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(54) **Electric propulsion system for ships**

(57) There is provided an electric propulsion system for a ship in which the cargo capacity of the ship is enhanced while the ship speed of the dead slow or less can be controlled. The electric propulsion system includes a variable speed engine (2), a synchronous generator (3) that generates electricity by the variable speed engine, an induction motor (6) that is connected to the synchronous generator, and a fixed-pitch propeller (7) that is driven by the induction motor.

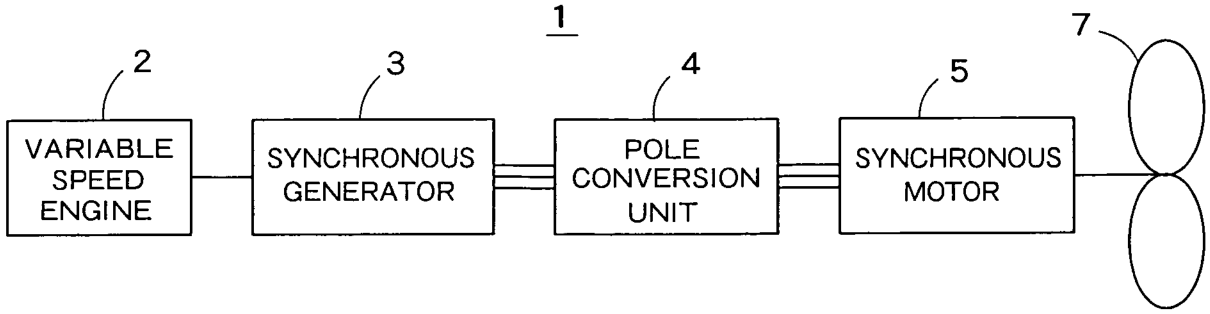

FIG. 1A

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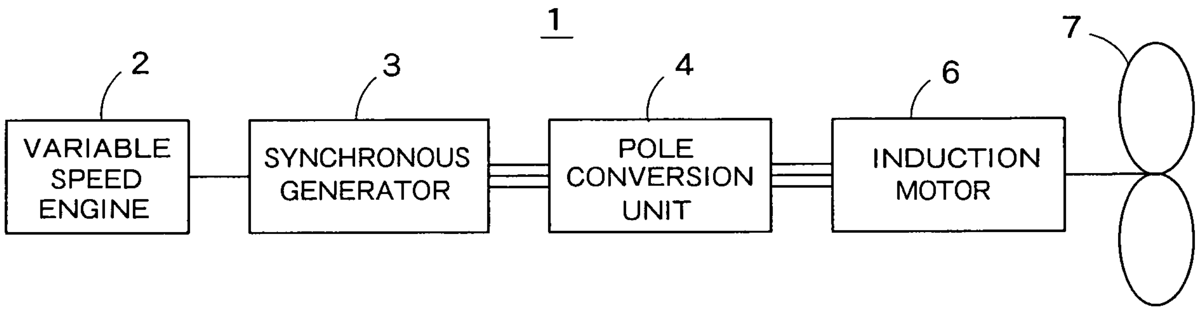

1
2
VARIABLE SPEED ENGINE
3
SYNCHRONOUS GENERATOR
4
POLE CONVERSION UNIT
6
INDUCTION MOTOR
7

F I G. 1B

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an electric propulsion system for ships. Particularly the invention relates to an extremely space-saving electric propulsion system for ships in which a ship speed can be controlled from dead slow or less to the maximum by a combination of a variable speed engine, a synchronous generator, and a synchronous motor or an induction motor.

Related Art

[0002] A diesel engine is used most commonly as a marine engine, and a direct-drive type marine propulsion device in which an engine and a screw propeller are directly connected has been used in the past.

[0003] It is necessary for the ship to control a speed from the viewpoint of marine navigation. Conventionally, a variable speed engine in which a rotating speed of the engine is variable or a variable pitch propeller in which a propeller mounting angle can arbitrarily change to vary a pitch has been used as a method for controlling the ship speed.

[0004] Further, a reversible engine in which a rotating direction is reversible or the variable pitch propeller in which going ahead, neutral, and going astern can be performed by varying the pitch has conventionally been used for the purpose of backward movement of the ship.

[0005] FIGS. 8 and 9 illustrate configurations of conventional direct-drive type marine propulsion devices.

[0006] FIG. 8 illustrates a conventional direct-drive type marine propulsion device in which the reversible engine and a fixed-pitch propeller are connected.

[0007] In the marine propulsion device in FIG. 8, the use of the reversible engine can perform going ahead, neutral, and going astern of the ship. Because usually the rotating speed is also variable in the reversible engine, the ship speed can be controlled to high speed, medium speed, and slow speed in the marine propulsion device in FIG. 8.

[0008] FIG. 9 illustrates a direct-drive type marine propulsion device in which an irreversible engine and the variable pitch propeller are combined.

[0009] In the marine propulsion device in FIG. 9, going ahead, neutral, and going astern of the ship and the high speed, medium speed, and slow speed can be controlled by varying the propeller pitch.

[0010] In both the direct-drive type marine propulsion devices in FIGS. 8 and 9, the engine and the screw propeller are directly connected. The marine propulsion device in which the engine and the screw propeller are directly connected has the following configuration as a shafting system from a main engine of the ship to the propeller.

[0011] That is, the shafting system sequentially includes the main engine of the ship, a reduction gear, an intermediate shaft, an intermediate bearing, a shaft coupling, a propeller shaft, a stern tube, a stern tube bearing, a shaft sealing device, a shaft bracket, a shaft bracket bearing, and the propeller. Because preferably the shafting system is linearly arrayed from the viewpoint of power transmission efficiency, usually the shafting system is linearly disposed on a keel near the stern.

[0012] Therefore, in the direct-drive type marine propulsion device, the main engine, that is, the engine breaks into a cargo space to cause reduction of a cargo capacity of the ship.

[0013] On the other hand, there has been proposed an electric propulsion type marine propulsion device, in which electricity is generated by the engine without directly connecting the engine and the screw propeller and the screw propeller is driven by the electricity.

