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(54) **WAVE ENERGY CONVERTOR USING OSCILLATING PENDULUMS**

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F03B 13/12 (2006.01)
F03B 13/20 (2006.01)

(52) **U.S. Cl.**
CPC . ***F03B 13/20*** (2013.01); *Y02E 10/38* (2013.01)

(58) **Field of Classification Search**
CPC F03B 13/20; Y02E 10/38
USPC 290/42, 43, 53
See application file for complete search history.

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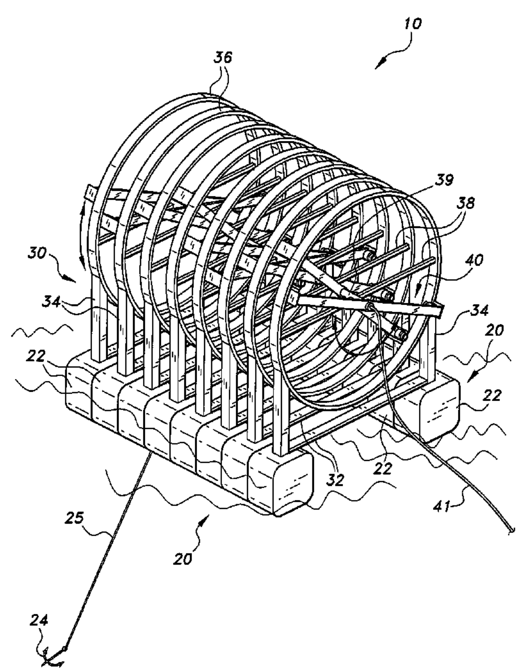
(57) **ABSTRACT**

The wave energy convertor using oscillating pendulums includes a buoyant base, a support frame mounted to the buoyant base, and a power generating assembly coupled to the support frame. A plurality of annular rails is disposed on the support frame and a reinforcement member extends diametrically across each annular rail. The power generating assembly includes a plurality of pendulum arms rotatably mounted on a central axle extending coaxially through the reinforcement members. One or more dynamos are mounted to support plates on opposite ends of the pendulum arms, and rotors extend from the dynamos to ride on the inner surface of the annular rails. Undulation of the buoyant base riding the waves of a body of water causes the pendulum arms to oscillate. Rotation of the rotors generates current, which is collected by a current collection assembly and transmitted to an onshore facility for distribution.

