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(54) DRIVE-LINE MOUNTED DIRECT COUPLED AC GENERATOR FOR MARINE WATER CRAFT

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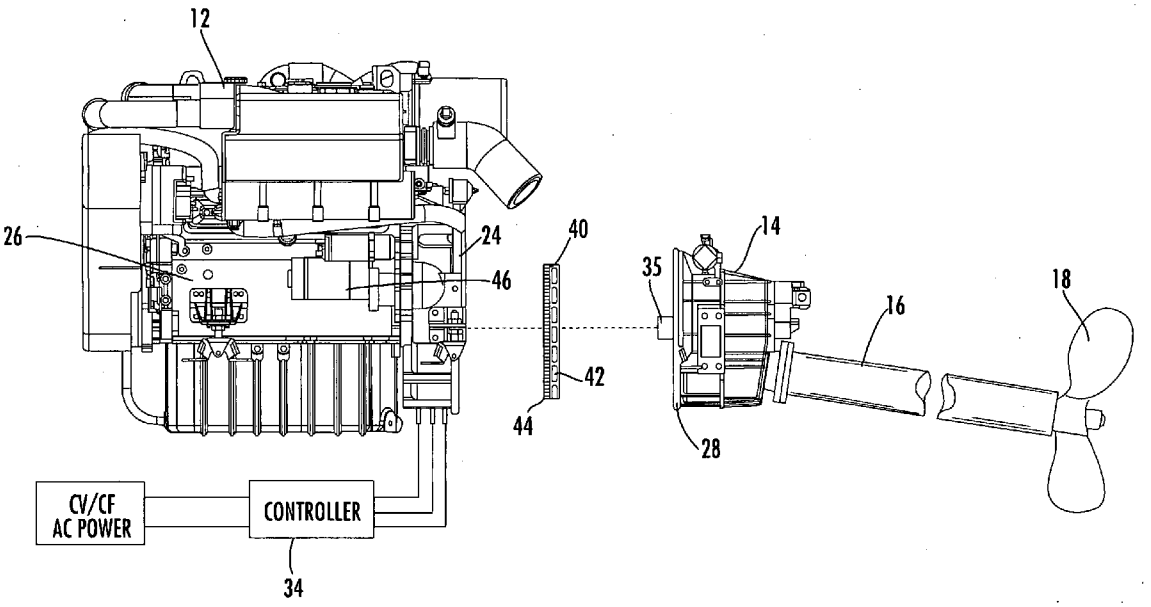
(57) **ABSTRACT**

A direct coupled, drive-line power generating system for use with marine water craft. The generator is preferably located between the engine and the marine drive system providing an auxiliary or primary source of substantially stabilized constant voltage constant frequency AC power from a variable speed marine engine.