[0014] For the electric propulsion type marine propulsion device, a layout of the main engine and the propeller is freely designed to eliminate the necessity to linearly provide the shafting system unlike the direct-drive type marine propulsion device.

[0015] FIGS. 10 and 11 illustrate configurations of conventional electric propulsion type marine propulsion devices.

[0016] FIG. 10 illustrates a conventional electric propulsion type marine propulsion device in which a constant speed engine, a synchronous generator, an inverter, an induction motor, and the fixed-pitch propeller are connected.

[0017] In the conventional electric propulsion type marine propulsion device in FIG. 10, a constant speed engine is used because the synchronous generator generates the electricity having a constant frequency, and the inverter is also provided in order that a speed of the induction motor is controlled to adjust the ship speed to the high speed, medium speed, and slow speed.

[0018] The reason why the constant speed engine is used for the synchronous generator is that the electricity can be converted by the inverter when the synchronous generator generates electricity having a constant frequency (50 Hz or 60 Hz). Additionally, the constant speed engine in which fuel consumption and output are optimally adjusted is suitably used so as to generate the electricity having the constant frequency.

[0019] There is another reason the electricity having the frequency of 50 Hz or 60 Hz can be utilized as other power of the ship.

[0020] FIG. 11 illustrates another conventional electric propulsion type marine propulsion device in which the constant speed engine, the synchronous generator, the synchronous motor, and the variable pitch propeller are connected.

[0021] In the conventional electric propulsion type marine propulsion device in FIG. 11, similarly the constant speed engine is used because the synchronous generator generates the electricity having a constant frequency, and the variable pitch propeller is also provided in order that the speed of the induction motor is controlled to adjust the ship speed to the high speed, medium speed, and slow speed.

[0022] In the invention, the variable speed engine is used instead of the conventional constant speed engine in which the fuel consumption and the output are optimally adjusted to generate the electricity having the constant frequency. Because conventionally the variable speed engine of the invention does not exist, there is no piece of information on prior art document.

[0023] In the conventional direct-drive type marine propulsion device in which the engine and the screw propeller are directly connected, as described above, the main engine, that is, the engine breaks into the cargo space to cause the reduction of the cargo capacity of the ship.

[0024] On the other hand, in the electric propulsion type marine propulsion device, in which the engine generates electricity and the screw propeller is driven by the electricity, the layout of the main engine and the propeller is freely designed compared with the direct-drive type marine propulsion device.

[0025] However, in the conventional electric propulsion type marine propulsion device in which the constant speed engine, the synchronous generator, the inverter, the induction motor, and the fixed-pitch propeller are connected, because the inverter occupies a large volume. Unfortunately, the cargo capacity of the ship is reduced by mounting the inverter instead of freely designing the layout of the main engine and the propeller.

[0026] FIG. 12 illustrates an example of the electric propulsion type marine propulsion device on which the inverter is mounted.

[0027] As illustrated in FIG. 12, in the layout of the electric propulsion type marine propulsion device, a constant speed engine 15 and a synchronous generator 16 are placed in a stern projecting portion, an inverter 17 is placed on a second deck, and an induction motor 21 is placed on the keel to drive a fixed-pitch propeller 22.

[0028] However, not only the inverter 17 has the large volume, but also accompanying facilities such as an electric switchboard 18, a resistance unit 19, and a transformer 20 are also required. Therefore, the inverter 17 occupies the large volume as a space for electric facilities as illustrated in FIG. 12.

[0029] Additionally, because the inverter is extremely expensive, the inverter drives up production cost of the ship.

[0030] On the other hand, the expensive, complicated variable pitch propeller unfortunately drives up the production cost of the ship in the conventional electric propulsion type marine propulsion device to which the constant speed engine, the synchronous generator, the synchronous motor, and the variable pitch propeller are connected.

[0031] In the conventional electric propulsion type marine propulsion device, unfortunately, energy efficiency becomes low at the ship speed of dead slow or less or in a low-load operation, and engine combustion becomes undesirable.

[0032] In the ship speed of dead slow or less, occasionally it is necessary to accelerate and decelerate the ship even in the dead slow region. For example, the ship is accelerated and decelerated even in the dead slow region in coming alongside the pier or leaving the pier. When the low-load operation is performed in the bay or port, it is necessary that the ship be repeatedly accelerated and decelerated while the engine rotation is suppressed to a low level.

[0033] The constant speed engine is designed so as to be rotated in a given narrow rotation region, and usually the engine output is designed according to the output of the low and medium speed or the medium and high speed.

[0034] However, in the ship speed of dead slow or less, because only energy that is lower than the minimum number of rotations of the rotation region is required, part of the generated energy is discarded although the engine is maintained at the minimum number of rotations, which results in an issue in that the energy goes to waste.

[0035] When the ship is accelerated and decelerated at the ship speed of dead slow or less in coming alongside the pier or leaving the pier, or in the low-load operation in the bay or port, the load on the constant speed engine occasionally increases or decreases while the constant speed engine is maintained at the minimum number of rotations of the rotation region.

[0036] The constant speed engine is adjusted such that the timing of compression and explosion becomes optimum at a specific rotating speed. Therefore, when the acceleration and the deceleration are performed near the minimum number of rotations, the load on the engine fluctuates, and the fuel is not ignited at an optimum explosion point, which results in an issue of a combustion defect.

[0037] Accordingly, the conventional electric propulsion type marine propulsion device has an issue in that the control is hardly performed at the ship speed of dead slow or less.

[0038] In order to solve the above-described problem, an object of the present invention is to provide a marine electric propulsion system in which the cargo capacity of the ship is enhanced while the ship speed of the dead slow or less can be controlled.

SUMMARY OF THE INVENTION

[0039] According to one aspect of the present invention, there is provided an electric propulsion system for ships comprising:

a variable speed engine;
a synchronous generator that generates electricity by the variable speed engine;
an induction motor that is connected to the synchronous generator; and

a fixed-pitch propeller that is driven by the induction motor.

