propeller shaft driving unit 118 may be transferred to the one or more propeller 108 through one or more of the pinion shaft 112, the gear assembly 114, and the propeller shaft 104.

[026] In some embodiments, the propulsion system 100 may further include a cooling system (not shown) for cooling one or more components of the propulsion system 100. By way of an example, the cooling system may be employed for cooling the at least one propeller shaft driving unit 118, the at least one pinion shaft driving unit 120, the gear assembly 114, and so forth. In some embodiments, the cooling system may include a heat exchanger for removing the heat generated in the one or more components of the propulsion system 100. In some embodiments, the heat exchanger may be an air-cooled type heat exchanger. For example, such a heat exchanger may include fins provided on the surface of the one or more components of the propulsion system 100. In alternate embodiments, the heat exchanger may be a water-cooled type heat exchanger. For example, such a heat exchanger may include a water jacket provided around the one or more components of the propulsion system 100. The heated water or the heated air may be circulated or discharged so as to release the heat in the environment.

[027] Referring now to FIG. 2, a cross-section view of another exemplary propulsion system 200, analogous to the propulsion system 100 of FIG. 1, for a marine vessel is illustrated, in accordance with some embodiments. Referring now to FIG. 2A, the propulsion system 200 may be coupled to a propeller 208. As stated, the propulsion system 200 may power the propeller 208 so as to rotate and, therefore, impart movement to the marine vessel across water. The propeller 208 may include a plurality of blades 210. In some embodiments, the propeller 208 may include at least two blades 210. Further, the propeller 208 may include, but may not be limited to, a fixed pitch propeller, a controllable pitch propeller, a highly skewed propeller, a self-pitching propeller, and balanced thrust propeller. It should be noted that the propeller 208 may be selected from any other type without deviating from the scope of the present disclosure. Further, the propulsion system 200 may include a pinion shaft section 200A and a propeller shaft section 200B. The pinion shaft section 200A and the propeller shaft section 200B may be

coupled through a gearing arrangement such that the pinion shaft section 200A and the propeller shaft section 200B may form a substantially orthogonal arrangement. The pinion shaft section 200A and the propeller shaft section 200B are further explained in greater detail in conjunction with FIG. 2B and FIG. 2C respectively.

[028] Referring now to FIG. 2B and FIG. 2C, the pinion shaft section 200A may include a pinion shaft 212, a pinion shaft driving unit 220, a plurality of bearing assemblies 206B, and a second coupling assembly 224. As stated above, in some embodiments, the pinion shaft section 200A may be aligned at a substantially vertical angle with respect to the propeller shaft section 200B. In particular, the pinion shaft 212 and the pinion shaft driving unit 220 may be aligned at a substantially vertical angle with respect to the propeller 208, the propeller shaft 204 and the propeller shaft driving unit 218. By way of an example, the substantially vertical angle may be selected from a range of about 75 degrees to about 105 degrees. By way of another example, the substantially vertical angle may be an angle of about 90 degrees or an angle of about 82 degrees. Further, it should be noted that, in some embodiments, axis of the pinion shaft driving unit 220 may be aligned at a substantially horizontal angle to axis of the pinion shaft 212. By way of an example, the substantially horizontal angle may be selected from a range of about -15 degrees to about 15 degrees. By way of another example, the substantially vertical angle may be an angle of about 0 degrees.

[029] The pinion shaft driving unit 220 may be coupled to the pinion shaft 212. As will be appreciated, the pinion shaft 212 may be a rotating machine element having a circular cross section. Further, the pinion shaft 212 may be manufactured using any suitable material, such as steel, iron or any other suitable material. In some embodiments, the pinion shaft driving unit 220 may include an electric induction motor. However, in some other embodiments, the pinion shaft driving unit 220 may include any other type of electric motor without deviating from the scope of the present subject matter.

[030] The pinion shaft 212 may be configured to freely rotate along its axis which may be aligned to the axis of the pinion shaft driving unit 220. In some embodiments, the pinion shaft 212 may rotate through the plurality of bearing assemblies 206B. As will be appreciated, the plurality of bearing assemblies 206B may be configured to constrain relative motion of the pinion shaft 212 to only a desired circular motion. As will be further appreciated, the plurality of bearing assemblies 206B may help in reducing friction faced during rotating motion of the pinion

shaft 212. In some embodiments, the plurality of bearing assemblies 206B may be provided at one or more locations along the length of the pinion shaft 212. The plurality of bearing assemblies 206B may include, but may not be limited to, a plain bearing, a rolling-element bearing, a ball bearing, a roller bearing, or a fluid bearing.

