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(54) **TRANSMISSION UNIT FOR A MARINE HYBRID SYSTEM AND MARINE HYBRID SYSTEM**

(57) The present invention relates to a transmission unit (1) for a marine hybrid system (100). The transmission unit (1) comprising a first input shaft (6), which is connectable to a combustion engine (2), a second input shaft (9) and an output shaft (10), which is connectable to a propeller (18). The transmission unit (1) further comprising a first electric machine (11) which is permanently connected to the second input shaft (9) and a second electric machine (12), which is permanently connected to the first input shaft (6). The second input shaft (9) is permanently connected to the output shaft (10).

The invention further relates to a marine hybrid system (100) with such a transmission unit (1).

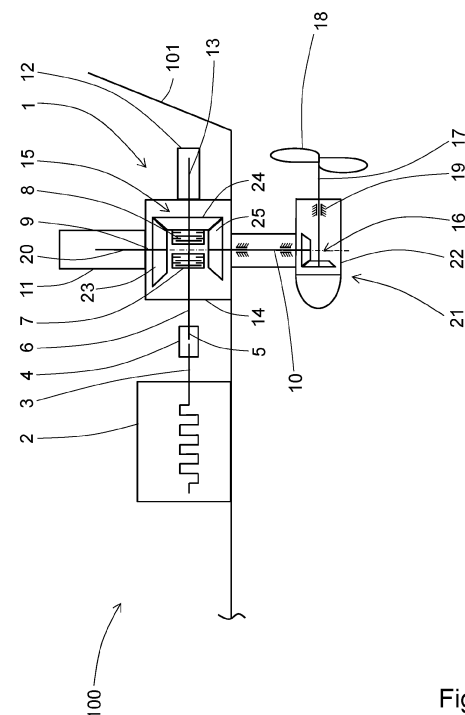


Fig. 1

Description

[0001] The present invention relates to a transmission unit for a marine hybrid system and to a marine hybrid system with a combustion engine and with two electric machines.

[0002] In recent years there is an increasing demand for marine drive units with electric drive machines for environmental and efficiency reasons. For these reasons several marine drive units have been proposed in form of hybrid systems and all-electric systems.

[0003] In the EP 1 426 287 A1 a power generating and propelling system of a vessel has been disclosed, comprising a combustion engine, an electric generator, a power transmission device with a clutch and an electric motor. The electric generator is installed between the combustion engine and the power transmission device. The electric motor is mounted at the power transmission device and an output shaft of the electric motor is connected to a transmission shaft in the power transmission device through the clutch. The power of the combustion engine is transferred to an input shaft of the power transmission device and further transferred to the drive shaft of a propeller through the clutch, a transmission shaft, and an output shaft. To drive a propeller of the vessel, it can be selected from three patterns by switching of the clutch: The first pattern is that the propeller is driven by only the combustion engine; the second pattern is that the propeller is driven by the combustion engine with assist of the electric motor; and the third pattern is that the propeller is driven by only the electric motor.

[0004] The purpose of the present invention is to provide an improved transmission unit for a marine hybrid system and a marine hybrid system with a high reliability and a wide range of applicability.

[0005] These purposes are achieved by a transmission unit according to claim 1 and by a marine hybrid system according to claim 9. Further embodiments are claimed in dependent claims.

[0006] The present invention provides a transmission unit for a marine hybrid system. The transmission unit comprising a first input shaft, a second input shaft and an output shaft. The transmission unit further comprising a first electric machine and a second electric machine. The first input shaft is connectable or connected to a combustion engine. The output shaft is connectable or connected to a propeller. The first electric machine is permanently connected to the second input shaft, while the second electric machine is permanently connected to the first input shaft. The second input shaft is permanently connected to the output shaft. Hence, the first electric machine is permanently connected to the output shaft via the second input shaft and the second electric machine is permanently connected to the combustion engine via the first input shaft. A permanent connection is a connection, which can not be disconnected during operations. As examples, the permanent connections can be done by one or more of a spline connection, a flange connection, a

coupling, or a connection by gears which are permanently meshing with each other.