[0040] In the electric propulsion system, the variable speed engine and the synchronous generator are disposed above a keel near a stern, the induction motor is disposed in an outboard pod, and the fixed-pitch propeller is driven by the induction motor.

[0041] The electric propulsion system further comprises an auxiliary generator that is disposed in a stern projecting portion.

[0042] In the electric propulsion system, the variable speed engine and the synchronous generator are disposed in a stern projecting portion or on an upper deck near a stern, the induction motor is disposed above a keel near the stern, and the fixed-pitch propeller is driven by the induction motor.

[0043] In the electric propulsion system, the variable speed engine and the synchronous generator are disposed in a stern projecting portion or on an upper deck near a stern, the induction motor is disposed in an outboard pod, and the fixed-pitch propeller is driven by the induction motor.

[0044] The electric propulsion system further comprises an auxiliary generator, and a package unit of the variable speed engine and the synchronous generator and the auxiliary generator are disposed in a nested manner.

[0045] In the electric propulsion system, the induction motor includes a pole conversion unit.

[0046] The electric propulsion system for ships (marine electric propulsion system) according to the invention includes the variable speed engine, the synchronous generator, the synchronous motor or the induction motor, and the fixed-pitch propeller.

[0047] The variable speed engine is designed so as to have a constant output width, so that the variable speed engine can generate the output in a moderate combustion state in a rotation region of a constant width. When the number of rotations of the variable speed engine changes, the frequency and voltage of the electricity generated by the synchronous generator change.

[0048] In the marine electric propulsion system according to the invention, the number of rotations of the variable speed engine changes according to the desired ship speed, and the frequency and voltage of the electricity generated by the synchronous generator change according to the number of rotations of the variable speed engine, thereby controlling the rotating speed of the synchronous motor or the induction motor.

[0049] In the marine electric propulsion system according to the invention, because the frequency of the generated electricity changes according to the ship speed, the generated electricity disadvantageously cannot be used as other power of the ship. However, the problem can be solved when the small auxiliary generator is used for other power of the ship. According to the present invention, in exchange for the disadvantage, the large-volume, expensive inverter or the expensive variable pitch propeller can advantageously be removed.

[0050] The removal of the inverter eliminates the accompanying electric facilities, and the entire electric propulsion system can be disposed in the narrow space of the stern. As a result, the cargo capacity of the ship can largely increase.

[0051] When the variable pitch propeller is removed, the production cost of the ship is reduced by removing the propeller having the expensive, complicated mechanism, and therefore reliability of the ship can be improved.

[0052] In the marine electric propulsion system according to the invention, the energy does not go waste at the ship speed of dead slow or less, and the output region of the variable speed engine is set so as to adapt to the ship speed of dead slow or less. Therefore, the marine electric propulsion system can avoid the problem of the engine combustion defect.

[0053] Further, the motor includes a pole conversion unit, so that the acceleration and the deceleration can be repeated without any problem even at the ship speed of dead slow or less. Additionally, the pole conversion unit drives the propeller at the dead slow speed with a high torque margin, so that the marine electric propulsion system suitable to a large-diameter propeller and an ice breaking ship in which a high torque is required can be obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0054]

FIGS. 1A and 1B are block diagrams illustrating a marine electric propulsion system according to an embodiment of the invention;

FIG. 2 is a diagram illustrating a configuration structure of the marine electric propulsion system of the embodiment;

FIG. 3 is a diagram illustrating another configuration structure of the marine electric propulsion system of the embodiment;

FIG. 4 is a diagram illustrating still another configuration structure of the marine electric propulsion system of the embodiment;

FIG. 5 is a diagram illustrating still another configuration structure of the marine electric propulsion system of the embodiment;

FIG. 6 is a plan view of the configuration structure in FIG. 5;

FIG. 7 is a diagram illustrating still another configuration structure of the marine electric propulsion system of the embodiment;

FIG. 8 is a diagram illustrating a configuration of a conventional direct-drive type marine propulsion device;

FIG. 9 is a diagram illustrating a configuration of a conventional direct-drive type marine propulsion device;

FIG. 10 is a diagram illustrating a configuration of a conventional electric propulsion type marine propulsion device;

FIG. 11 is a diagram illustrating a configuration of a conventional electric propulsion type marine propulsion device; and

FIG. 12 is a diagram illustrating a configuration structure of a conventional electric propulsion type marine propulsion device.

DETAILED DESCRIPTION OF THE INVENTION

[0055] Hereafter, an embodiment of the present invention will be described more specifically with reference to the drawings.

[0056] FIGS. 1A and 1B are block diagrams illustrating a marine electric propulsion system (an electric propulsion system for ships) according to an embodiment of the invention.

[0057] As illustrated in FIGS. 1A and 1B, a marine electric propulsion system 1 of the embodiment includes a variable speed engine 2, a synchronous generator 3, a pole conversion unit 4, a synchronous motor 5 or an induction motor 6, and a fixed-pitch propeller 7.

[0058] The marine electric propulsion system in FIG. 1A includes the variable speed engine 2, the synchronous generator 3, the pole conversion unit 4, the synchronous motor 5, and the fixed-pitch propeller 7. The marine electric propulsion system in FIG. 1B includes the variable speed engine 2, the synchronous generator 3, the pole conversion unit 4, the induction motor 6, and the fixed-pitch propeller 7.

[0059] The variable speed engine 2 is designed to be able to generate output in a moderate combustion state in a rotation region having a constant width.

[0060] The synchronous generator 3 is driven by the variable speed engine 2 to generate the electricity.

[0061] The synchronous motor 5 or the induction motor 6 is electrically connected to the synchronous generator 3 and rotated and driven at a variable speed according to the electric frequency of the synchronous generator 3.

[0062] The pole conversion unit 4 converts the number of poles of the synchronous motor 5 or the induction motor 6. For example, when the number of poles of the synchronous motor 5 or the induction motor 6 is converted from 6 poles to 12 poles, the number of rotations of the synchronous motor 5 or the induction motor 6 becomes half by the electricity having the same frequency, and therefore the rotating speed of the fixed-pitch propeller 7 is reduced by half.