15 Claims, 5 Drawing Sheets



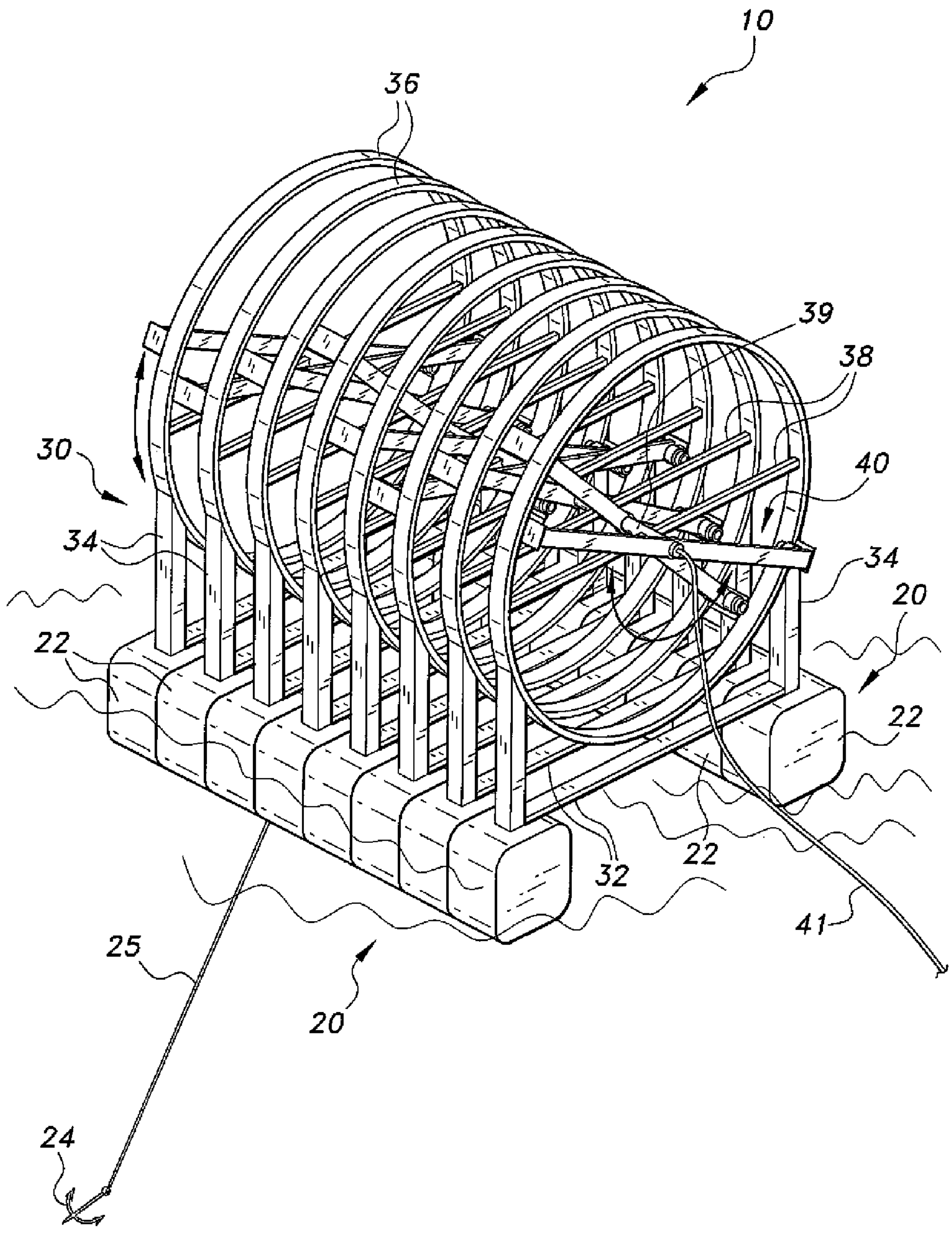


Fig. 1A