[031] In some embodiments, the pinion shaft driving unit 220 may selectively engage or disengage with the pinion shaft 212 via the second coupling assembly 224. In other words, the pinion shaft driving unit 220 may be couplable to the pinion shaft 212 via the second coupling assembly 224. In some embodiments, the second coupling assembly 224 may include one of a clutch assembly or a spline assembly. As will be appreciated, the clutch or the spline assembly is a mechanical device which, when engaged, allows power transmission from one rotating shaft to another rotating shaft. The second coupling assembly 224 may therefore engage or disengage the pinion shaft driving unit 220 with the pinion shaft 212. As will be appreciated, when engaged, the pinion shaft driving unit 220 may rotate the pinion shaft 212. The pinion shaft 212 may further be coupled to the propeller 208 via the gear assembly, collectively referred to as 214, either directly or through the propeller shaft 204. Thus, the pinion shaft 212, when engaged by the pinion shaft driving unit 220, may rotate the propeller 208.

[032] As illustrated in FIG. 2C, in some embodiments, the pinion shaft 212 may be coupled to the propeller shaft 204 via the gear assembly 214. The gear assembly 214 may include a bevel gear assembly. As will be appreciated, the bevel gear assembly (e.g., the spiral gear assembly) may be employed for transmitting motion between two shafts when axes of the two shafts are inclined at an angle to each other. In some embodiments, the gear assembly 214 may further include a parallel gear assembly. As will be appreciated, the parallel gear assembly (e.g., the helical gear assembly) may be employed for transmitting motion between two shafts when axes of the two shafts are aligned to each other.

[033] In some embodiments, the coupling between the pinion shaft 212 and the propeller shaft 204 via the gear assembly 214 may involve an intermediary shaft 216. In some embodiments, the intermediary shaft 216 may be positioned such that it may be aligned at a substantially horizontal angle to the propeller shaft 204 and at a substantially vertical angle to the pinion shaft 212. Further, the intermediary shaft 216 may be coupled to the pinion shaft 212 via the bevel gear assembly 214A. In such embodiments, one end of the pinion shaft 212 may include a first bevel gear (e.g., a first spiral bevel gear). Similarly, the intermediary shaft 216

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may include a corresponding second bevel gear (i.e., a second spiral bevel gear). Thus, the pinion shaft 212 may be coupled to the intermediary shaft 216 through mating of the first bevel gear on pinion shaft 212 and the corresponding second bevel gear on the intermediary shaft 216. It should be noted that, in some embodiments, the gear ratio between the gear on the pinion shaft 212 and the corresponding gear on the intermediary shaft 216 may be selected so as to amplify or reduce the power transmitted from the pinion shaft 212 to the intermediary shaft 216.

[034] Further, the intermediary shaft 216 may be coupled to the propeller shaft 204 via the parallel gear assembly 214B. In such embodiments, the propeller shaft 204 may include a first parallel gear (e.g., a first helical gear). Similarly, the intermediary shaft 216 may include a corresponding second parallel gear (a second helical gear). Thus, the propeller shaft 204 may be coupled to the intermediary shaft 216 through mating of the first parallel gear on propeller shaft 204 and the corresponding second parallel gear on the intermediary shaft 216. Again, it should be noted that, in some embodiments, the gear ratio between the gear on the propeller shaft 204 and the corresponding gear on the intermediary shaft 216 may be selected so as to amplify or reduce the power transmitted from the intermediary shaft 216 to the propeller shaft 216.

[035] The intermediary shaft 216 may be configured to freely rotate along its axis. In some embodiments, the intermediary shaft 216 may rotate through a plurality of bearing assemblies 206C. As will be appreciated, the plurality of bearing assemblies 206C may be configured to constrain relative motion of the intermediary shaft 216 to only a desired circular motion, and may help in reducing friction faced during rotating motion of the intermediary shaft 216. In some embodiments, the plurality of bearing assemblies 206C may be provided at one or more locations along the length of the intermediary shaft 216. The plurality of bearing assemblies 206C may include, but may not be limited to, a plain bearing, a rolling-element bearing, a ball bearing, a roller bearing, or a fluid bearing.

[036] Moreover, in some embodiments, the pinion shaft 112 may be coupled to an additional pinion shaft driving unit (not shown) so as to have back-up in case of any emergency or to cater to higher power requirement (i.e., higher thrust requirement) in case of need. The additional pinion shaft driving unit (not shown) may be positioned at one end of the pinion shaft. In such embodiments, the pinion shaft 112 may extend beyond the at least one pinion shaft driving unit 120. It should be noted that, in some embodiments, the additional pinion shaft driving unit (not shown) may be external to the propeller system 200. For example, the

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additional pinion shaft driving unit (not shown) may be placed on the marine vessel surface. In such embodiments, the pinion shaft 112 may extend beyond the at least one pinion shaft driving unit 120 and further beyond a pod or an enclosure 228.