[0063] The pole conversion unit 4 can be removed when the output region of the variable speed engine 2 can be designed to fit to the speed of dead slow or less.

[0064] In the marine electric propulsion system 1 according to the embodiment, when the number of rotations of the variable speed engine 2 changes according to the desired ship speed, the frequency of the electricity generated by the synchronous generator 3 changes according to the number of rotations of the variable speed engine 2, and the number of rotations of the synchronous motor 5 or the induction motor 6 is controlled to adjust the rotating speed of the fixed-pitch propeller 7, which allows the desired ship speed to be obtained.

[0065] Therefore, the necessity of the inverter or variable pitch propeller is eliminated.

[0066] For going astern, the synchronous motor 5 or the induction motor 6 may be electrically reversed. That is, going astern can be achieved by flipping a switch, and the necessity of the mechanical reversing mechanism is eliminated.

[0067] In the marine electric propulsion system 1, the output region of the variable speed engine 2 is set so as to adapt to the ship speed of dead slow or less. Therefore, the marine electric propulsion system 1 can adapt to the ship speed of dead slow or less by controlling the number of rotations of the variable speed engine 2.

[0068] When the number of rotations of the variable speed engine 2 falls within the set output region of the variable speed engine 2, the problem of the engine combustion defect can be avoided even in the ship speed of dead slow or less.

[0069] The marine electric propulsion system 1 also includes the pole conversion unit 4. Therefore, because the number of poles of the synchronous motor 5 or the induction motor 6 is converted by the pole conversion unit 4 while the number of rotations of the variable speed engine 2 is kept constant, the rotation of further dead slow can be obtained to perform delicate ship maneuvering in coming alongside the pier or leaving the pier.

[0070] When the number of poles of the synchronous motor 5 or the induction motor 6 is converted double by the pole conversion unit 4 while the number of rotations of the variable speed engine 2 is kept constant, a torque margin of the fixed-pitch propeller 7 largely increases while the number of rotations of the fixed-pitch propeller 7 becomes half.

[0071] As used herein, the torque margin means a capacity that can maintain the number of rotations even if a load fluctuates. In the invention, the marine electric propulsion system suitable to a large-diameter propeller and an ice breaking ship can be obtained by the increased torque margin.

[0072] In the marine electric propulsion system 1 according to the embodiment, the space for the propulsion device can be minimized to improve the cargo capacity of the ship.

[0073] FIG. 2 illustrates a configuration structure of the marine electric propulsion system of the embodiment.

[0074] FIG. 2 illustrates a stern portion of the ship. Referring to FIG. 2, the variable speed engine 2 and the synchronous generator 3 are disposed above a keel 8 near the stern, the synchronous motor 5 or the induction motor 6 is disposed in an outboard pod 9, and the fixed-pitch propeller 7 is attached to the outboard pod 9 so as to be driven by the synchronous motor 5 or the induction motor 6.

[0075] As used herein, "above the keel" includes both the case of an upper surface of the keel and the case of a surface of some sort of support above the keel from the vertical viewpoint.

[0076] An auxiliary generator 10 can be provided in a stern projecting portion 11 in order to generate general-use electricity of the ship.

[0077] The variable speed engine 2 and the synchronous generator 3 are formed into a compact package unit as much as possible, and the electricity generated by the variable speed engine 2 and synchronous generator 3 is sent to the synchronous motor 5 or the induction motor 6 in the outboard pod 9 through a cable (not illustrated) to drive the synchronous motor 5 or the induction motor 6, and then drive the fixed-pitch propeller 7.

[0078] In the embodiment, the variable speed engine 2 and the synchronous generator 3 can be placed in the stern as much as possible because the shafting system is eliminated between the engine and the propeller, a second deck 12 can maximally be utilized because only the auxiliary generator 10 is disposed in the stern projecting portion 11 on the second deck 12, and the space for the propulsion device is minimized in the ship to largely improve the cargo capacity of the ship because the synchronous motor 5 or the induction motor 6 is disposed in the outboard pod 9.

[0079] FIGS. 3 and 4 illustrate other configuration structures of the marine electric propulsion system of the embodiment.

[0080] In the configuration structure in FIG. 3, the variable speed engine 2 and the synchronous generator 3 are disposed in the stern projecting portion 11, the synchronous motor 5 or the induction motor 6 is disposed on the keel 8 near the stern, and the fixed-pitch propeller 7 is driven by the synchronous motor 5 or the induction motor 6.

[0081] The configuration structure in FIG. 4 is similar to that in FIG. 3 except that the variable speed engine 2 and the synchronous generator 3 are disposed on an upper deck 13 near the stern.

[0082] As illustrated in FIGS. 3 and 4, in the marine electric propulsion system of the embodiment, the variable speed engine 2 and the synchronous generator 3 can be disposed in any position, and therefore the cargo volume can be maximized on the bottom deck while the cargo space of the ship is freely designed.

[0083] FIGS. 5 and 6 illustrate still other configuration structures of the marine electric propulsion system of the embodiment.

[0084] FIG. 5 illustrates a side face of the stern portion, and FIG. 6 illustrates a plane of the stern portion of the same configuration structure.

[0085] As illustrated in FIGS. 5 and 6, in the configuration structure, the variable speed engine 2 and the synchronous generator 3 are disposed in the stern projecting portion 11, the synchronous motor 5 or the induction motor 6 is disposed in the outboard pod 9, and the fixed-pitch propeller 7 is driven by the synchronous motor 5 or the induction motor 6.

[0086] As is clear from FIG. 5, in the configuration structure, the variable speed engine 2 and the synchronous generator 3 are disposed in the stern projecting portion 11, and the synchronous motor 5 or the induction motor 6 is disposed in the outboard pod 9, which allows the cargo volume to be maximized.