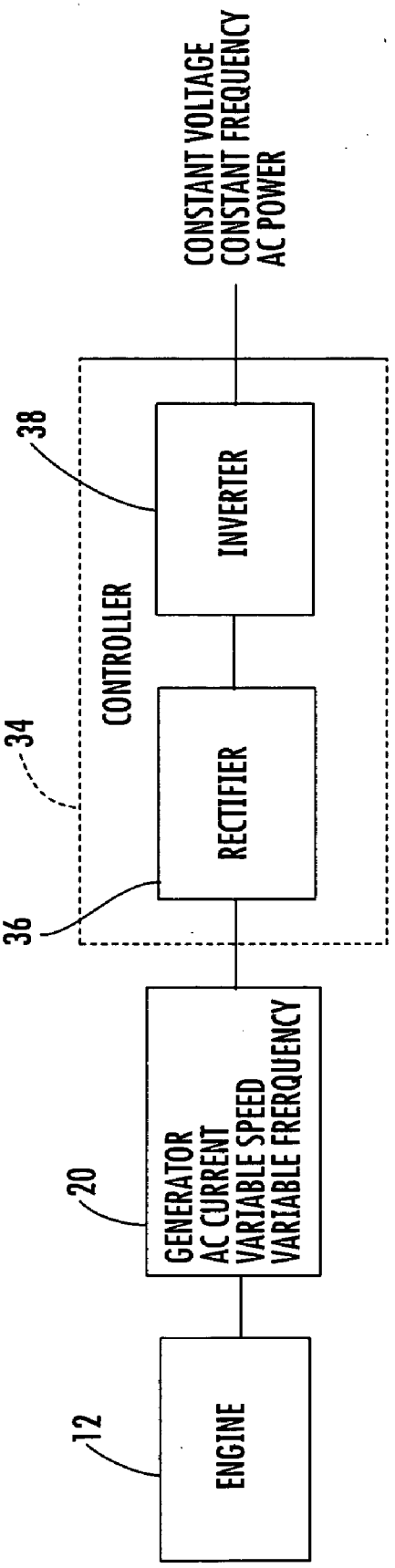
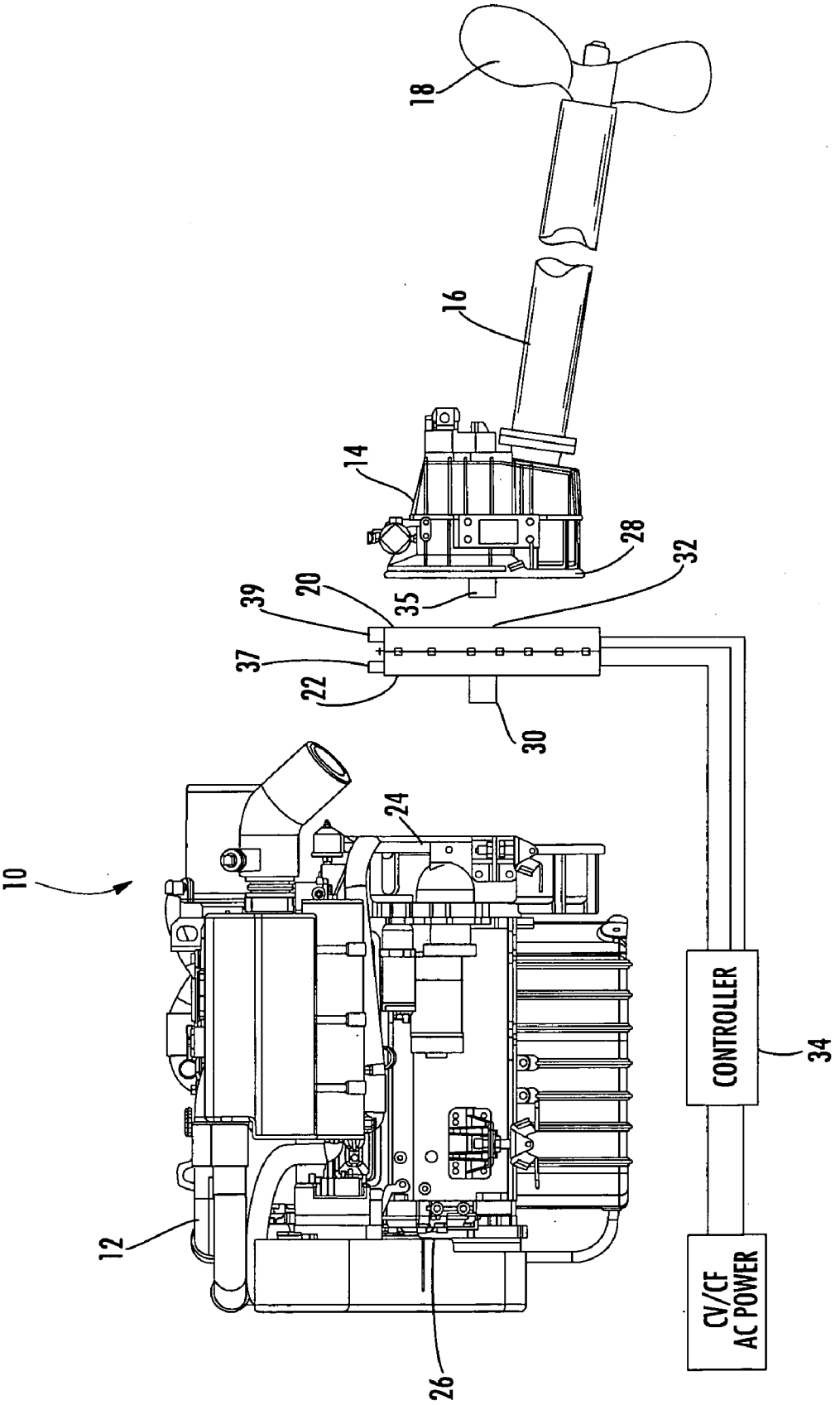

CONSTANT VOLTAGE
CONSTANT FREQUENCY
AC POWER
38
INVERTER
CONTROLLER
34
RECTIFIER
36
GENERATOR
AC CURRENT
VARIABLE SPEED
VARIABLE FRERQUENCY
20
ENGINE
12