[037] The pod or the enclosure 228 may be designed so as to substantially house the propulsion system 200. As stated above, the design of the pod 228 may be streamlined for better hydrodynamics. For example, in some embodiments, the shape of the pod 228 may be similar to the shape of a gondola. Further, the pod 228 may be designed to secure the propulsion system 200 within the water. For example, in some embodiments, the pod 228 may be a pressurized casing with a double wall arrangement.

[038] Referring now to FIG. 2C, the propeller shaft section 200B may include the propeller shaft 204, the propeller shaft driving unit 218, a plurality of bearing assemblies 206A, and a first coupling assembly 222. It should be noted that, in some embodiments, axis of the propeller shaft driving unit 218 may be aligned at a substantially horizontal angle to axis of the propeller shaft 204. By way of an example, the substantially horizontal angle may be selected from a range of about -15 degrees to about 15 degrees. By way of another example, the substantially vertical angle may be an angle of about 0 degrees.

[039] The propeller shaft driving unit 218 may be coupled to the propeller shaft 208. As will be appreciated, the propeller shaft 204 may be a rotating machine element having a circular cross section, and may be manufactured using any suitable material, such as steel, iron or any other suitable material. In some embodiments, the propeller shaft driving unit 218 may include an electric induction motor. However, in some other embodiments, the propeller shaft driving unit 218 may include any other type of electric motor without deviating from the scope of the present subject matter.

[040] The propeller shaft 204 may be configured to freely rotate along its axis which may be aligned to the axis of the propeller shaft driving unit 218. In some embodiments, the propeller shaft 204 may rotate through the plurality of bearing assemblies 206A. As will be appreciated, the plurality of bearing assemblies 206A may be configured to constrain relative motion of the propeller shaft 204 to only a desired circular motion, and may help in reducing friction faced during rotating motion of the propeller shaft 204. In some embodiments, the plurality of bearing assemblies 206A may be provided at one or more locations along the length of the propeller shaft 204. The plurality of bearing assemblies 206A may include, but may not be

limited to, a plain bearing, a rolling-element bearing, a ball bearing, a roller bearing, or a fluid bearing.

[041] In some embodiments, the propeller shaft driving unit 218 may selectively engage or disengage with the propeller shaft 204 via the first coupling assembly 222. In other words, the propeller shaft driving unit 218 may be couplable to the propeller shaft 204 via the first coupling assembly 222. In some embodiments, the first coupling assembly 222 may include one of a clutch assembly or a spline assembly. The first coupling assembly 222 may therefore engage or disengage the propeller shaft driving unit 218 with the propeller shaft 212. As will be appreciated, when engaged, the propeller shaft driving unit 218 may rotate the propeller shaft 204. The propeller shaft 204 may further be coupled to the propeller 208. Thus, the propeller shaft 204, when engaged by the propeller shaft driving unit 218, may rotate the propeller 208.

[042] As stated above, the propeller 208 may be powered to create thrust and impart movement to the marine vessel in one or more mode of operations. For example, the one or more mode of operations may include, but may not be limited to, a standard mode of operation (i.e., standard or moderate power requirement), a low power mode of operation (i.e., low power requirement), and a high power mode of operation (i.e., high power requirement). During either of the low power mode of operation or the standard mode of operation, the propeller 208 may be powered to rotate either by the propeller shaft driving unit 218 through the propeller shaft 204, or by the pinion shaft driving unit 220 through the pinion shaft 212, the gear assembly 214, and the propeller shaft 204. Further, during the high power mode of operation, the propeller 208 may be powered to rotate by both the pinion shaft driving unit 220 and the propeller shaft driving unit 218.

[043] For example, in some embodiments, the pinion shaft driving unit 220 may be of higher power rating as compared to the propeller shaft driving unit 218. In such embodiments, during low power mode of operation, the propeller 208 may be powered to rotate solely by the propeller shaft driving unit 218. Further, in such embodiments, during standard mode of operation, the propeller 208 may be powered to rotate solely by the pinion shaft driving unit 220. However, in certain situation, the high power requirement may not be met by the propeller shaft driving unit 218 or by the pinion shaft driving unit 220 individually. In such situations, the high power mode of operation may be initiated and the propeller 208 may be powered to rotate by the propeller shaft driving unit 218 and by the pinion shaft driving unit 220 simultaneously.

