



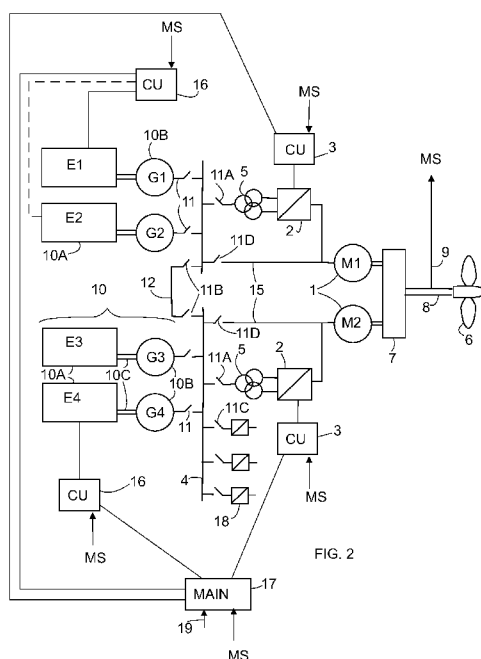
- (51) **International Patent Classification:**
B63H 23/24 (2006.01) *B60L 11/08* (2006.01)
- (21) **International Application Number:**
PCT/FI2015/050469
- (22) **International Filing Date:**
26 June 2015 (26.06.2015)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (71) **Applicant:** WÄRTSILÄ FINLAND OY [FI/FI]; Tarhaajantie 2, FI-65380 Vaasa (FI).
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- (81) **Designated States** (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) **Designated States** (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: AN ELECTRIC SHIP PROPULSION DRIVE ARRANGEMENT

(57) Abstract: An electric ship propulsion drive arrangement according to the invention comprises an electric motor (1) and a propeller (6) that is connected to the electric motor, and a frequency converter (2) that is arranged to supply power to the electric motor. The arrangement further comprises a direct electric connection (15) between the electric motor and a power bus (4). The arrangement is arranged to switch the frequency converter (2) or the direct electric connection (15) for supplying power to the electric motor (1) in such a way that the frequency converter (2) is switched to supply power at lower cruising speeds and the direct electric connection (15) is switched to supply power at higher cruising speeds.

An electric ship propulsion drive arrangement

5 Field of technology

The present invention relates to an electric ship propulsion drive arrangement. In ship environment the propulsion arrangement comprises usually a propeller.

Prior art

10 Diesel/gas electric solutions have become common in ships, especially in LNG tankers. An engine that uses diesel and/or gas as fuel is in connection with a generator for producing electric power. The power is fed into a power bus. The electric power distributed by the bus is used for rotating an electric motor that rotates a propeller in order to move the ship.

15 Figure 1 illustrates an example of a known electric propulsion arrangement having an electric motor 1 to rotate a propeller 6. The connection between the motor and the propeller is performed through a transmission case 7 and shaft 8. A frequency converter 2 supplies power to the electric motor 1. The frequency converter is connected to a power bus 4 through a transformer 5 in order to receive power from
20 the bus 4. At least one genset 10 provides electric power into the power bus 4. The genset comprises a generator 10B, an engine 10A, and a connection shaft 10C between the engine and the generator. As said the engine uses diesel/gas as fuel. As can be seen, the example of Figure 1 has double devices to supply power into the transmission case 7. The double devices may not be compulsory, but they provide
25 redundancy against faults of the devices.

The arrangement comprises also a control unit 3 in order to control the frequency converter 2. The control unit drives the frequency converter in order to achieve a desired rotating speed for the propeller 6. So the control unit receive speed instruction 14 usually from the cabin of the ship. Usually the speed of the shaft 8 is

also measured 9 which is used as feedback by the control unit 3. In addition, it can be noted that there are circuit breakers 11, 11A, 11B, 11C in order to connect and disconnect the devices with each other. For example the circuit breakers 11C are used to provide connections between the power bus 4 and different loads of the ship.

- 5 So the power bus or power buses 4 are used to distribute power to all over the ship for different loads 13, like to warming, lighting and other electric devices.