FIG. 1


18
16
14
28
32
39
20
35
37
22
30
24
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12
26
CONTROLLER
34
CV/CF
AC POWER

FIG. 2

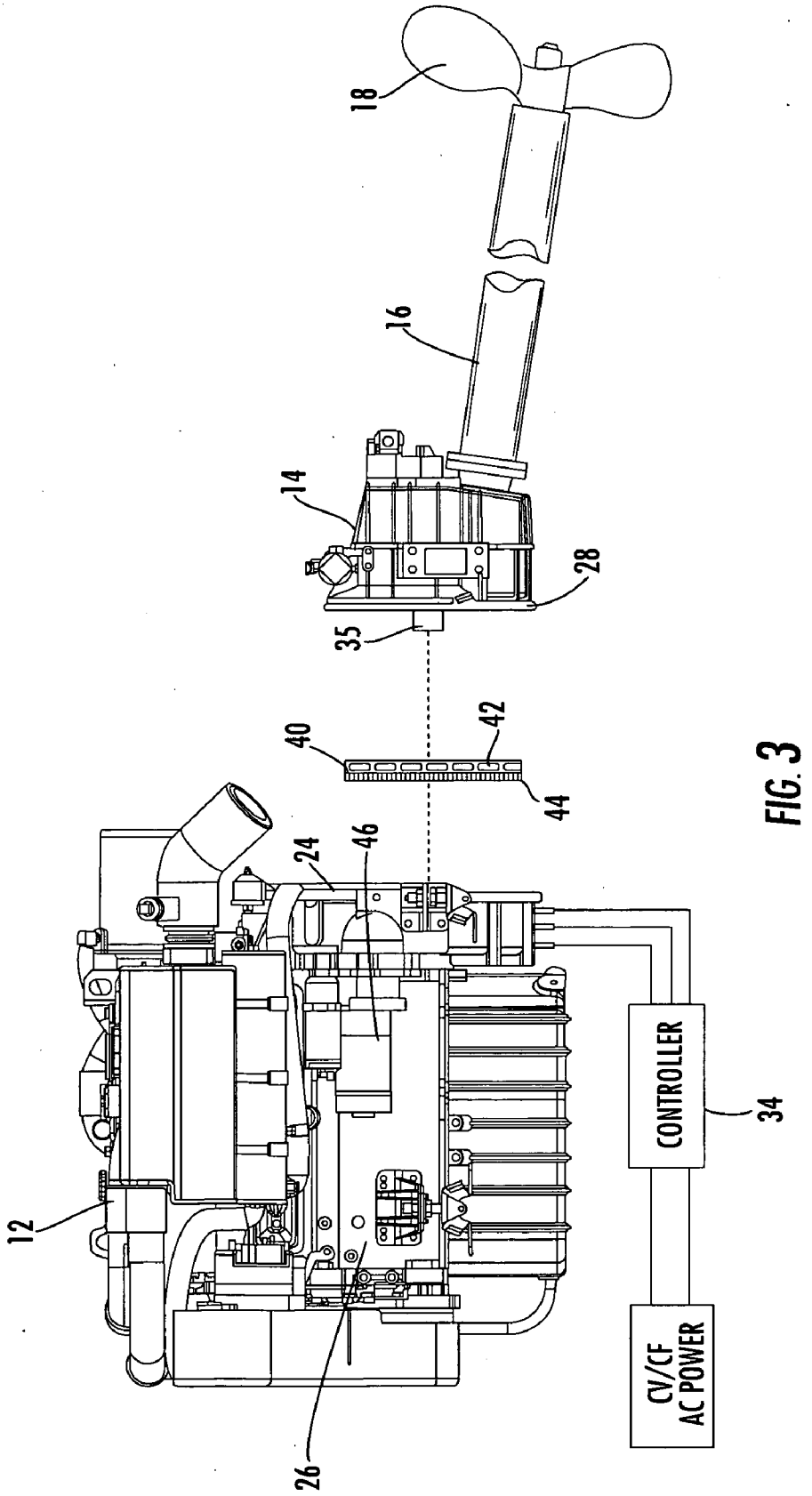

FIG. 3

DRIVE-LINE MOUNTED DIRECT COUPLED AC GENERATOR FOR MARINE WATER CRAFT

FIELD OF THE INVENTION

[0001] The field of the invention is marine generators and, more specifically, a drive-line power AC generating system that is directly coupled and delivers substantially stabilized constant voltage constant frequency from a variable speed marine engine.