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[044] During low power mode of operation, the propeller shaft driving unit 218 may operate while the pinion shaft driving unit 220 may not operate. The propeller shaft driving unit 218 may further engage with the propeller shaft 204 through the first coupling assembly 222 so as to rotate the propeller shaft 204. As the propeller shaft 204 is coupled to the propeller 208, the rotating propeller shaft 204 may, in turn, rotate the propeller 208.

[045] During standard mode of operation, the pinion shaft driving unit 220 may operate while the propeller shaft driving unit 218 may not operate. The pinion shaft driving unit 220 may further engage with the pinion shaft 212 through the second coupling assembly 224 so as to rotate the pinion shaft 212. The pinion shaft 212 is coupled to the propeller shaft 204 via the gear assembly 214. As such, the rotating pinion shaft 212 may, in turn, rotate the propeller shaft 204. In particular, the rotating pinion shaft 212 may first rotate the intermediary shaft 216 through the bevel gear assembly 214A. The rotating intermediary shaft 216 may then rotate the propeller shaft 204 through the parallel gear assembly 214B. As the propeller shaft 204 is coupled to the propeller 208, the rotating propeller shaft 204 may, in turn, rotate the propeller 208.

[046] During high power mode of operation, the propeller shaft driving unit 218 as well as the pinion shaft driving unit 220 may operate so as to rotate the propeller 208. By way of an example, a situation of high power requirement may be experienced during starting of the marine vessel, when a high torque may be required. The propeller shaft driving unit 218 may engage with the propeller shaft 204 through the first coupling assembly 222 so as to rotate the propeller shaft 204. Similarly, the pinion shaft driving unit 220 may engage with the pinion shaft 212 through the second coupling assembly 224. The pinion shaft 212 is coupled to the propeller shaft 204 via the gear assembly 214. As such, the rotating pinion shaft 212 may, in turn, further rotate the rotating propeller shaft 204. As the propeller shaft 204 is coupled to the propeller 208, the rotating propeller shaft 204 may, in turn, rotate the propeller 208.

[047] In some embodiments, the propulsion system 200 may further include a controller (not shown) to as to effect each of the mode of operation by coordinating with each of the propeller shaft driving unit 218, the pinion shaft driving unit 220, the first coupling assembly 222, and the second coupling assembly 224. The controller (not shown) may include a processor and a memory. The memory may store data about each of the propeller shaft driving unit 218 and the pinion shaft driving unit 220. By way of an example, the data may include power rating of

the propeller shaft driving unit 218 and the pinion shaft driving unit 220. Based on a current power requirement and the data, the processor may select one or combination of the propeller shaft driving unit 218 and the pinion shaft driving unit 220 to drive the propeller 208.