[0087] In the configuration structure of the embodiment, as illustrated in FIG. 6, sizes in length directions of the generators and the like can be minimized by disposing the package unit of the variable speed engine 2 and the synchronous generator 3 and the auxiliary generators 10 in a nested manner. Therefore, the space of the entire marine electric propulsion system 1 can be minimized to maximize the cargo space.

[0088] FIG. 7 illustrates still another configuration structure of the marine electric propulsion system of the embodiment.

[0089] The configuration structure in FIG. 7 is similar to that in FIG. 5 except that the variable speed engine 2 and the synchronous generator 3 are disposed on the upper deck 13 near the stern.

[0090] In the configuration structure in FIG. 7, the variable speed engine 2 and the synchronous generator 3 are disposed on the upper deck 13 near the stern, and the synchronous motor 5 or the induction motor 6 is disposed in the outboard pod 9, which allows the cargo volume to be maximized.

[0091] Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

EXPLANATION OF REFERENCE NUMERALS

[0092]

1: MARINE ELECTRIC PROPULSION SYSTEM
2: VARIABLE SPEED ENGINE
3: SYNCHRONOUS GENERATOR
4: POLE CONVERSION UNIT
5: SYNCHRONOUS MOTOR
6: INDUCTION MOTOR
7: FIXED-PITCH PROPELLER
8: KEEL
9: OUTBOARD POD
10: AUXILIARY GENERATOR
11: STERN PROJECTING PORTION
12: SECOND DECK
13: UPPER DECK
15: CONSTANT SPEED ENGINE 16: SYNCHRONOUS GENERATOR
17: INVERTER
18: ELECTRIC SWITCHBOARD 19: RESISTANCE

UNIT
20: TRANSFORMER
21: INDUCTION MOTOR
22: FIXED-PITCH PROPELLER

Claims

1. An electric propulsion system for ships comprising:

   a variable speed engine;
   a synchronous generator that generates electricity by the variable speed engine;
   an induction motor that is connected to the synchronous generator; and
   a fixed-pitch propeller that is driven by the induction motor.

2. The electric propulsion system for ships according to claim 1, wherein the variable speed engine and the synchronous generator are disposed above a keel near a stern,
   the induction motor is disposed in an outboard pod, and the fixed-pitch propeller is driven by the induction motor.

3. The electric propulsion system for ships according to claim 2, further comprising an auxiliary generator that is disposed in a stern projecting portion.

4. The electric propulsion system for ships according to claim 1, wherein the variable speed engine and the synchronous generator are disposed in a stern projecting portion or on an upper deck near a stern,
   the induction motor is disposed above a keel near the stern, and
   the fixed-pitch propeller is driven by the induction motor.

5. The electric propulsion system for ships according to claim 1, wherein the variable speed engine and the synchronous generator are disposed in a stern projecting portion or on an upper deck near a stern,
   the induction motor is disposed in an outboard pod, and the fixed-pitch propeller is driven by the induction motor.

6. The electric propulsion system for ships according to claim 5, further comprising an auxiliary generator, wherein a package unit of the variable speed engine and the synchronous generator and the auxiliary generator are disposed in a nested manner.

7. The electric propulsion system for ships according to any one of claims 1 to 6, wherein the induction motor includes a pole conversion unit.