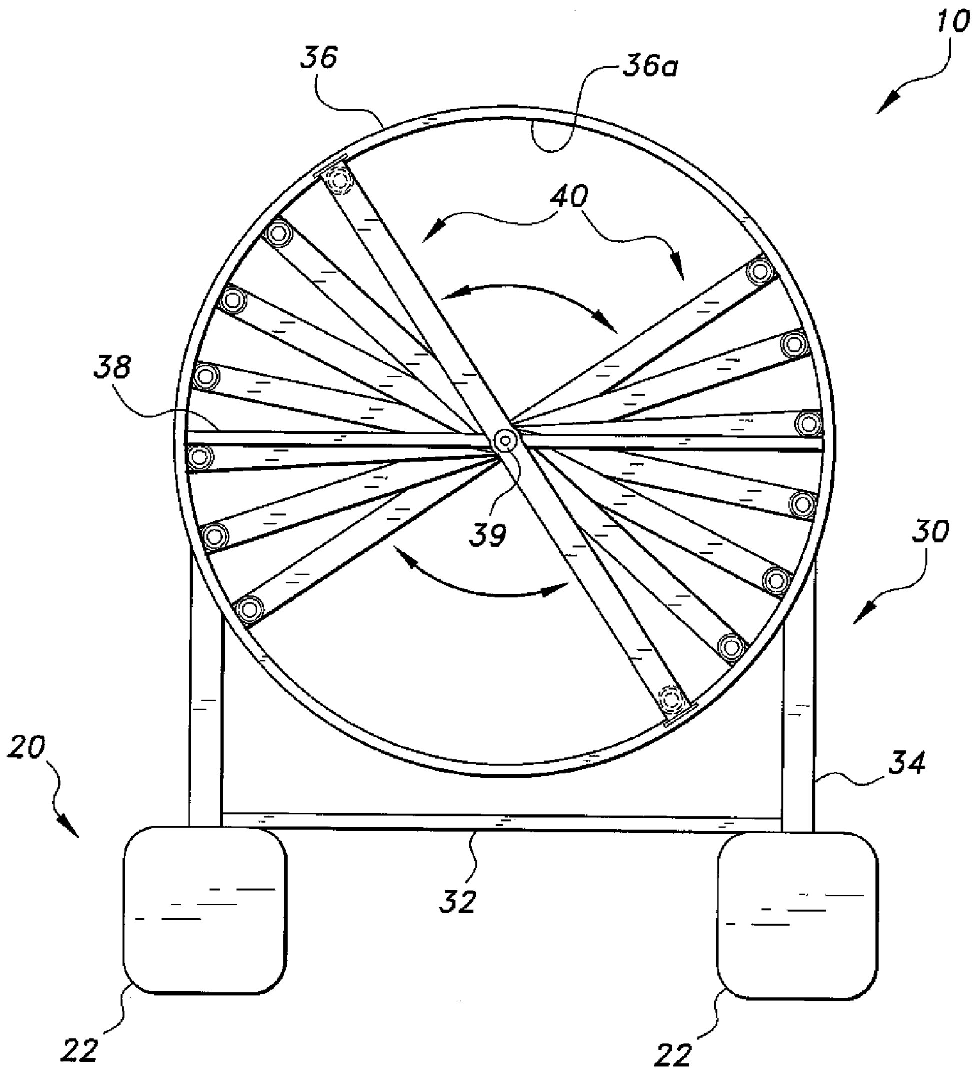
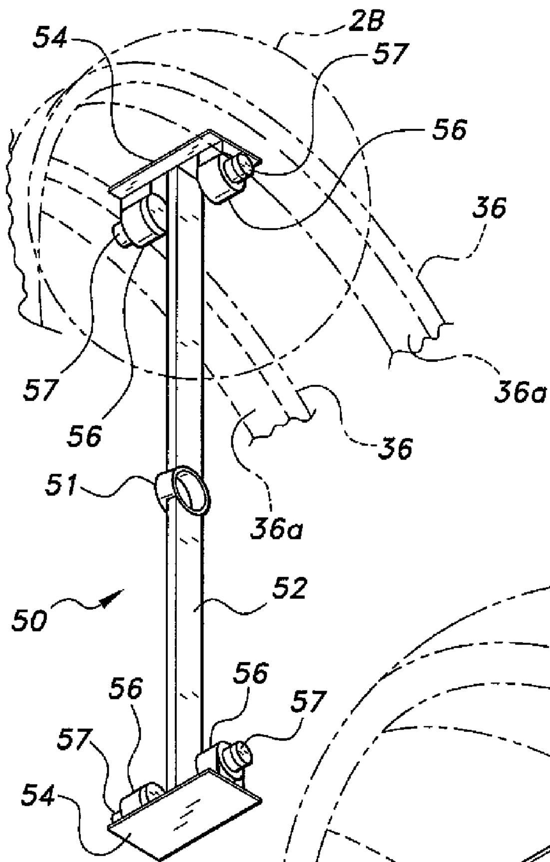