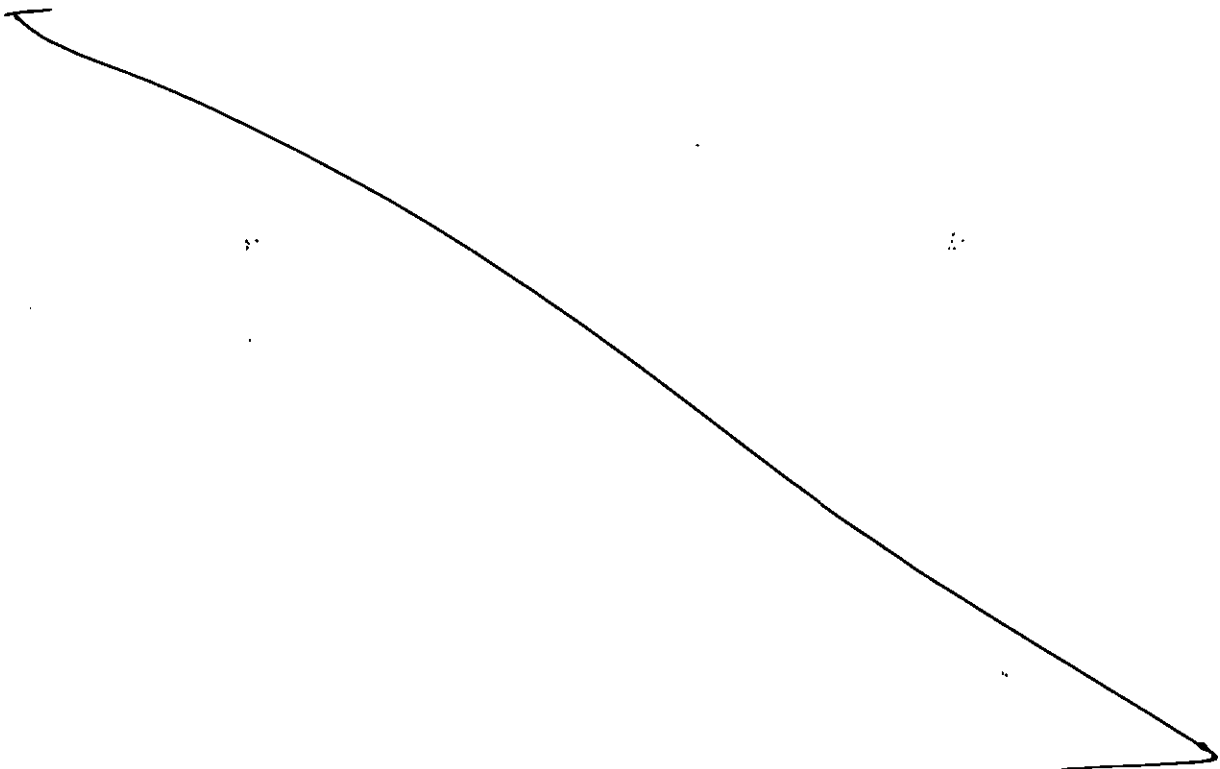
[048] Referring now to FIG. 3, an isometric section view of the exemplary propulsion system 200 of FIG. 2 is illustrated, in accordance with some embodiments. As illustrated, the propulsion system 200 may include at least one pinion shaft driving unit 220, at least one second coupling assembly 224, a pinion shaft 212, a gear assembly 214A and 214B, a propeller shaft 204, at least one first coupling assembly 222, and at least one propeller shaft driving unit 218. The at least one pinion shaft driving unit 220 may selectively engage with the pinion shaft 212 via the at least one second coupling assembly 224. Similarly, the at least one propeller shaft driving unit 218 may selectively engage with the propeller shaft 204 via at least one first coupling assembly 222. The propeller shaft 204 may further be coupled to one or more propellers 208 at one end of the propeller shaft 204. The pinion shaft 212 may be coupled to the propeller shaft 204 via the gear assembly 214A and 214B. In particular, the pinion shaft 212 may couple with an intermediary shaft 216 via a bevel gear assembly 214A. The intermediary shaft 216 may then couple with the propeller shaft 204 via a parallel gear assembly 214B.

[049] The propulsion system, described in various embodiments discussed above, may employ multiple driving units with smaller power ratings and gearing arrangement so as to effectively and efficiently utilize space as well as power. As discussed, the propulsion system may selectively utilize one or both of the at least propeller shaft driving unit (e.g., a low power rating electric motor) and the at least one pinion shaft driving unit (e.g., a high power rating electric motor) based on power and thrust need. For example, during starting of the marine vessel, as the torque requirement is high, efficiency may be improved by using both the driving units. Similarly, during low power requirement, efficiency may be improved by using the low power rating driving unit. As will be appreciated, the use of two different driving units with different power ratings and the use of gearing arrangement may enable the propulsion system to do away with the requirement of expensive single high power rating driving unit and to reduce the size of the driving units. Additionally, the use of two electric motors and the gearing arrangement may enable the electro-mechanical propulsion system to employ low power and high speed motors (i.e., up to 1000 rpm). Further, by varying current supply to the electric

motors, unnecessary power losses may be avoided which may help in increasing the overall efficiency of the marine vessel.

[050] Further, the propulsion system, described in various embodiments discussed above, may efficiently mount both the driving units in a pod (i.e., enclosure) of the marine vessel, the propulsion system may be made compact. As a result, the propulsion system may provide for better and efficient utilization of space in the marine vessel. It should be noted that the compact pod including the motors may be operated remotely as a separate unit. The propulsion system may also provide for a reduced overall propeller arm length (PAL) length. Additionally, the propulsion system may provide for reduction in noise due to replacing of combustion engines with the electric motors. Further, the propulsion system may provide for speed amplification or reduction by using gear assembly having different gear ratios for different speeds. For example, in some embodiments, speed may be amplified or reduced up to 3 times. Moreover, the propulsion system may provide for reduced installation time, reduced fuel consumption, and improved exhaust emission.

[051] It is intended that the disclosure and examples be considered as exemplary only, with a true scope and spirit of disclosed embodiments being indicated by the following claims.