[0007] The permanent connection between the combustion engine and the second electric machine allows the generation of electric energy at any time the combustion engine is running. There is no clutch engagement necessary for this connection, what provides a simple and reliable solution. The generated electric energy can be used to recharge a battery, to supply electric energy to drive the first electric machine and to feed other electric consumers.

[0008] The permanent connection between the first electric machine and the output shaft allows forward and reverse maneuvers of the corresponding water vessel, without any interaction of a clutch in the transmission unit. The first electric machine is always connected to the propeller and allows the electric energy generation and the battery recharge from the hydrogeneration effect. The effect of hydrogeneration can be used during sailing, when the propeller is driven by the water streaming through the propeller area. Hence, the propeller drives the shafts of the first electric machine shaft via the propeller shaft and the output shaft. The first electric machine is switched to a generator mode and electric energy is generated. The generated electric energy can be used to recharge a battery or to feed other electric consumers. The hydrogeneration can particularly be used during sailing. Therefore the proposed transmission unit can be beneficially applied in a saildrive.

[0009] The first electric machine can be controlled completely independently from other components of the transmission unit. Hence, the first electric machine can be controlled by its own control system, which can be operated independently from a transmission control system.

[0010] In such a transmission unit both electric machines can selectively be used to drive the output shaft or to generate electric energy. This allows to use the transmission unit in a wide range of applications and gives a high level of reliability. In this regard, the first electric machine provides a backup solution in case of failure or lack of the combustion engine, or the clutches as described below. The second electric machine provides a backup solution in case of failure or lack of a starting system of the combustion engine.

[0011] The first input shaft can be selectively connected to the output shaft by at least one clutch. A typical clutch unit in marine transmission units however provides a forward clutch and a reverse clutch, especially when driven by a combustion engine. So the combustion engine can be used to propel the water vessel in a forward or in a reverse direction, depending on the corresponding clutch engagement. On the other hand, the at least one clutch allows for a complete disconnection between the first input shaft and the output shaft. This enables the recharging of batteries by the combustion engine driving the second electric machine in a generator mode, while the propeller is not rotating.

[0012] The first input shaft can have a connection element to be coupled to the combustion engine at one end, while the other end of the first input shaft is directly coupled to a motor shaft of the second electric machine. This means, that the second electric machine is arranged on the opposite side of the combustion engine. This enables an easy assembly and disassembly of the second electric machine on a side of a transmission housing opposite to the combustion engine. The connection element and the connection to the motor shaft of the second electric machine at the other end can be flanges or splines, as examples.

[0013] In one embodiment of the invention each of the first input shaft, the second input shaft and the output shaft are supported in a housing of the transmission unit. Said shafts can all at least partially be enclosed in the housing, as well as the at least one clutch.

[0014] According to another embodiment, the second input shaft is arranged coaxial to the output shaft. In one preferred embodiment the first input shaft is arranged in a substantially horizontal direction, wherein the output shaft is arranged in a substantially vertical direction. A bevel gear unit connects the first input shaft to the output shaft, when the at least one clutch is engaged. A bevel gear unit is a typical component of an upper gearbox in a marine pod drive, wherein the vertical output shaft of the upper gearbox is connected to a horizontal propeller shaft by a lower bevel gear unit. The latter is arranged in a pod underneath a hull of a water vessel. The terms horizontal and vertical refer to a marine pod drive mounted in an operating position on a water vessel in calm water, with the water surface being a horizontal plane. However, the terms horizontal and vertical do not limit the corresponding direction to an exact direction but include deviations from an exact horizontal or vertical direction up to an angle of 15 degrees.

[0015] The permanent connection between the second input shaft and the output shaft can also be realized by said bevel gear unit. For this embodiment, the second input shaft can be fixed to a first crown gear of the bevel gear unit. The first crown gear permanently meshes with a pinion and the pinion permanently meshes with a second crown gear, which is fixed on the output shaft.

[0016] The at least one clutch can preferably be arranged within the outline of the bevel gear unit. With regard to the described embodiment with a first and second crown gear, the at least one clutch can be arranged in a space between the two crown gears. This allows for very compact layout of the transmission unit.

[0017] The invention further regards to a marine hybrid system including a combustion engine and a transmission unit as described above. Such a marine hybrid system can be designed in form of a pod drive, comprising a lower bevel gear unit to connect the output shaft to a substantially horizontal propeller shaft.