Fig. 1B


2B
54
57
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36
36a
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36a
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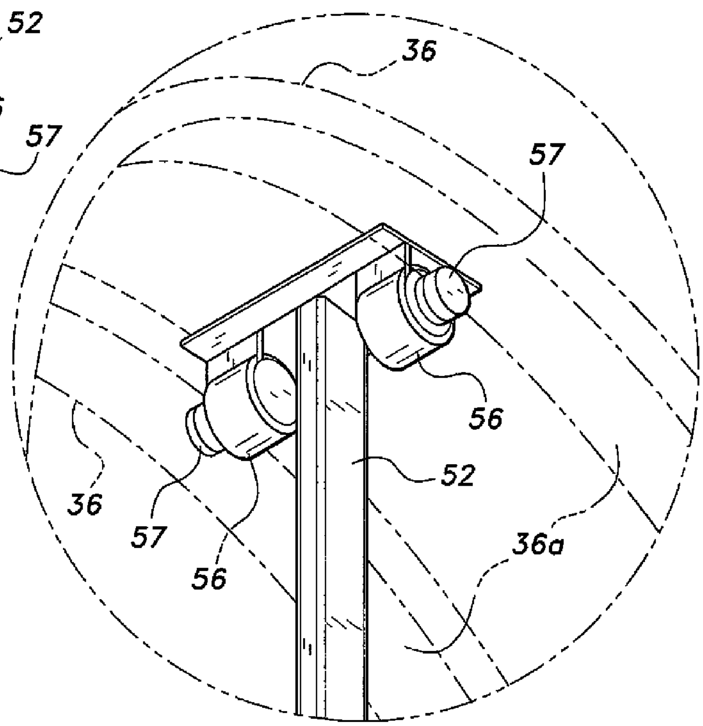
Fig. 2A


36
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56
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36
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56
36a