The challenge for the electric ship propulsion drive arrangement utilizing the diesel/gas engine/s is to minimize losses. With a variable pitch propeller it is possible to adjust the propulsion power demand by adjusting the propeller pitch. But with a
10 fixed pitch propeller, the electric motor is 1 equipped with a variable speed drive in order to be able to control the speed of rotation. So the frequency converter drive 2 is used despite of a fact that it introduces some electrical losses and produces harmonics. So the existing fixed pitch propeller solutions are based on using frequency converters that convert the stator feed frequency to the motor, i.e. the
15 entire power of the motor is converted.

Short description of invention

Although the efficiency of the prior art arrangement is good, the efficiency can be still improved according to an inventive solution. An electric ship propulsion drive
20 arrangement according to the invention comprises an electric motor and a propeller that is connected to the electric motor, and a frequency converter that is arranged to supply power to the electric motor. The arrangement has a control unit to control the frequency converter, and the arrangement further comprises a direct electric connection between the electric motor and a power bus. The power bus has
25 connections for at least one genset. The arrangement has a second control unit for controlling at least one genset, which control unit is arranged to control power supply to the electric motor.

The arrangement further comprises a third control unit that is arranged to switch the frequency converter or the direct electric connection for supplying power to the
30 electric motor, in such a way that the frequency converter is switched to supply power

at lower cruising speeds and the direct electric connection is switched to supply power at higher cruising speeds. In this way better efficiency than in known arrangements is achieved.

5 List of figures

In the following, the invention is described in more detail by reference to the enclosed drawings, where

- Figure 1 illustrates an example of a known electric ship propulsion drive arrangement,
- 10 Figure 2 illustrates an example of an inventive electric ship propulsion drive arrangement, and
- Figure 3 illustrates another example of the inventive arrangement.

15 Description of the invention

Figure 2 illustrates an example of an electric ship propulsion drive arrangement. The electric ship propulsion drive arrangement comprises an electric motor 1 and a propeller 6 that is connected to the electric motor 1, and a frequency converter 2 that is arranged to supply power to the electric motor. In addition the arrangement has a control unit 3 to control the frequency converter 2 as already showed in Figure 1 also. The arrangement further comprises a direct electric connection 15 between the electric motor 1 and a power bus 4, which power bus has connections 11 for at least one genset 10. The arrangement has a second control unit 16 for controlling at least one genset 10, which second control unit 16 is arranged to control power supply to the electric motor 1.

The arrangement further comprises a third control unit 17 that is arranged to switch the frequency converter 2 or the direct electric connection 15 for supplying power the electric motor 1, in such a way that the frequency converter 2 is switched to supply power at lower cruising speeds and the direct electric connection 15 is switched to supply power at higher cruising speeds.

As already said the at least one genset 10 comprising the generator 10B, the engine 10A, and the connection shaft 10C provides electric power into the power bus 4. The engine uses diesel/gas as fuel. The control unit 3 drives the frequency converter in order to achieve a desired rotating speed for the propeller 6. The control
5 unit receives speed instruction and can utilize the speed of the shaft 8 that is measured 9.

As can be seen in Figure 2 or 3 the electric propulsion system of the invention is arranged in such a way that there is the electric direct drive 15 which can be used when the ship is operating relatively close to a nominal operating point. Let's say, for
10 example, that the nominal operating point of the ship is about 19 knots. The ship is usually operated at lower cruising speed than the operation point for example 17 – 18 knots which is an usual cruising speed.

When the direct electric connection 15 is used during an usual cruising speed or higher speed, losses of the frequency converter 2 and the possible transformer 5 can
15 be avoided. This is possible if the frequency of the power bus 4 can be changed and controlled. However as already said the power bus 4 is used to distribute power to different loads 13 on the ship. In order to provide this task the frequency of the power bus 4 is kept at a certain value like 50 Hz or 60 Hz. This is not the case in the invention when the direct electric connection 15 is used. So if the other loads like
20 lighting are connected to the bus 4, the arrangement comprises further frequency converters 18 that are in connection with the power bus 4 in order to supply power to the loads.