BACKGROUND OF THE INVENTION

[0002] In marine applications, the operation of water craft onboard electrical AC appliances and electrical conveniences (e.g., air conditioners, cooking ranges, microwaves, electric fans, televisions, video cassette recorders, refrigerators, freezers, coffee pots, blenders, hot water heaters, flood lighting, battery-chargers, computers, etc.) required alternating current ("VAC"). While a water craft is moored, AC electric power can be supplied by a removable shore power cable connection.

[0003] When a water craft is underway, or anchored apart from shore power, use of VAC electric power is possible only be generation of such power onboard the water craft. Typically, such power is from the use of a generator set. Unfortunately, the space limitations onboard a water craft is most limited. In fact, the marine industry has long recognized that " . . . finding room for a genset can be a problem, especially in boats in the less-than-40-foot range." Motor Boating & Sailing/December 1999.

[0004] Unlike generator systems that are used on land, marine generator systems must address inherent hazards, such as disposing of hot exhaust gases, carbon monoxide issues, exposure to salt water, all of which is compounded due to the lack of space available. For optimum efficency, the internal combustion engine must typically operate at continuously high RPMs to maintain the proper voltage frequency. Thus, their operation produces an inordinate amount of noise and vibration requiring larger mufflers, sound enclosures, vibration isolators, and so on. Further, marine electrical generating systems mounted inside the boat's hull necessitates special installation requirements to permit safe operation because of the hazards in operating internal combustion engines in such an enclosed space.

[0005] Marine generator sets are heavy and, therefore, increase the weight of the boat. In many cases, the designer must accommodate for the weight of larger generators, as even a few hundred pounds can cause a problem if improperly positioned within a boat hull. Adding a generator set to the rear of a small marine water craft, such as a 35 foot boat, can result in handling problems if the weight is not balanced properly. A large portion of the weight associated with marine generator sets can be attributed to the internal combustion engines used in the generator sets, as well as the elaborate muffler, sound enclosures and cooling systems necessary for muffling the sound and cooling the internal combustion engine. In addition, the cooling and muffler systems occupy a large space, thereby diminishing the below-deck space. Thus, this type of inboard power generating system is complex, heavy, expensive to install, subject to many safety hazards while operating, and is typically limited only to larger boats which have ample space below deck for such an installation.

[0006] Another alternative for providing onboard electrical power is via the use of inverters that convert DC battery power into AC electrical power. However, several disadvantages exist in using inverters. For example, the inverters are only good as long as there is battery power; once the boat's battery(ies) are depleted, the inverters are rendered useless, along with all other electrical components requiring the battery power. In order to recharge the batteries with the small alternator provided on most marine engines, the engine must be run for an extended period of time. In addition, when inverters are used to supply power to appliances, additional batteries are required to allow sufficient amperage draw extended use without depleting the batteries. The additional batteries are expensive, heavy, and if wet cell type, hard to maintain. A single 8D battery can weight 150 lbs, quickly increasing the weight of the boat.

[0007] While auxiliary generators are the primary means for providing electrical power to water craft that is anchored or under way, the following U.S. patents provide examples of other attempts to address the problems with marine generator systems. U.S. Pat. No. 3,619,632 to Labombarde discloses an outboard Direct Current generator unit for sailboats. The outboard generator unit comprises a housing arranged to be attached to the transom of a sailboat. A propeller is mounted in a housing coupled via a drive shaft to the generator so that when the sailboat is moving through the water, the propeller is rotated, thereby rotating the generator and producing Direct Current electricity. The DC is then fed via cables back to a bank of batteries stored in the hold of the boat that is shared by the inboard propulsion engine.

[0008] U.S. Pat. No. 4,010,377 to McKenzie discloses a generator mounted on a propulsion unit of an outboard motor through an interposed adaptor. The adaptor includes various plug receptacles into which electrical plugs can be connected to provide electrical power to electrical appliances in the boat on which the unit is mounted. This generator fails to disclose a method of controlling the voltage and frequency, which are dependent upon engine speed in such an installation.

[0009] U.S. Pat. No. 6,435,925 discloses an outboard marine generator having the appearance of an outboard motor. The generator and engine is placed into a housing that appears similar to an outboard motor except there is no propellor or drive system. The device is designed to secure to the transom of a boat in a similar manner as an outboard engine.

[0010] U.S. Pat. No. 6,624,533 is a power controller employing DC bus voltage. In the preferred embodiment the DC-DC converter is adapted to transfer electrical power from a battery to supplement DC bus voltage during high loads. When the generator is off, an inverter provides AC power and in one embodiment automatically starts the engine. Still another embodiment includes a voltage sensor adapted to control engine speed as a function of the DC voltage bus.