Fig. 2B

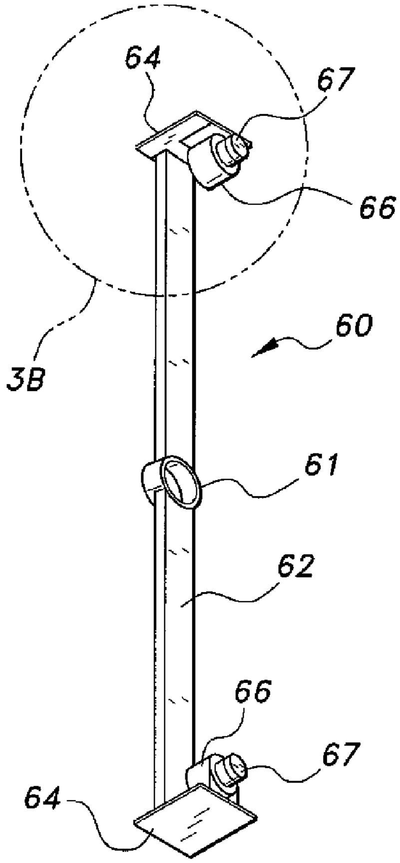

Fig. 3A

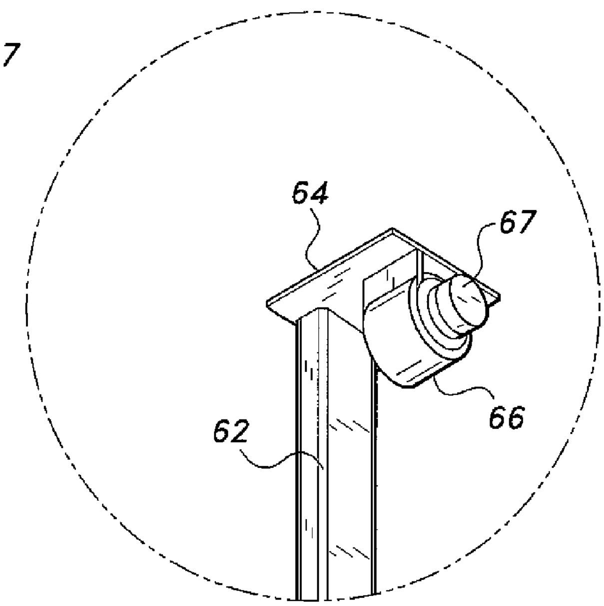

Fig. 3B

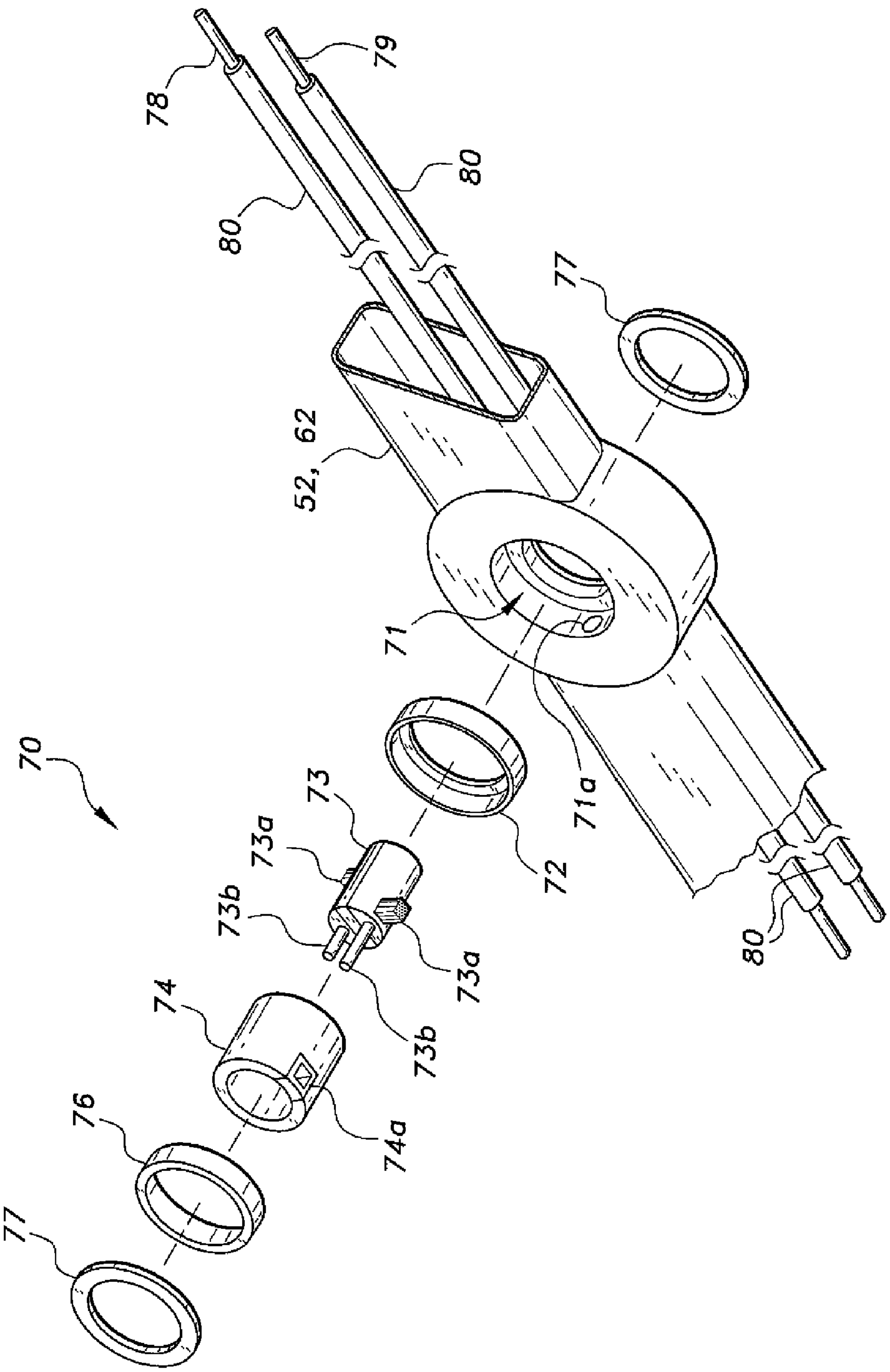

Fig. 4

WAVE ENERGY CONVERTOR USING OSCILLATING PENDULUMS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to power generators, and particularly to a wave energy convertor using oscillating pendulums that is relatively simple in structure and produces power in an economical manner.