Speed of the genset 10 affects to the frequency of the bus 4, so by controlling the the speed of the genset the frequency of the power bus 4 changes and also the
25 speed of the electric motor 1, which in turn changes the rotating speed of the propeller 6. Efficiency of the genset 10 remains good despite of a relatively small change of its speed. For example, if the nominal speed is 19 knots and the genset is driven to produce this speed of the ship, 10 % decrease of the genset's speed can reduce the ship's speed to about 13,8 knots. What can be seen is that a relatively
30 small speed change of the genset creates a relatively large change at the speed of the ship. It can be noted that the direct electric connection 15 provides a very good

efficiency at higher speeds of the ship containing the ships nominal speed that is normally a designed maximum speed or near the maximum speed.

In addition to the direct electric connection the frequency converter is used at lower cruising speeds. In this way it is possible to achieve the flexibility of operation during manoeuvring at lower speeds using the variable frequency drive, and to achieve high efficiency when operating at cruising speed. Typically a known diesel electric drive arrangement losses are about 6%, but using the inventive arrangement it is possible to reduce the losses to 3%. When operating at cruising speed, it is possible to make adjustments at the propulsion speed by adjusting the engine speed as said above.

10 A threshold cruising speed between the lower cruising speeds and the higher cruising speeds is in the range of 13 – 16 knots. A good threshold cruising speed is 15 knots for most ships where the invention can be utilized.

As said the third control unit 17 is arranged to switch the frequency converter 2 or the direct electric connection 15 for supplying power the electric motor 1. The frequency converter 2 is switched to supply power at lower cruising speeds and the direct electric connection 15 is switched to supply power at higher cruising speeds. The speed of the electric motor 1 at the higher cruising speeds is arranged to be controlled by changing the speed of the genset 10, which in turn changes frequency of the power bus 4 when the direct electric connection 15 is switched to supply power. At the lower cruising speeds the frequency converter changes the frequency of the electric power to be supplied to the motor 1, which changes the rotation speed of the motor 1.

The third control unit 17 is connected with the first control unit/s 3 and the second control unit/s 16. The second control unit may control one or more gensets 10. The second control unit can receive also speed information from the measurement 9 of the shaft's 8 speed. It is efficient that the second control unit 16 is arranged to control an engine 10A of the genset 10. In order that the frequency converter 2 can be switched off and the direct electric connection 15 can be switched on with the rest of the arrangement, the frequency of the bus bar (each phase) is synchronized with the phases the electric motor. Synchronizing is not needed when the direct electric

connection 15 is switched off and the frequency converter 2 is switched on, because the genset/s 10 and the electric motor are already in synchronization. So said switch actions comprises a synchronization step before the switch in order to match phases of the electric motor 1 and the power bus 4. It should be noted that the power bus 4 is
5 normally 3-phase system i.e. there are three separate buses, although the figures show only one bus for the sake of clarity of the drawings.

The switch actions are arranged to be made by controlling circuit breakers 11A, 11D, so the third control unit 17 controls the circuit breakers. The third control unit, called also main control unit, receives also speed information from the measurement
10 9 of the shaft's 8 speed and the frequency of the power bus/es 4 (not showed in the figures) and speed instruction 19.

Figure 2 shows further circuit breakers 11D in order to connect and disconnect the direct electric connection. Circuit breakers can be placed at suitable point of the arrangement. Figure 3 illustrates further circuit breakers 11E, 11F, 11G in order to
15 separate the frequency converter 2 and the direct electric connection 15 from the rest of the arrangement if needed. As the example of Figure 3 shows, the arrangement has systems for starboard and port sides of the ship which systems can be connected via a connection bus 12. The connection bus is also illustrated in Figure 1 and 2. So in this example the starboard side and the port side have the propeller 6,
20 the electric motor 1, the frequency converter 2, the possible transformer 5 if needed, the power bus 4, the direct electric connection 15, and the gensets that are only partly showed in Figure 3. So it can be noted that the inventive arrangement can be achieved in many ways.