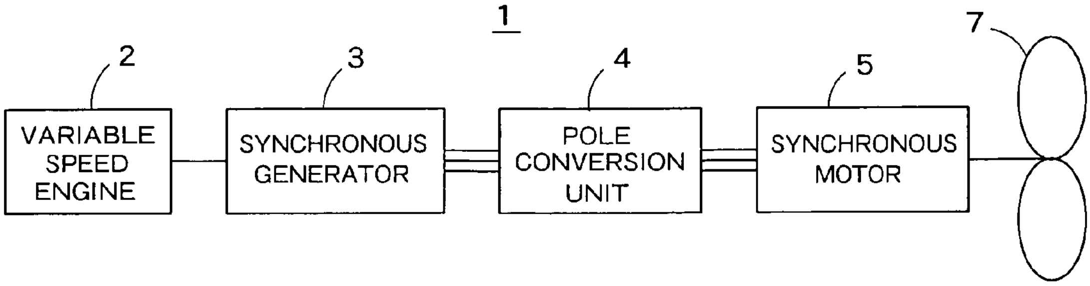


FIG. 1A

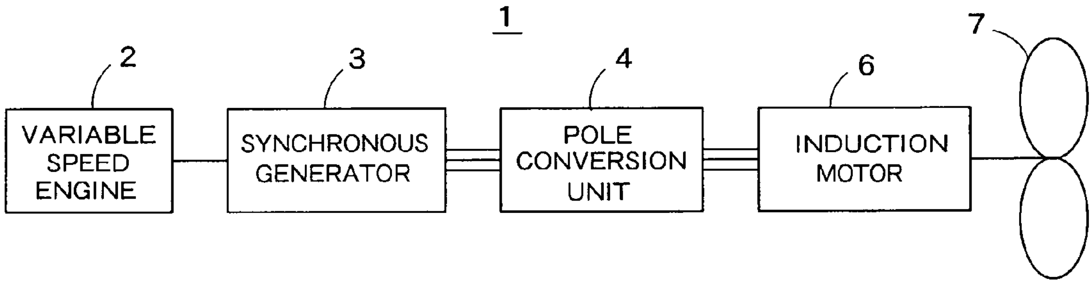


FIG. 1B

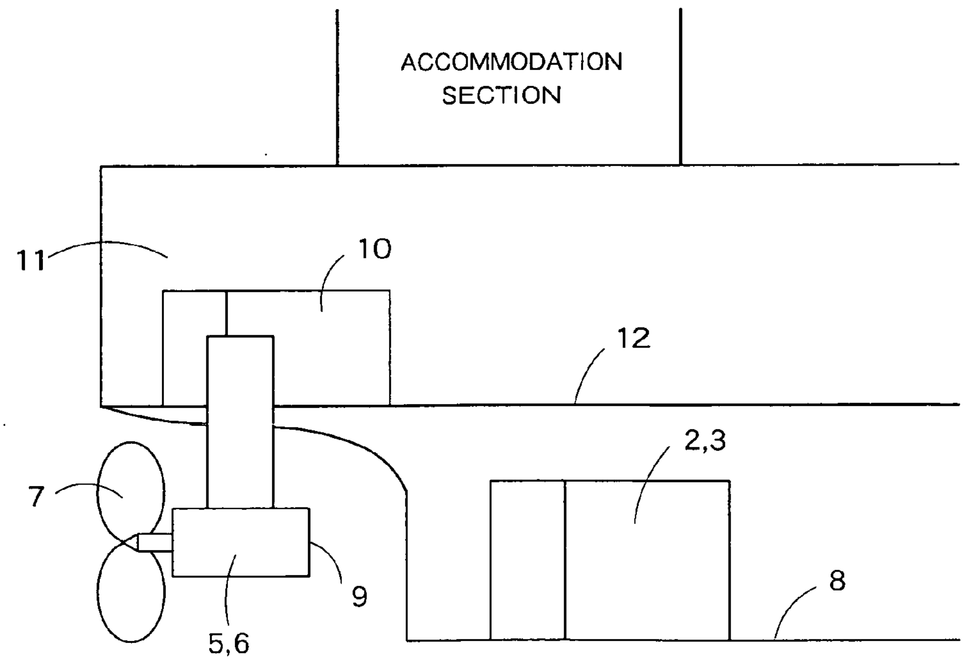
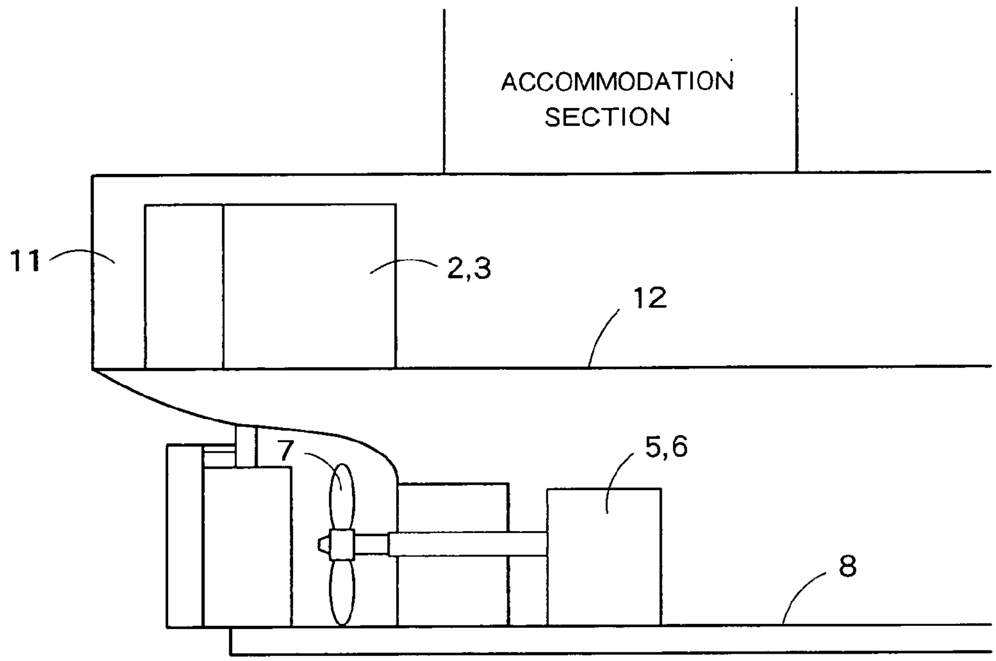