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Sheet No. 1 of 5

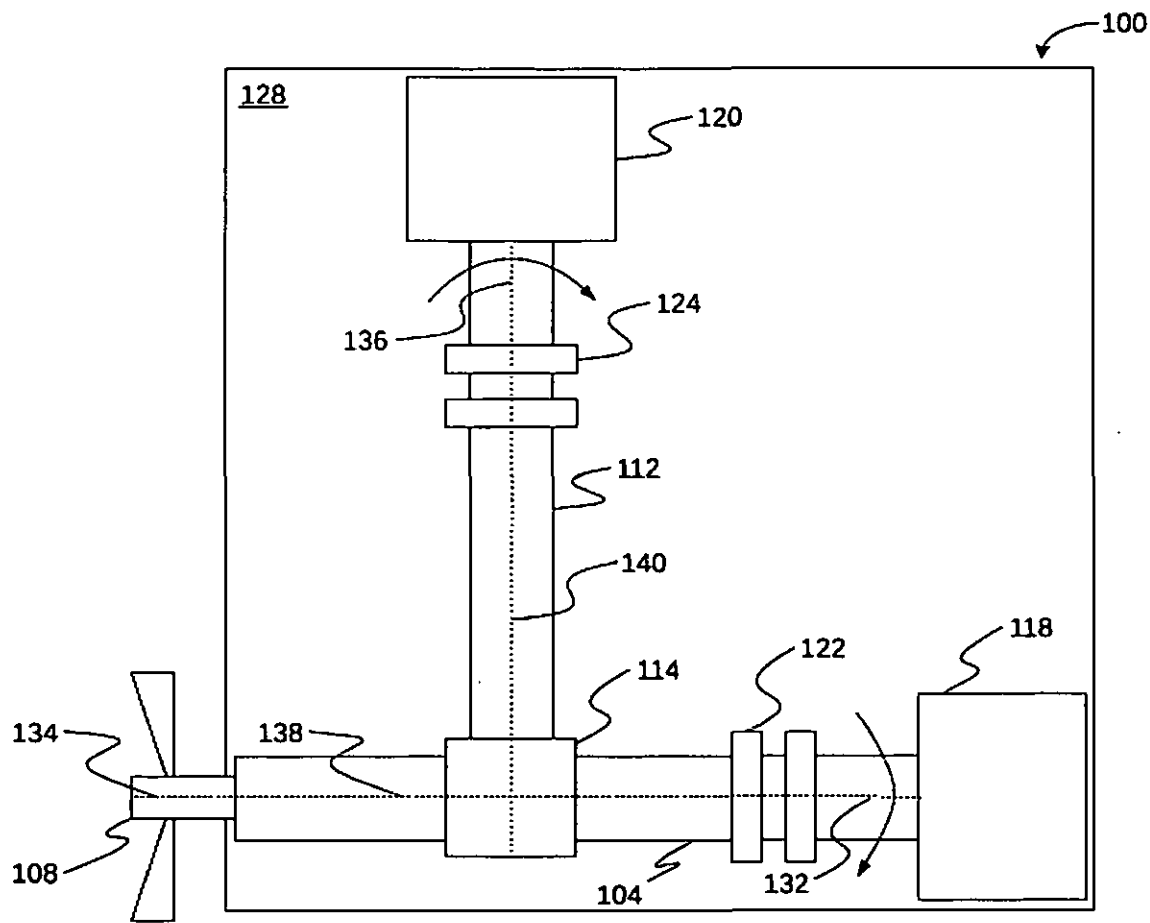


Figure 1

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