[0018] The marine hybrid system can be operated in different operation modes. In a boost mode the electric motor power output of the first and second electric machines can be added to the combustion engine power output. In other operation modes the power of the first and the second electric machines could contribute to the total drive power of the marine hybrid system both together or each one at a time. With an appropriate control of the power output of one or of both electric machines it is possible to get the best efficiency, fuel savings and emission reductions of the combustion engine. As an example, the power of one or of both electric machines can be used for small accelerations or changes in speed. Another possibility of the proposed marine hybrid system is the pure electric cruising in protected areas or no-wake areas with low noise and zero emission. The pure electric drive can also be used for docking maneuvers. An eco-mode can be realized, by operating the combustion engine only when power requirements exceed available electric energy from renewable sources and battery capacity.

[0019] The proposed marine hybrid system can be used as a saildrive for sailing boats and as a propulsion unit for other water vessels. An appropriate size and nominal power of the first and the second electric machines can be chosen according to meet the requirements of the individual application. The power range of the first electric machine can be in a range between 15 to 100 kilowatts. It can be operated on low voltage, per example on 48V or on high voltage, per example 360 to 400V.

[0020] The invention and its benefits will be further and more particularly described in the following, by way of example only, and with reference to the accompanying figure.

Fig. 1 shows a marine hybrid system according to the invention in a schematic drawing and

Fig. 2 shows a marine hybrid system according to the invention.

The transmission unit 1 for a marine hybrid system 100 as shown in Fig. 1 is installed partially inside the hull 101 of a water vessel. The transmission unit 1 can be driven by a main drive, in form of a combustion engine 2, which is mounted inside the hull 101. The transmission unit 1 is part of a marine hybrid system 100. The marine hybrid system 100 is a pod drive, comprising a pod 21, which is rotatably mounted to the bottom of the hull 101.

[0021] The transmission unit 1 comprises a first electric machine 11 and a second electric machine 12. The first electric machine 11 is installed in a vertical position above a housing 14 of the transmission unit 1, whereas the second electric machine 12 is installed in a horizontal position on the opposite side of the housing 14 with regard to the combustion engine 2.

[0022] The transmission unit 1 further comprises a first input shaft 6, which is connected to the combustion engine 2. The first input shaft 6 has a connection element 5 at one end, to be coupled to the combustion engine 2 by means of a coupling 4. The other end of the first input

shaft 6 is directly coupled to a motor shaft 13 of the second electric machine 12, so that the second electric machine 12 is permanently connected to the first input shaft 6. This enables generation of electric energy by operating the second electric machine 12 in a generator mode, when the combustion engine 2 is running. In other embodiments the second electric machine 12 may also be connected to the first input shaft 6 via a further input shaft.

[0023] The first input shaft 6 can selectively be connected to an output shaft 10 by one of a first clutch 7 and a second clutch 8. The output shaft 10 is in a driving connection with a propeller 18. Propeller 18 is fixed on propeller shaft 17, which is supported in a bearing 19 inside a pod housing 22 of the pod 21. A lower bevel gear unit 16 connects the vertical output shaft 10 to a horizontal propeller shaft 17. The propeller is positioned at the rear end of the pod 21 and operates as pushing propeller.

[0024] Said clutches 7 and 8 enable the combustion engine 2 to propel the water vessel in a forward direction and in a reverse direction. As long as neither clutch 7 nor clutch 8 is engaged, there is no driving connection between the combustion engine 2 and the output shaft 10.

[0025] The first electric machine 11 is mounted on top of the housing 14 of the transmission unit 1. The first electric machine 11, i.e. a motor shaft 20 of the first electric machine 11 is permanently connected to the output shaft 10 via a second input shaft 9 of the transmission unit 1. The second input shaft 9 is arranged in a vertical direction and coaxial to the output shaft 10. The second input shaft 9 is permanently connected to the output shaft 10 by means of the bevel gear unit 15. Bevel gear unit 15 comprises an upper crown gear 23 and a lower crown gear 25 which are coupled to each other by a pinion 24, which is permanently meshing with both crown gears 23, 25. Hence, the first electric machine 11 is in a permanent driving connection with the output shaft 10 via the upper crown gear 23, pinion 24 and lower crown gear 25. This permanent connection between the first electric machine 11 and the output shaft 10 enables forward and reverse maneuvers without any interaction of a clutch, what ensures a high reliability of the whole marine drive system 100. In addition the first electric machine 11 can be also operated in a generator mode, what allows the electric energy generation and the battery recharge from the hydrogenation effect.