In addition, the inventive arrangement may be performed in such a way that a
25 number of poles in a generator 10B of the genset 10 is arranged to provide a frequency of the power bus 4, which frequency is lower than 50 Hz, and a number of poles in the electric motor 1 is arranged to provide a low speed utilizing said frequency lower than 50 Hz. For example, the number of the poles in the generator 10B can be 12, and the number of the poles in the electric motor 1 can be 28. So, the
30 invention enables the use of lower number of poles in the electric motor for the propulsion (benefit to dimensions and efficiency of the machine). Normally as known

the electric motor is designed according to 50Hz bus frequency, in which case a direct drive without gearbox would have very high number of poles. For example 500 rpm engine with a generator having 12 poles performs 50Hz in the power bus 4, and electric motor having 84 poles provides 71 rpm at the shaft 8 of the propeller 6. In case of the invention 500 rpm engine with a generator having 4 poles means 16.7Hz in the power bus 4, and the electric motor having 28 poles provides 71 rpm. As can be seen, the structures of the generator 10B and the electric motor 1 can be more simple and cost-effective.

Figure 2 shows that the control units are situated separately having the relatively long connections between them. However, they all can also be situated at the same location, like in a central control processing unit, which can be a central computer for controlling. Whatever a physical construction is, the first 3, second 16 and third 17 units provide their specific duties. The units can be realized as circuit boards and/or software. Further it should be noted that the example of Figure 3 is showed only schematically without the control units, but it is evident that they also are in real solutions.

The invention provides a very cost-effective electric ship propulsion drive arrangement relating to constant pitch propeller applications. Good manoeuvring properties of the frequency converter drive at lower cruising speeds and very low losses of the direct electric connection drive at higher cruising speeds can be obtained. This can be achieved when the frequency of the power bus/es of the ship can vary and not kept at 50 or 60 Hz. The use of the transmission case can be avoided and generators and motors can have more simple structures. The electric motor can be a normal induction AC motor.

As showed above, the invention can be performed in many way, for example comprising the transmission gear 7 between the electric motor 1 and the propeller 6, or not. It is evident from the above that the invention is not limited to the embodiments described in this text but can be implemented in many other different embodiments within the scope of the inventive idea.

Claims

1. An electric ship propulsion drive arrangement comprising an electric motor (1) and a propeller (6) that is connected to the electric motor (1), and a frequency converter (2) that is arranged to supply power to the electric motor, the arrangement
5 having a control unit (3) to control the frequency converter (2), **characterised** in that the arrangement further comprises a direct electric connection (15) between the electric motor (1) and a power bus (4), which power bus has connections (11) for at least one genset (10), and the arrangement has a second control unit (16) for controlling at least one genset (10), the second control unit (16) being arranged to
10 control power supply to the electric motor (1),

the arrangement further comprising a third control unit (17) that is arranged to switch the frequency converter (2) or the direct electric connection (15) for supplying power to the electric motor (1), in such a way that the frequency converter (2) is switched to supply power at lower cruising speeds and the direct electric connection
15 (15) is switched to supply power at higher cruising speeds.

2. An electric ship propulsion drive arrangement according to Claim 1, **characterised** in that said switch actions comprises a synchronization step before the switch in order to match phases of the electric motor (1) and the power bus (4).

3. An electric ship propulsion drive arrangement according to Claim 1 or 2,
20 **characterised** in that speed of the electric motor (1) providing the cruising speed through the propeller (6) is arranged to be controlled by changing the speed of the genset (10), which in turn changes frequency of the power bus (4) when the direct electric connection (15) is switched to supply power.

4. An electric ship propulsion drive arrangement according to any of Claims 1 to 3,
25 **characterised** in that a threshold cruising speed between the lower cruising speeds and the higher cruising speeds is in the range of 13 – 16 knots.

5. An electric ship propulsion drive arrangement according to Claim 4, **characterised** in that the threshold cruising speed is 15 knots.

6. An electric ship propulsion drive arrangement according to any of the Claims
30 from 4 to 5, **characterised** in that said switch actions are arranged to be made by controlling circuits breakers (11A, 11D).

7. An electric ship propulsion drive arrangement according to Claim 6, **characterised** in that the said controlling of the genset (10) by the second control unit (16) is arranged to control an engine (10A) of the genset (10).

5 8. An electric ship propulsion drive arrangement according to any of the Claims from 6 to 7, **characterised** in that arrangement comprises a transmission gear (7) between the electric motor (1) and the propeller (6).