FIG. 2


ACCOMMODATION SECTION
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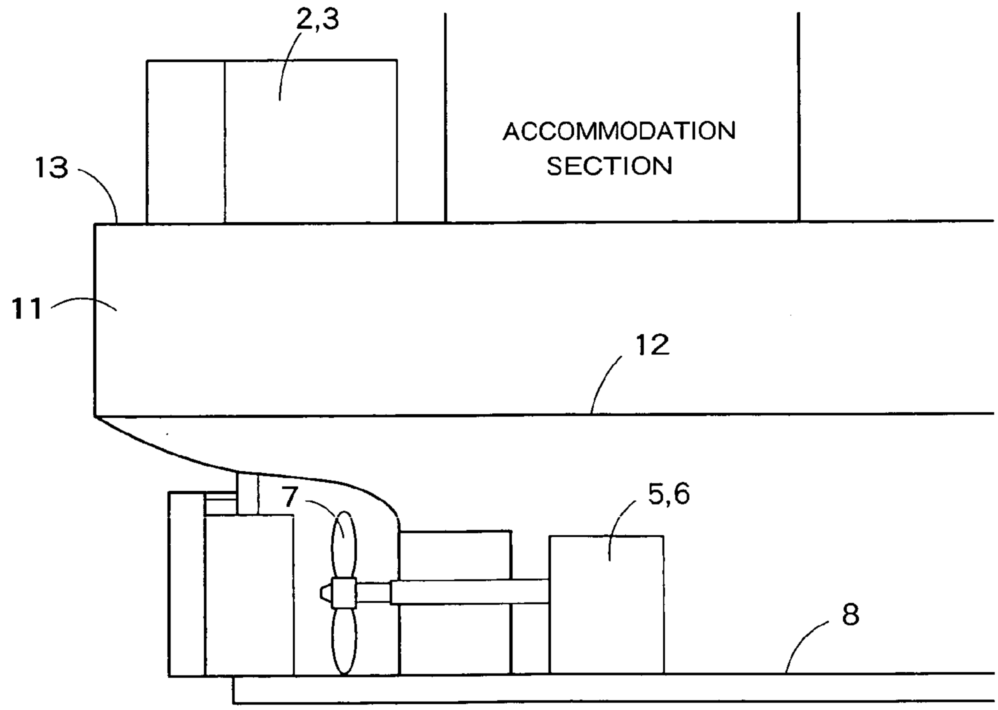
F I G. 3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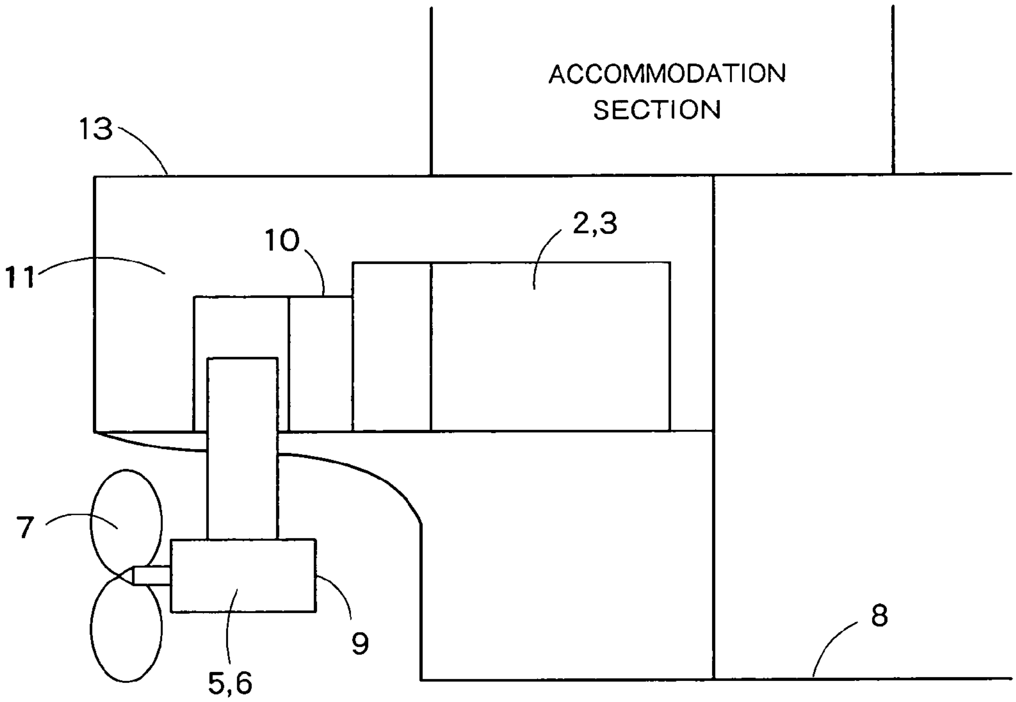

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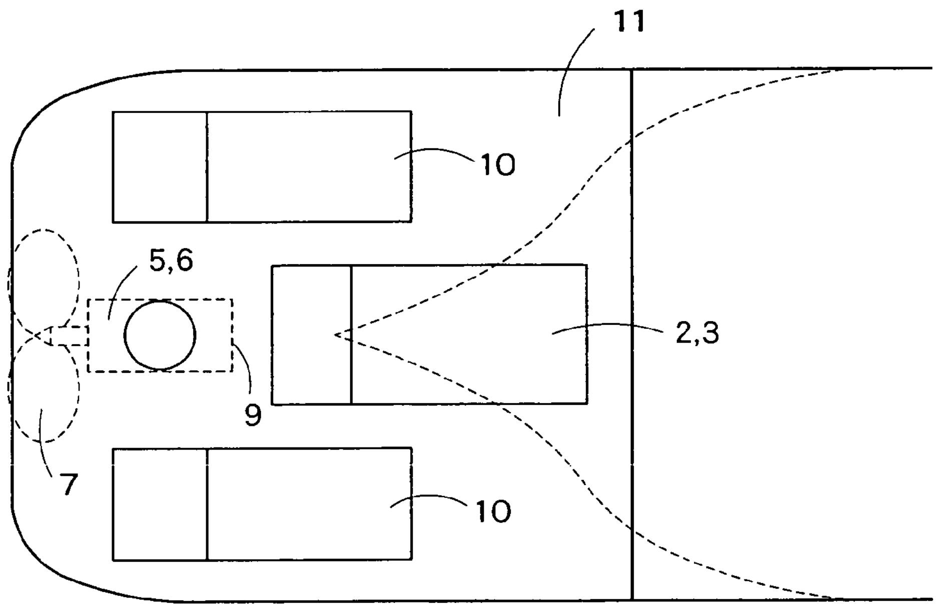
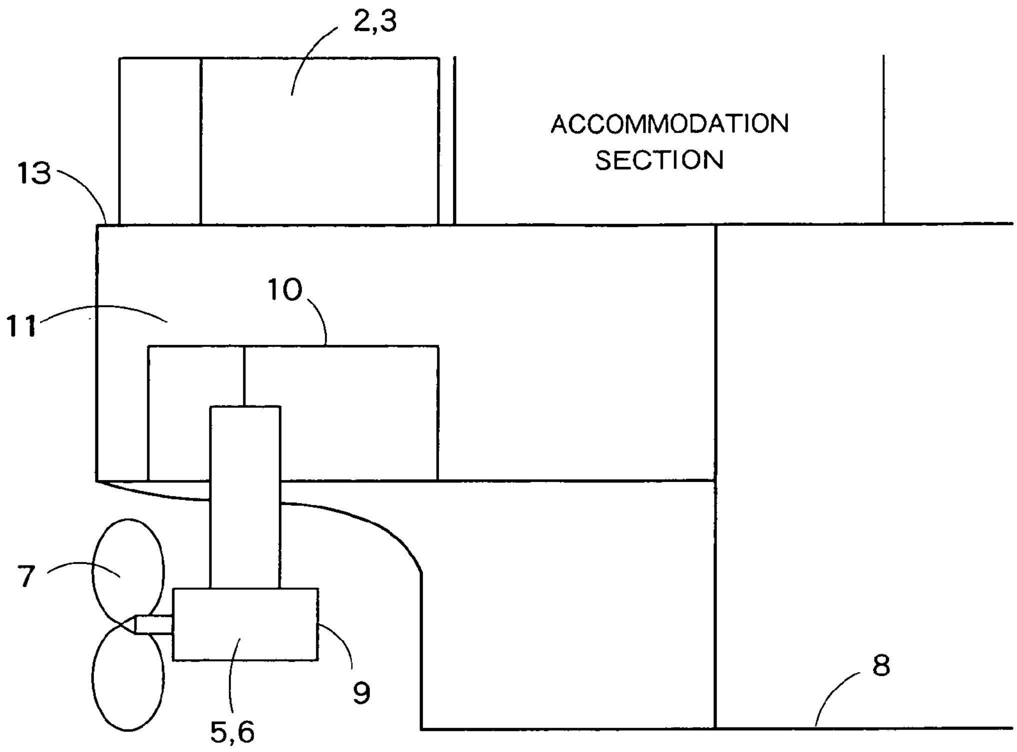
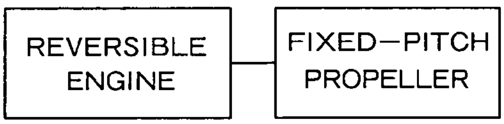