[0026] The first input shaft 6 is arranged in a horizontal direction, wherein the second input shaft 9 and the output shaft 10 are arranged in a vertical direction. A bevel gear unit 15 connects the horizontal first input shaft 6 to the vertical output shaft 10, when one of the clutches 7, 8 is engaged. Each of the first input shaft 6, the second input shaft 9 and the output shaft 10 is supported in the housing 14.

[0027] The first clutch 7 and the second clutch 8 are both arranged within the outline of the bevel gear unit 15, so that a very compact design of the transmission unit 1 is

achieved.

[0028] Fig. 2 shows a marine hybrid system 100 in a more detailed view. The same components of the system refer to the same numbers of Fig. 1 and therefore not further explained at this point.

[0029] The permanent connection between the combustion engine 2 and the second electric machine 12 by means of the first input shaft 6 can be seen in Fig. 2, as the first input shaft 6 extends from the connection element 5 with the combustion engine 2 through the bevel gear unit 15 to the motor shaft 13 of the second electric motor 12.

[0030] As well can be seen the further permanent connection between the first electric machine 11 and the output shaft 10 via the components of the bevel gear unit 15, namely the upper crown gear 23, pinion 24 and the lower crown gear 25. The upper crown gear 23 is rigidly mounted to the second input shaft 9 and the lower crown gear 25 is rigidly mounted to the output shaft 10.

[0031] The components of the hybrid marine system 100 which are mounted inside the hull 101 show a compact design and good accessibility, due to the positioning of the combustion engine 2, the first electric machine 11 and the second electric machine 12 on three sides of the housing 14 of the transmission 1. The good accessibility enables easy assembly and maintenance of components.

Referrals

[0032]

1	transmission unit
2	combustion engine
3	crank shaft
4	coupling
5	connection element
6	first input shaft
7	first clutch
8	second clutch
9	second input shaft
10	output shaft
11	first electric machine
12	second electric machine
13	motor shaft
14	housing
15	bevel gear unit
16	lower bevel gear unit
17	propeller shaft
18	propeller
19	bearing
20	motor shaft
21	pod
22	pod housing
23	upper crown gear
24	pinion
25	lower crown gear
100	marine hybrid system
101	hull

Claims

1. Transmission unit (1) for a marine hybrid system (100) comprising

- a first input shaft (6), which is connectable to a combustion engine (2),
 - a second input shaft (9),
 - an output shaft (10), which is connectable to a propeller (18),
 - a first electric machine (11) which is permanently connected to the second input shaft (9),
 - a second electric machine (12), which is permanently connected to the first input shaft (6),
 and

wherein the second input shaft (9) is permanently connected to the output shaft (10).

2. Transmission unit (1) according to claim 1, wherein the first input shaft (6) can be selectively connected to the output shaft (10) by at least one clutch (7, 8).

3. Transmission unit (1) according to claim 1 or 2, wherein the first input shaft (6) has a connection element (5) to be coupled to the combustion engine (2) at one end, and wherein the other end of the first input shaft (6) is directly coupled to a motor shaft (13) of the second electric machine (12).

4. Transmission unit (1) according to one of the preceding claims, wherein the second input shaft (9) is arranged coaxial to the output shaft (10).

5. Transmission unit (1) according to one of the preceding claims, wherein each of the first input shaft (6), the second input shaft (9) and the output shaft (10) is supported in a housing (14) of the transmission unit (1).

6. Transmission unit (1) according to one of the claims 2 to 5, wherein the first input shaft (6) is arranged in a horizontal direction, wherein the output shaft (10) is arranged in a vertical direction, and wherein a bevel gear unit (15) connects the first input shaft (6) to the output shaft (10), when the at least one clutch (7, 8) is engaged.