[0011] U.S. Pat. No. 5,011,442 to Polcz et al. discloses an auxiliary power generating means for outboard motors including an alternator adapted for installation between the flywheel and the recoil starter of an outboard engine. The auxiliary power generation device includes output electrical connections for providing electrical power to electrical

appliances on the boat. However, such a device could only be used for small installations due to the side loading of such devices. The side loading required large brackets and belts, all of which is limited in practice to the production of a small KW output.

[0012] U.S. Pat. No. 3,812,379 to Kaufman et al. discloses a combination propulsion system for boats. The propulsion system is an outboard mounted unit including an engine and an electric motor and means for coupling the motor to the engine, whereby the electric motor can be reversed for use as a generator when the engine is running. In this mode of operation, the battery for the motor can be recharged.

[0013] Thus, there remains a need for an electrical generating system capable of providing an economical, safe, reliable, and quiet means of generating electricity for large and small boats. The system should provide AC electrical power of substantially stabilized constant voltage constant frequency during operation of at least one of the propulsion engines. The system should be adapted to cooperate with new as well as pre-existing boat drive-lines with minimum modification.

SUMMARY OF THE INVENTION

[0014] The instant invention provides a new and improved AC power generating system for marine water crafts. More specifically, the instant invention provides a AC power generating system that fits between the engine and marine drive system within the drive-line of the boat's propulsion system. The power generating system delivers substantially stabilized constant voltage constant frequency throughout the operational range of a marine engine.

[0015] A marine propulsion system normally comprises a Prime Mover, such as a diesel or gasoline internal combustion engine, coupled to a marine drive system or an out-drive. Out-drives are typically available in the form of an inboard-outboard drive, jet drive, surface drive, or the like. The output of the marine drive system or out-drive is operably connected to a propeller for rotation in response to operation of the engine. In such systems the engine speed varies over the operational envelope of the water craft. The instant invention positions a generator between the prime mover and the marine drive system or out-drive to deliver substantially stabilized constant voltage constant frequency power for use in powering AC devices on board the marine water craft.

[0016] In one embodiment, the generator includes a generator housing suitable for securement to the rear portion, e.g. bell housing flange, of the engine block as well as the mounting flange, e.g. bell housing, of the marine drive system or out-drive assembly. A stator and rotor are removably mounted within the generator housing around the inside perimeter thereof, and a rotor is mounted for rotation within the stator in response to rotation of the engine. A first end of the rotor is constructed and arranged for cooperation with the crankshaft of the engine, and a second end of the rotor is constructed and arranged for cooperation with the input shaft of the marine drive system or out-drive. In this manner, when the engine rotates, the rotation will be imparted to the rotor of the generator as well as the input shaft of the marine drive system or out-drive. A controller is in electrical communication with the generator to accept the variable frequency and variable voltage power produced thereby. The controller is constructed and arranged to convert the variable frequency variable voltage into substantially stabilized constant AC voltage, constant 60 Hz (or 50 Hz for Europe) frequency power for use on the water craft.

[0017] A second embodiment of the instant invention replaces the Original Equipment Manufacturer (OEM) engine flywheel with a rotor flywheel having permanent magnets inset either on the flywheel or surrounding the flywheel. In this embodiment the stator is mounted within the bell housing flange of the engine and the marine drive system or out-drive bell housing is mounted to the bell-housing flange. The variable output from the generator is supplied to the controller, as in the previously described embodiment, which produces substantially stabilized constant voltage constant frequency.

[0018] Accordingly, it is a general objective of the instant invention to provide a drive line mounted, direct drive apparatus which improves upon and overcomes the disadvantages of the prior art.

[0019] It is another objective of this invention to provide a solution to a long felt need of safely generating AC electrical power for utilization onboard a water craft (e.g., power boats, sailboats, inboard/outboard engines, inboard engines and the like).

[0020] It is another object of this invention to provide an apparatus for supplying AC electrical power to equipment onboard a water craft (e.g., power boats, sailboats, inboard/outboard engines, inboard engines, and the like) wherein the apparatus is specially designed for boats with little or no space.

[0021] It is another object of this invention to provide an apparatus for supplying AC electrical power to equipment on board a water craft (e.g., power boats, sailboats, inboard/outboard engines, inboard engines, and the like) wherein the device is mounted in-line with the marine vessel's drive-line.