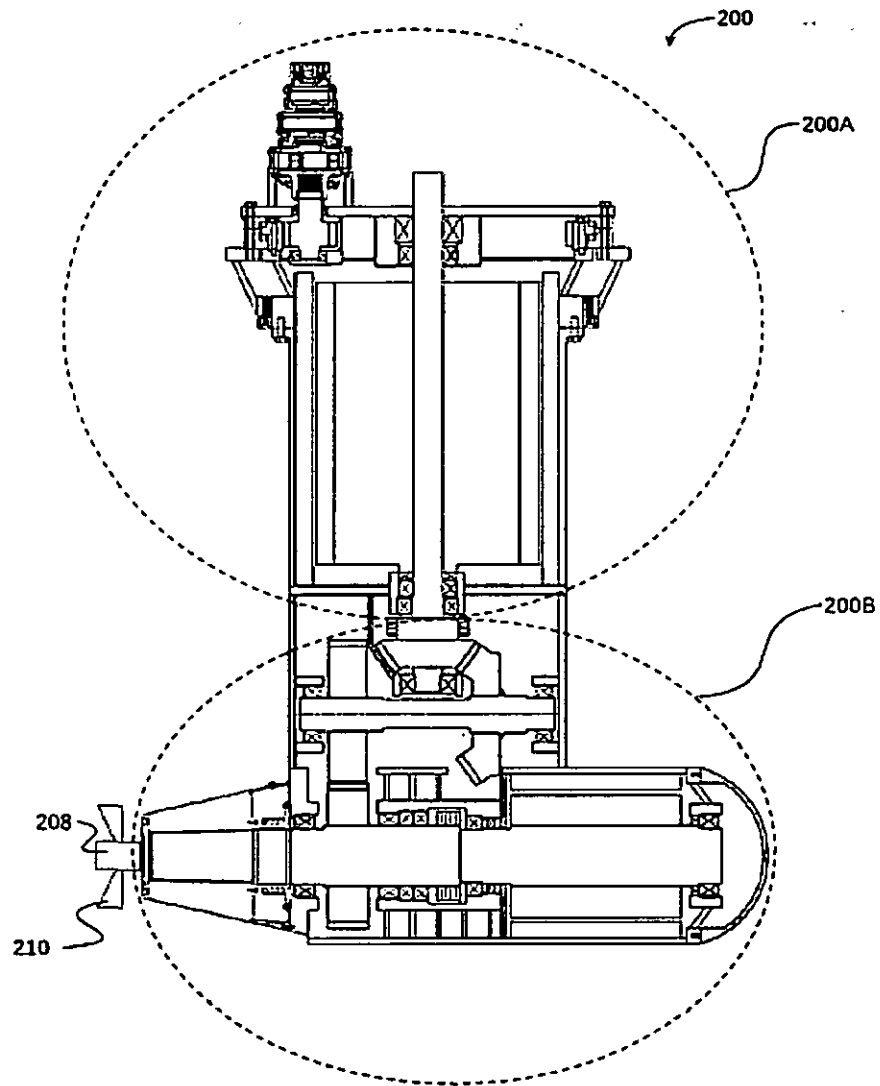


Figure 2A

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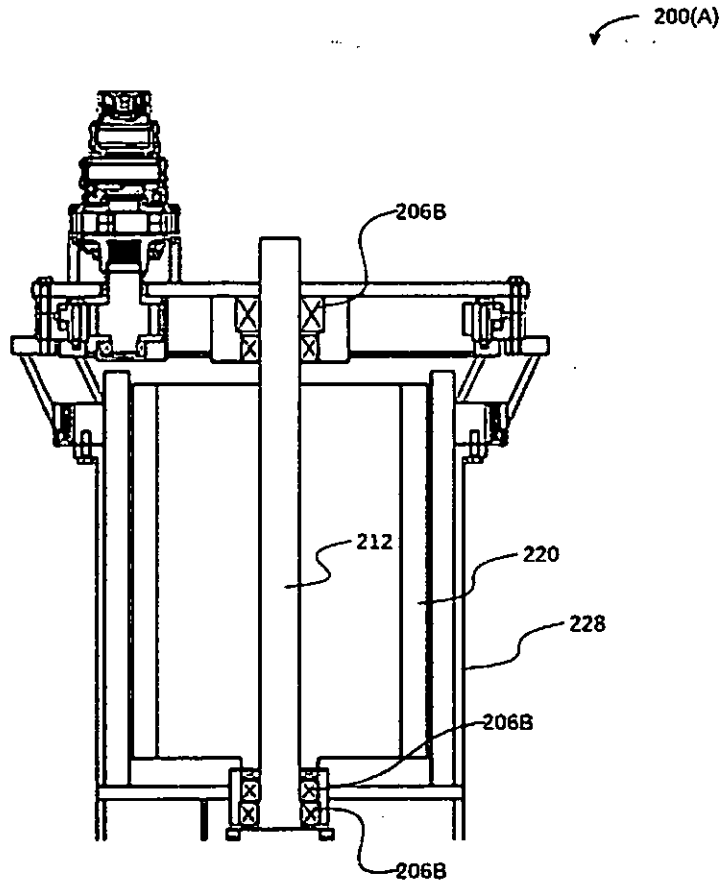