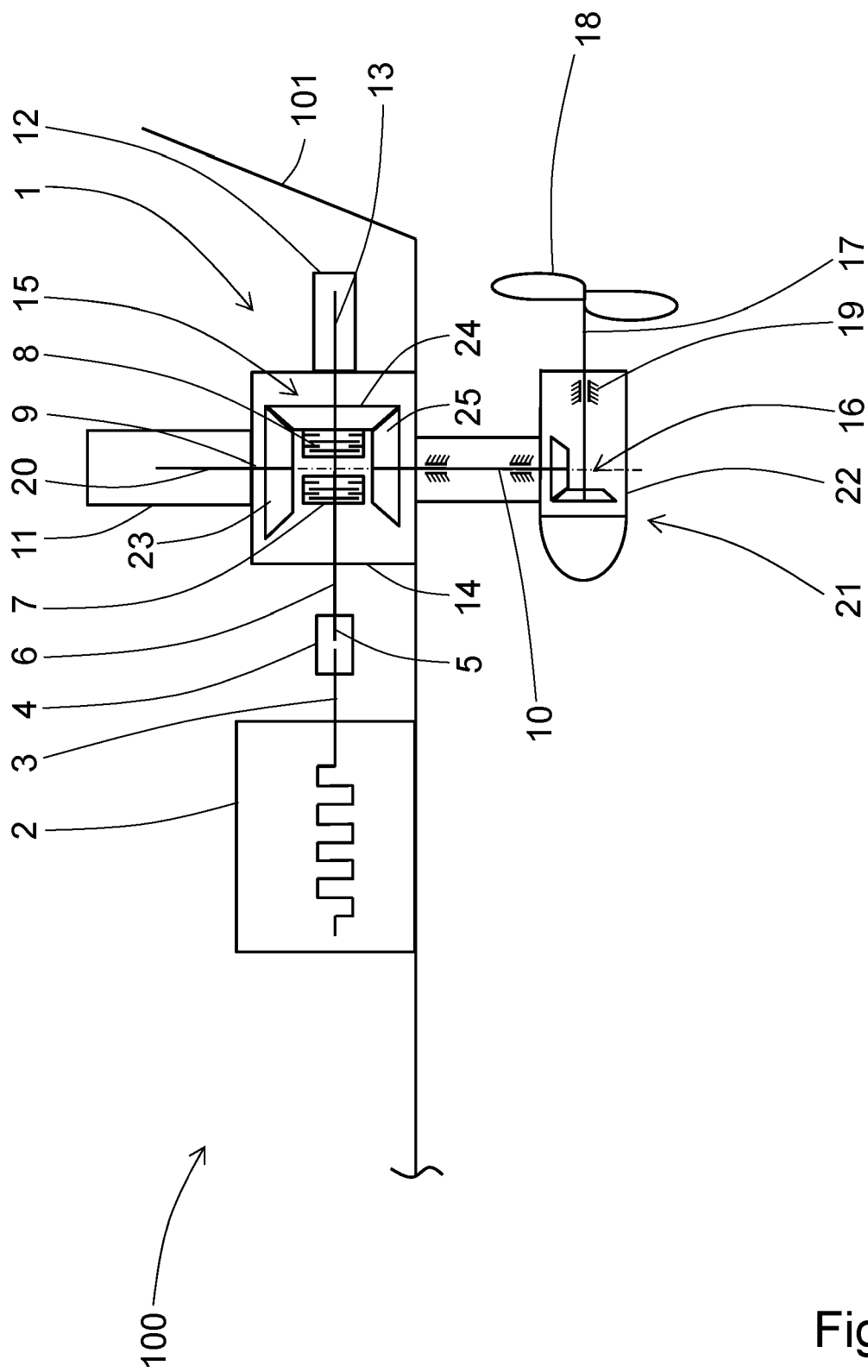
7. Transmission unit (1) according to claim 6, wherein the at least one clutch (7, 8) is arranged within the outline of the bevel gear unit (15).

8. Transmission unit (1) according to claim 6 or 7, wherein the bevel gear unit (15) permanently connects the second input shaft (9) to the output shaft (10).

9. Marine hybrid system (100) with a combustion en-

gine (2) and with a transmission unit (1) according to one of the preceding claims.