[0022] It is another object of this invention to provide an apparatus for supplying AC electrical power to equipment on board a water craft (e.g., power boats, sailboats, inboard/outboard engines, inboard engines, and the like) wherein the device is mounted between the rear portion of the engine and the front portion of the marine drive system within the vessel's drive-line.

[0023] It is still another object of this invention to provide an apparatus for supplying AC electrical power to on board equipment on a water craft (e.g., power boats, sailboats, inboard/outboard engines, inboard engines, and the like) wherein the power generated is independent of the water craft's motion.

[0024] It is still another object of this invention to provide an apparatus for supplying AC electrical power to equipment on board a water craft (e.g., power boats, sailboats, inboard/outboard engines, inboard engines, and the like) which is simple to install, and which is ideally suited for original equipment and aftermarket installations.

[0025] It is still yet a further object of this invention to provide an apparatus for supplying AC electrical power to equipment on board a water craft (e.g., power boats, sailboats, inboard/outboard engines, inboard engines, and the like) that minimizes noise and vibration during operation of the apparatus.

[0026] It is still yet another object of this invention to provide an apparatus for supplying AC electrical power to on board equipment on a water craft (e.g., power boats, sailboats, inboard/outboard engines, inboard engines, and the like) that can be inexpensively manufactured and which is simple and reliable in operation.

[0027] It is still yet another object of this invention to provide an apparatus for supplying AC electrical power to equipment on board a water craft (e.g., power boats, sailboats, inboard/outboard engines, inboard engines, and the like) that minimizes fume and combustion hazards by utilizing the prime mover of the vessel's propulsion. system for electrical power generation.

[0028] It is still yet another object of this invention to provide an apparatus for supplying AC electrical power to equipment onboard a water craft (e.g., power boats, sailboats, inboard/outboard engines, inboard engines, and the like) that is light weight in comparison to conventional generator sets used onboard boats.

[0029] It is even yet a further object of this invention to provide an apparatus for supplying AC electrical power to onboard equipment on a water craft (e.g., power boats, sailboats, inboard/outboard engines, inboard engines, or sails, etc.) that may utilize water-cooling of the generator and/or controller for maximum electrical power generation.

[0030] It is even yet a further object of this invention to provide an apparatus for supplying AC electrical power to onboard equipment on a water craft (e.g., power boats, sailboats, inboard/outboard engines, inboard engines, or sails, etc.) that provides electrical power when a marine water craft is operating at a slow speed without the need of a separate generator set.

[0031] Other objectives and advantages of this invention will become apparent from the following description taken in conjunction with any accompanying drawings wherein are set forth, by way of illustration and example, certain embodiments of this invention. Any drawings contained herein constitute a part of this specification and include exemplary embodiments of the present invention and illustrate various objects and features thereof.

BRIEF DESCRIPTION OF THE FIGURES

[0032] FIG. **1** is a schematic view of one embodiment of the instant invention;

[0033] FIG. **2** is a side view illustrating one embodiment of the instant invention;

[0034] FIG. **3** is a side view illustrating one embodiment of the instant invention.

DETAILED DESCRIPTION OF THE INVENTION

[0035] Although the invention is described in terms of a preferred specific embodiment, it will be readily apparent to those skilled in this art that various modifications, rearrangements and substitutions can be made without departing from the spirit of the invention. The scope of the invention is defined by the claims appended hereto.

[0036] Referring to FIG. **1** and **2**, a preferred, albeit non-limiting embodiment is illustrated. Set forth is a propulsion system for a marine water craft at **10**. The propulsion system comprises a conventional variable speed internal combustion engine **12**, a marine drive system **14** which is commonly referred to as a transmission, a reversible driven propeller shaft **16** and a fixed pitch propeller **18**. Positioned and operably coupled between the engine and the marine drive system, such as a transmission or out-drive, is a generator **20**. In one embodiment, the generator includes a generator housing **22** suitable for securement to the rear portion, e.g. bell housing flange **24**, of the engine block **26** as well as the mounting flange, e.g. bell housing **28**, of the marine drive system assembly. A stator (not shown) is removably mounted within the generator housing **22** around the inside perimeter thereof and a rotor (not shown) is mounted for rotation within the stator in response to rotation of the engine. A first end **30** of the rotor is constructed and arranged for cooperation with the crankshaft (not shown) of the engine **12** and a second end **32** of the rotor is constructed and arranged for cooperation with the input shaft of the marine drive system. In this manner, when the engine rotates the rotation will be imparted to the rotor of the generator as well as the input shaft **35** of the marine drive system **14**. It should be noted that the generator can also be sized and weighted to operate as a flywheel thereby replacing the conventional flywheel. A controller **34** is in electrical communication with the generator to accept the variable frequency and variable voltage power produced thereby. The controller includes a rectifier **36** for converting the three phase variable frequency and variable voltage produced by the generator and converting it to direct current (DC) power. The DC power is supplied to an invertor **38** which converts the DC power to single or three phase AC constant voltage constant frequency power for use on the water craft. The generator housing may be sealed and further include a water inlet **37** in communication with a water cooling jacket (not shown) constructed and arranged to cool the stator and a water outlet **39**. The water inlet and outlet may be connected to the engine cooling system or alternatively may be connected to an independent cooling system suitable to provide a sufficient amount of water to control the operating temperature of the generator. Alternatively, a frequency converter or an AC to AC converter can be employed.