2. Description of the Related Art

Wave energy, or water-wave energy, is one of several alternative sources of energy being pursued as a viable alternative resource for conversion into useful power, such as electricity. The demand for power is relatively high, and due to dwindling resources, such as coal and fossil fuel, economic costs are also on the rise, impacting both the producers and the consumers. Conventional power plants utilizing such fuels as coal, fossil fuel, and even uranium for nuclear power plants, produce wastes that are harmful to the environment. These factors contribute to a persistent demanding need for alternative renewable energy.

Despite existing advances, there is still a need for a power generator harnessing the motion of the waves that is relatively simple and compact in construction and economical in manufacture, maintenance, and production. Thus, a wave energy convertor using oscillating pendulums solving the aforementioned problems is desired.

SUMMARY OF THE INVENTION

The wave energy convertor using oscillating pendulums includes a buoyant base, a support frame mounted to the buoyant base, and a power generating assembly coupled to the support frame. A plurality of annular rails is disposed on the support frame, and a reinforcement member extends diametrically across each annular rail. The power generating assembly includes a plurality of pendulum arms rotatably mounted to a central axle extending coaxially through the reinforcement members. One or more dynamos are mounted to support plates on opposite ends of the pendulum arms, and rotors extend from the dynamos to ride on the inner surface of the annular rails. Undulation of the buoyant base riding the waves of a body of water causes the pendulum arms to oscillate. Rotation of the rotors generates current, which is collected by a current collection assembly and transmitted to an onshore facility for distribution.

These and other features of the present invention will become readily apparent upon further review of the following specification and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is an environmental, perspective view of a wave energy convertor using oscillating pendulums according to the present invention.

FIG. **1**B is an end view of the wave energy convertor of FIG. **1**A.

FIG. **2**A is a perspective view of a first pendulum assembly in the wave energy convertor of FIG. **1**A, shown with annular rails in phantom for clarity, the pendulum arm having quad dynamos mounted thereon.

FIG. **2**B is a detailed perspective view showing two dynamos mounted to one end of the pendulum arm of FIG. **2**A, the opposite end of the pendulum arm also having two dynamos mounted thereon.

FIG. **3**A is a perspective view of a second pendulum assembly in the wave energy convertor of FIG. **1**A, the second pendulum assembly having dual dynamos mounted thereon.

FIG. **3**B is a detailed perspective view showing a single two dynamo mounted to one end of the pendulum arm of FIG. **2**A, the opposite end of the pendulum arm also having a single dynamo mounted thereon.

FIG. **4** is an exploded perspective view of the current collector assembly in the first and second pendulum assemblies of FIGS. **2**A and **3**A.

Similar reference characters denote corresponding features consistently throughout the attached drawings.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The wave energy convertor using oscillating pendulums, generally referred to by the reference number **10** in the drawings, provides a relatively simple and compact, floating power generating plant that can be easily installed offshore and maintained with minimal costs. As best seen in FIGS. **1**A and **1**B, the wave energy convertor **10** includes a buoyant base **20**, a support frame **30** mounted on top of the buoyant base **20**, and a power generator assembly **40** coupled to the support frame **30**.

The buoyant base **20** includes at least one pair of spaced floats **22** for each power generating unit of the power generating assembly **40**. The floats **22** may be arranged in two parallel rows, as shown in FIG. **1**A, each row forming an elongate aggregate float or pontoon. The plurality of separate floats **22** in each row can be connected in series by conventional means, such as fasteners, welds, hinges, latches, ropes, etc. The floats **22** provide a platform for the support frame **30** and the power generator assembly **40** mentioned above. The buoyant base **20** permits the wave energy convertor **10** to float on a body of water, such as the sea, and to passively ride the waves, which causes the buoyant base **20** to rock or undulate on the water. This rocking motion provides the motive force needed by the power generator assembly **40** to facilitate power production.