10. Marine hybrid system (100) according to claim 9, comprising a lower bevel gear unit (16) to connect the output shaft (10) to a substantially horizontal propeller shaft (17).



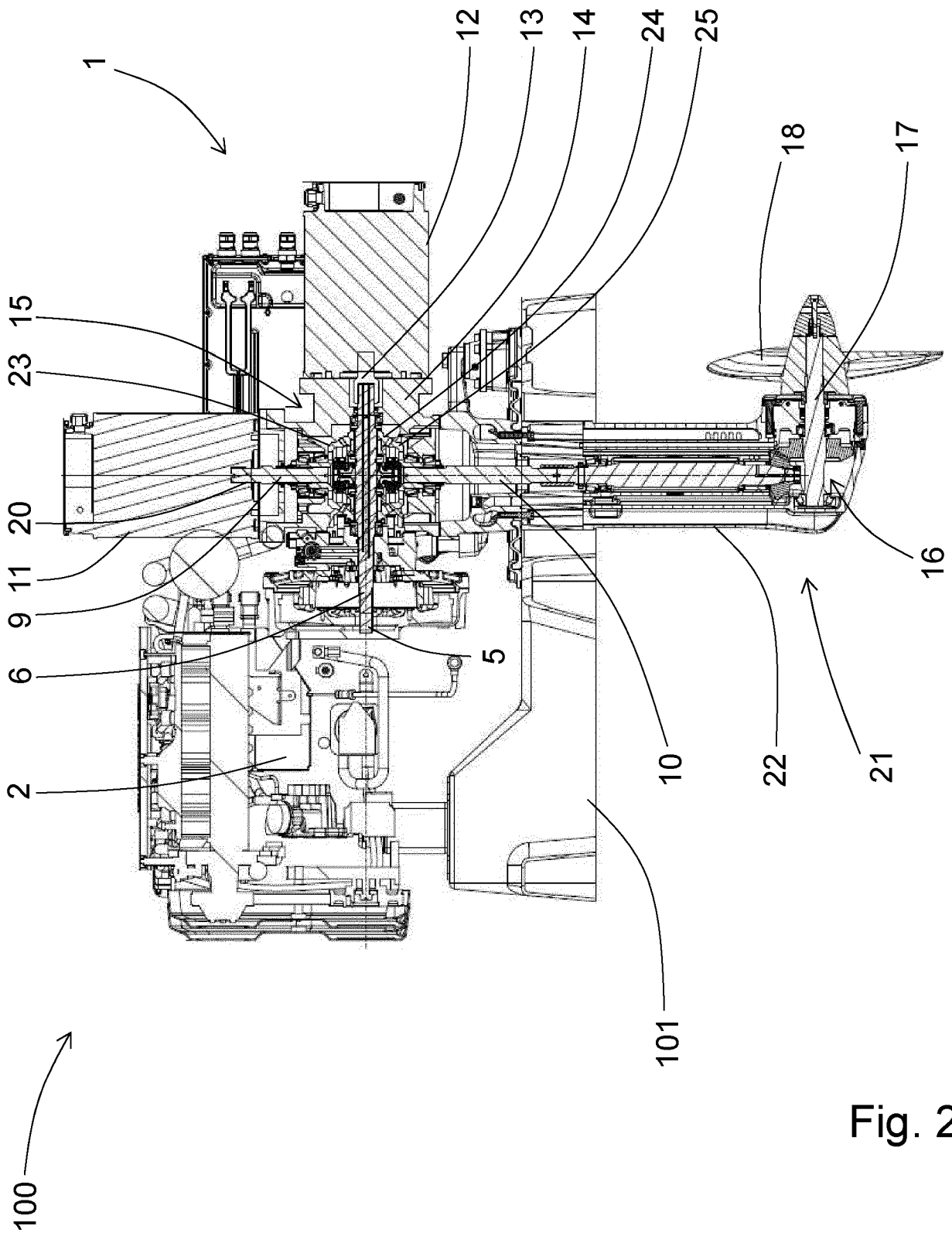


Fig. 2



EUROPEAN SEARCH REPORT

Application Number

EP 23 20 0473

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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		12 March 2024	Ibarrondo, Borja
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X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
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