[0037] It should be noted that in the system described above, other types of marine drive systems may be termed a transmission without departing from the scope of the invention Such drive systems may include, but should not be limited to out-drives in the form of inboard-outboard drives, jet drives, surface drives, V-drives and the like.

[0038] Referring to FIG. **3** an alternative embodiment is illustrated. In this embodiment the OEM flywheel is removed from the engine **12** and replaced with a rotor flywheel **40** having permanent magnets **42** inset therein. The rotor flywheel also includes a starter ring **44** for cooperation with a starter **46**. A stator (not shown) is removably mounted within the bell housing flange **24** of the engine **12** to surround the perimeter of the rotor flywheel **40**. A controller **34** is in electrical communication with the generator to accept the variable frequency and variable voltage power produced thereby. The controller includes a rectifier **36** for converting the variable frequency and variable voltage power from the generator and converting it to direct current DC power. The DC power is supplied to an invertor **38** which converts the DC power to single phase AC constant voltage constant frequency power for use on the water craft.

[0039] Alternatively, the controller adjusts variable AC voltage and frequency from a variable speed motor to a substantially stabilized constant AC voltage constant frequency power.

[0040] One of the major advantages of the instant invention is the space saved below deck of the water craft. The only additional space below deck that is required is the length of the generator. Since it is positioned between the engine and the marine drive system, this space could easily be obtained by shortening the propeller shaft. Another advantage occurs when the marine water craft is operated at slow speeds, such as in "No Wake" zones or areas. Normally appliances that require high amounts of power, such as refrigerators and air conditioners, are operated during these periods. Rather than utilizing an auxiliary generator set and encountering the problems of operating another engine, the main propulsion engine is used to operate the generator. A further advantage is that the weight of an auxiliary engine need not be added to the water craft, therefore the existing balanced distribution of weight may be maintained.

[0041] This invention is especially beneficial on sailboats. Most sailboats have a small engine to propel the boat when not under sail; for example, when the sailboat is in a harbor or in close proximity to a dock. Also, the limited below deck space on sailboats is extremely valuable. Providing a generator set on a sailboat consumes valuable space and may require an additional supply of fuel. The instant invention overcomes these problems by locating the generator between the propulsion engine and the marine drive system. The only additional space required would be that equal to the length of the generator. This again could be obtained by shortening the propeller shaft. Also, the additional weight of an auxiliary engine is not added to the sailboat which may upset the proper distribution of weight.

[0042] It is to be understood that while a certain form of the invention is illustrated, it is not to be limited to the specific form or arrangement herein described and shown. It will be apparent to those skilled in the art that various changes may be made without departing from the scope of the invention and the invention is not to be considered limited to what is shown and described in the specification and any drawings/figures included herein.

[0043] One skilled in the art will readily appreciate that the present invention is well adapted to carry out the objectives and obtain the ends and advantages mentioned, as well as those inherent therein. The embodiments, methods, procedures and techniques described herein are presently representative of the preferred embodiments, are intended to be exemplary and are not intended as limitations on the scope. Changes therein and other uses will occur to those skilled in the art which are encompassed within the spirit of the invention and are defined by the scope of the appended claims. Although the invention has been described in connection with specific preferred embodiments, it should be understood that the invention as claimed should not be unduly limited to such specific embodiments. Indeed, various modifications of the described modes for carrying out the invention which are obvious to those skilled in the art are intended to be within the scope of the following claims.