9. An electric ship propulsion drive arrangement according to any of the Claims from 1 to 8, **characterised** in that arrangement comprises further frequency converters (18) that are in connection with the power bus (4) in order to supply power
10 to loads.

10. An electric ship propulsion drive arrangement according to any of the Claims from 1 to 9, **characterised** in that a number of poles in an generator (10B) of the genset (10) is arranged to provide a frequency of the power bus (4) being lower than 50 Hz, and a number of poles in the electric motor (1) is arranged to provide a low
15 speed utilizing said frequency lower than 50 Hz.

11. An electric ship propulsion drive arrangement according to Claim 10, **characterised** in that the number of the poles in the generator (10B) is 12, and the number of the poles in the electric motor (1) is 28.

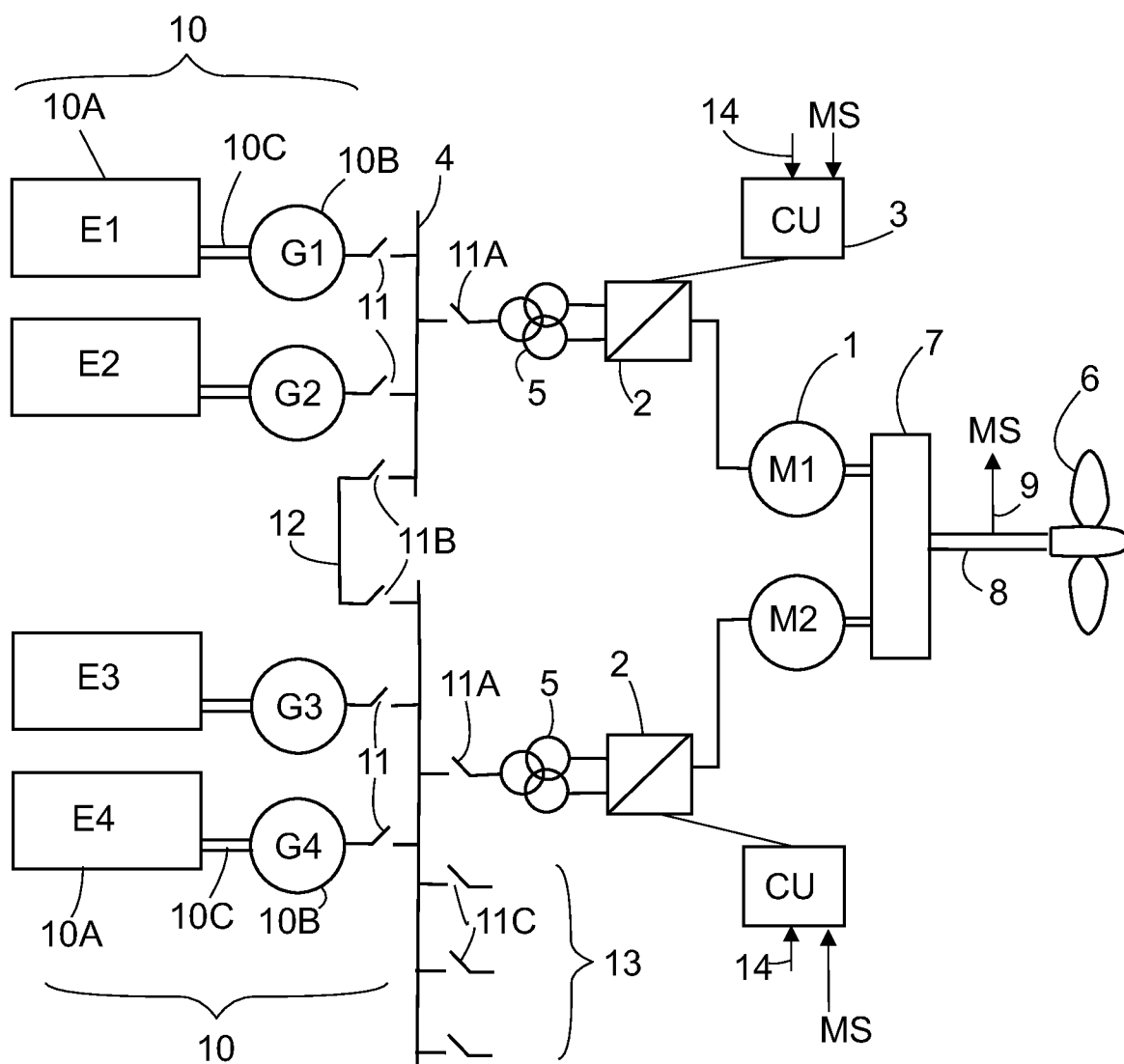
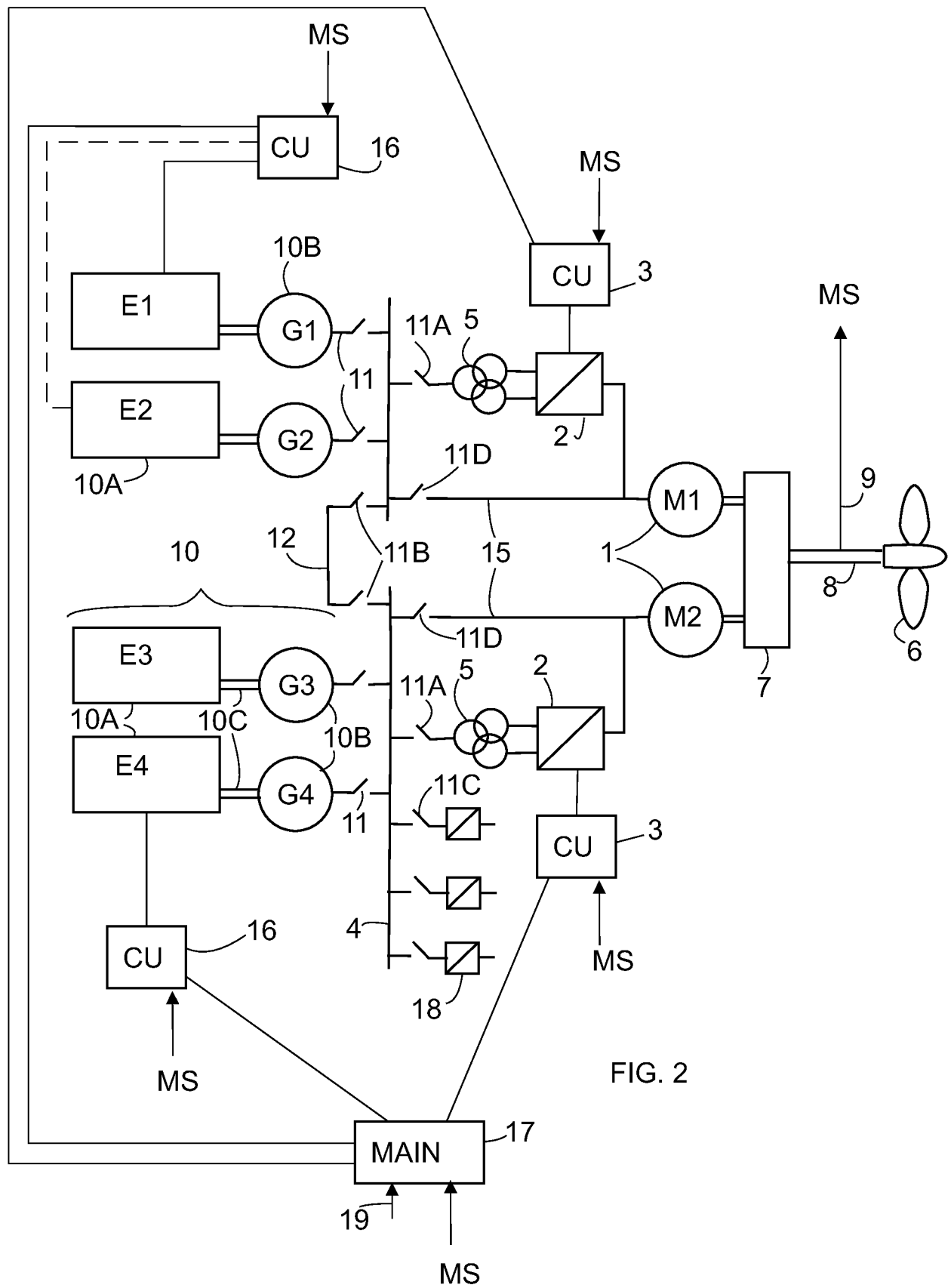