Figure 2B

  
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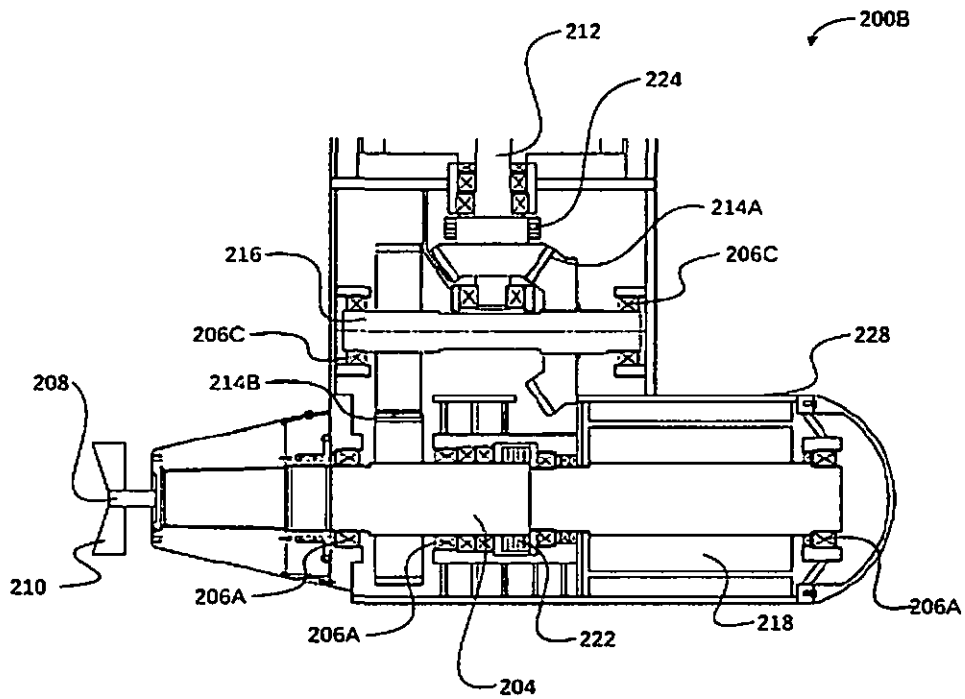


Figure 2C

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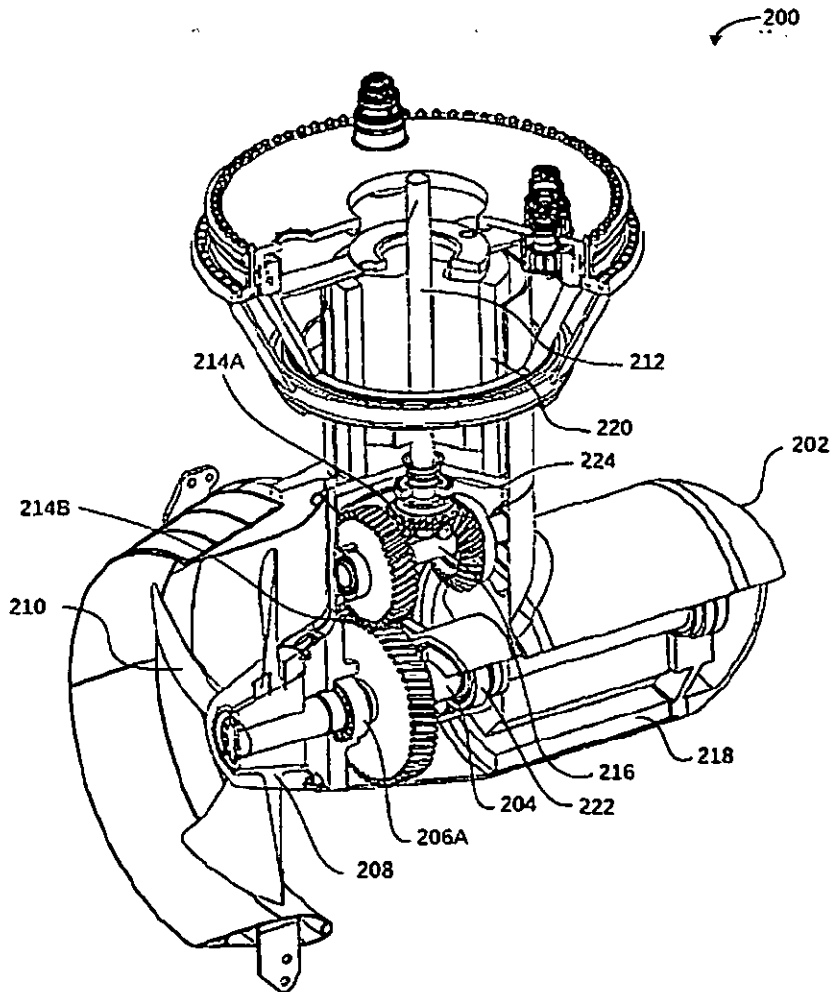


Figure 3

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