What is claimed is:

1. A direct coupled electrical generator for drive-line installation on a marine water craft comprising:

a variable speed internal combustion engine providing rotational output;

a generator having a first and second side surface, said first side surface coupled to said engine wherein said rotational output of said engine produces an electrical output;

means for correcting said electrical output to a substantially stabilized constant AC voltage having a constant frequency;

a marine drive system connected to said second side surface of said generator wherein said rotational output of said engine supplies rotary motion to said marine drive system during operation thereof;

a propeller shaft having a proximal end coupled to said marine drive system and a distal end coupled to at least one propeller;

whereby said variable speed internal combustion engine drives said propeller through said marine drive system and said generator, said generator generating an electrical output of variable voltage variable frequency and said means for correcting placing said electrical output into a substantially constant AC voltage constant frequency.

2. The electrical generator of claim 1 wherein said generator is sealed.

3. The electrical generator of claim 2 wherein said generator is water cooled.

4. The electrical generator of claim 1 wherein said means for correcting is further defined as an externally positioned controller for converting said variable voltage variable frequency electrical power to substantially stabilized constant AC voltage having a substantially constant frequency.

5. The electrical generator of claim 4 wherein said controller is water cooled.

6. The electrical generator of claim 4 wherein said means for correcting adjusts AC voltage to a substantially stabilized constant AC voltage constant frequency power for use onboard said water craft.

7. The electrical generator of claim 4 wherein said means for correcting is an AC to AC converter that adjusts AC voltage to a substantially stabilized constant AC voltage constant frequency power for use onboard said water craft.

8. The electrical generator of claim 4 wherein said means for correcting includes a rectifier and an inverter, wherein said rectifier converts said variable voltage variable frequency electrical power to DC, wherein said inverter converts said direct current into substantially stabilized constant AC voltage constant frequency power for use onboard said water craft.

9. The electrical generator of claim 1 wherein said generator includes a stator and a rotor.

10. The electrical generator of claim 1 wherein said generator operates as a flywheel.

11. A direct coupled electrical generator for drive-line installation on a marine water craft comprising:

a variable speed internal combustion engine having rotational output;

a generator connected to the rotatable output of said internal combustion engine;

an out-drive connected to said generator such that said variable speed internal combustion engine supplies rotary motion to said generator and said out-drive during operation thereof;

a propulsion means coupled to said out-drive;

whereby said variable speed internal combustion engine drives said generator at a variable speed which in turn generates electrical power of variable voltage and variable frequency.

12. The electrical generator of claim 11 including a controller for converting said variable voltage variable frequency electrical power to substantially stabilized constant voltage constant frequency power.

13. The electrical generator of claim 12 wherein said means for correcting adjusts AC voltage to a substantially stabilized constant AC voltage constant frequency power for use onboard said water craft.

14. The electrical generator of claim 12 wherein said controller includes a rectifier and an inverter, wherein said rectifier converts said variable voltage variable frequency electrical power to direct current, wherein said inverter converts said direct current into substantially stabilized constant voltage constant frequency power for use onboard said water craft.

15. The electrical generator of claim 11 wherein said out-drive is coupled to a propulsion system selected from the group consisting of inboard drive, inboard-outboard drive, jet drive, and surface drive.

16. The electrical generator of claim 11 wherein said generator is sealed.

17. The electrical generator of claim 11 wherein said generator includes a stator and a rotor.

18. The electrical generator of claim 11 wherein said generator operates as a flywheel.

19. The electrical generator of claim 12 wherein said generator is water cooled.

20. The electrical generator of claim 11 wherein said controller is water cooled.

21. In a drive train of a water craft including at least one variable speed internal combustion engine in mechanical communication with at least one power transmission device which is further in mechanical communication with at least one impeller means constructed and arranged to provide motive thrust, the improvement comprising:

at least one generator for generating electricity, wherein said generator is constructed and arranged for direct coupling between said internal combustion engine and said power transmission device;

means for conditioning electrical power produced by said generator to a substantially stabilized constant voltage constant frequency electrical power.

22. The electrical generator of claim 21 wherein said generator is sealed.

23. The electrical generator of claim 21 wherein said generator is water cooled.

24. The electrical generator of claim 21 including a controller for converting said variable voltage variable frequency electrical power to substantially stabilized constant AC voltage having a substantially constant frequency.

25. The electrical generator of claim 21 wherein said controller is water cooled.

26. The electrical generator of claim 21 wherein said means for correcting includes a rectifier and an inverter, wherein said rectifier converts said variable voltage variable frequency electrical power to DC, wherein said inverter converts said direct current into substantially stabilized constant AC voltage constant frequency power for use onboard said water craft.

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