FIG. 1

2/3



3/3

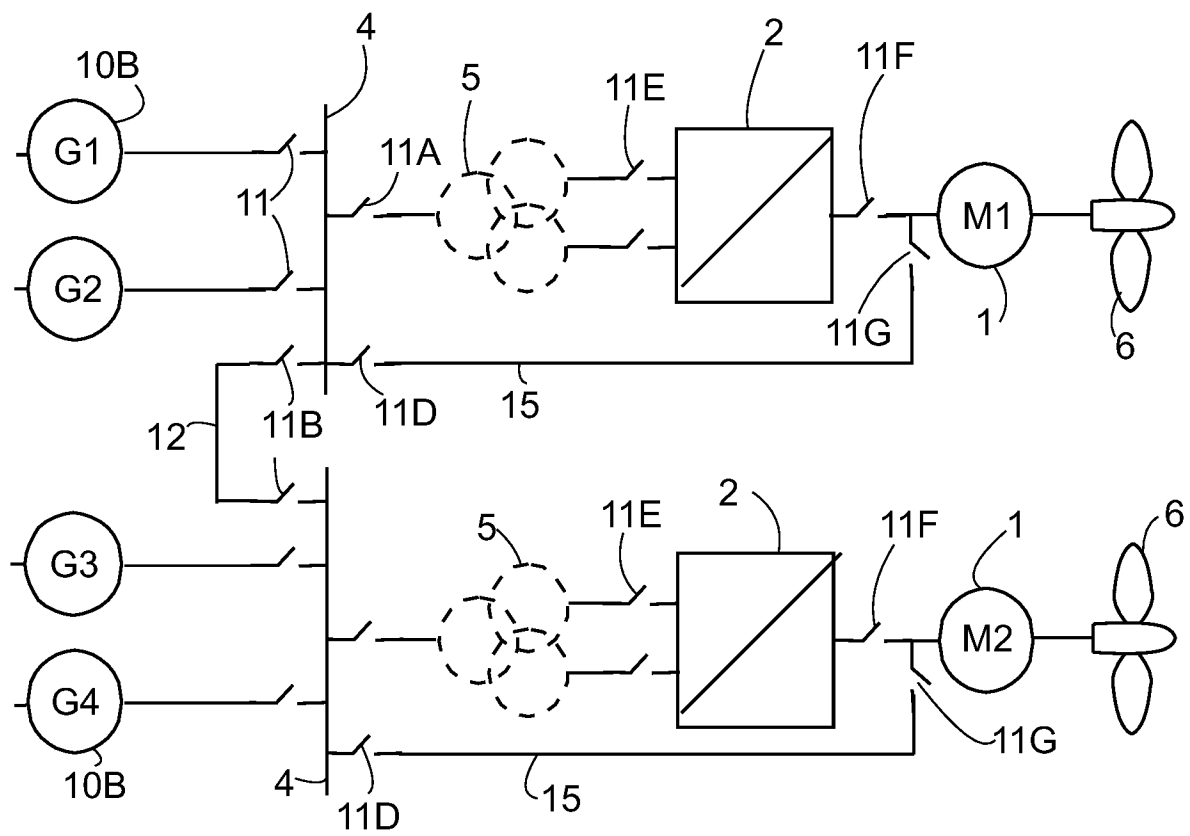


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2015/050469

A. CLASSIFICATION OF SUBJECT MATTER
INV. B63H23/24 B60L11/08
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B63H B60L

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/184575 A1 (ARMSTRONG RICHARD [US] ET AL) 23 July 2009 (2009-07-23)	1,3-9
Y	paragraph [0025]; figure 2	2
A	paragraph [0027]	10,11

Y	WO 2011/029805 A1 (SIEMENS AG [DE]; MAIER REINHARD [DE]; GRIEPENTROG GERD [DE]) 17 March 2011 (2011-03-17) the whole document	2



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

23 March 2016

Date of mailing of the international search report

01/04/2016

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Wansing, Ansgar

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/FI2015/050469

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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