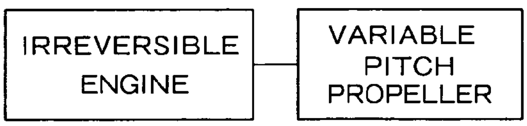
F I G. 6



F I G. 7



F I G. 8



F I G. 9

F I G. 10

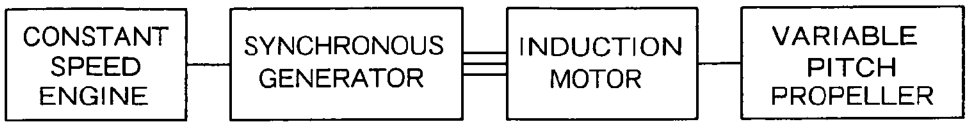

CONSTANT
SPEED
ENGINE
SYNCHRONOUS
GENERATOR
INDUCTION
MOTOR
VARIABLE
PITCH
PROPELLER

FIG. 11

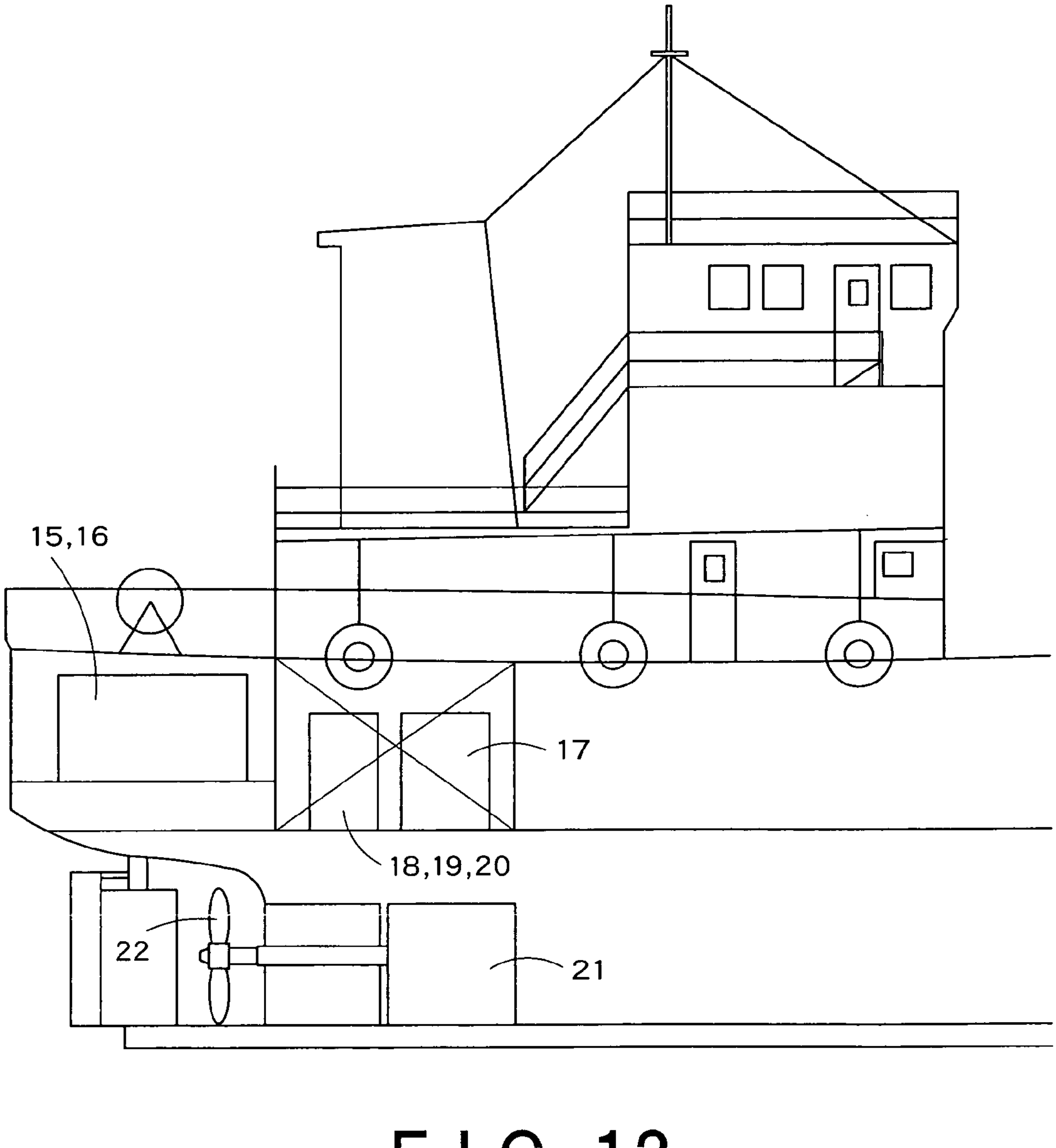

15,16
17
18,19,20
22
21

FIG. 12