Each float **22** can be constructed from buoyant materials, such as foam, plastic, wood, and the like, as is known in the art. Each float **22** can be provided as a substantially solid structure or a hollow structure. The substantially solid-type structure can be suitable for most use scenarios where the floating stability of the wave energy convertor **10** is not a substantial concern. In the case of the substantially hollow structure, the floats **22** can be selectively and partially filled with filler material, such as water, sand, and the like, to function as ballast. When so constructed, the floats **22** will be partially submerged in the water, more so than without the added weight of the filler material, to increase the floating stability of the wave energy convertor **10** on the water. The float **22** or pontoon can also be provided as a single, integral elongate body to support multiple arms of the support frame **30**, if desired. During use, the buoyant base **20** is substantially fixed at a predetermined or designated relative position on the body of water by an anchor **24** connected to a cable **25** attached to one of the floats **22**, or to any other part of the buoyant base **20**. The cable **25** can be constructed from chains, sturdy rope, or similar material.

The buoyant base **20** supports the support frame **30** mounted on top of the buoyant base **20**. The support frame **30** includes a cross beam, bar, or member **32** connecting each pair of spaced floats **22** per power generating unit. An upright support beam, bar, or member **34** extends upward from each float **22**. In each power generating unit, the cross member **32** and the pair of upright support members **34** extending from the pair of floating bodies **22** provide a stable frame for supporting an annular rail **36**. Each annular rail **36** is preferably reinforced by a reinforcement beam, bar, or member **38**. The reinforcement member **38** spans the diameter of the annular rail **36** and assists in maintaining the general circular shape of the annular rail **36** by substantially preventing warping of the annular rail **36**.

The cross members **32** and the upright support members **34** can be provided as substantially square or rectangular beams, as shown in FIGS. **1**A and **1**B, and they are preferably constructed from sturdy, durable, corrosion-resistant materials that can withstand the elements and the effects of the sea environment. Some examples of corrosion-resistant materials include, but are not limited to, carbon-fiber reinforced plastic, stainless steel, fiberglass, composites, combinations thereof, and the like. The cross members **32** and the upright support members **34** can be provided in any shape, so long as they can provide the required support and corrosion resistance. The cross member **32** is preferably smaller in length than the diameter of the annular rail **36**, and the length of the upright support member **34** is preferably longer than the radius of the annular rail **36**. This arrangement results in a stable frame for the respective annular rail **36**, supporting the same from the bottom thereof so that the respective annular rail **36** is elevated from the corresponding cross member **32**.

The annular rail **36** is preferably constructed as a relatively flat, wide circular band made from similar materials as the cross members **32** and upright support members **34**. The outer surface of the annular rail **36** can be provided in any shape or form. However, at least a major portion of the inner surface **36***a* of the annular rail **36** is flat so that a follower for the power generator assembly **40** can ride along the rail, as further described herein.

The support frame **30** also includes a central shaft or axle **39** mounted coaxially through the plurality of annular rails **36**. A through hole on each reinforcement member **38** rigidly supports the central axle **39** at the center or axis of each annular rail **36**. Wires, which will be further described, run through the central axle **39** to transmit generated current from the power generator assembly **40** to an output transmission line **41**. The output transmission line **41** extends from one end of the central axle **39**, and can be connected to a plurality of other output transmission lines **41** from other wave energy converters **10** within the vicinity. The output transmission line **41** transmits the generated current to a power collection facility onshore for ultimate distribution onto an existing power grid.

The power generator assembly **40** includes a plurality of pendulum assemblies rotatably mounted on the central axle **39**. The pendulum assemblies are freely rotatable on the central axle **39** at spaced intervals along the length of the central axle **39**, and each power generating unit of the wave energy convertor **10** can include one or more of the pendulum assemblies.

As best seen in FIGS. **2**A and **2**B, one of the pendulum assemblies is a first or intermediate pendulum assembly **50**. Each first pendulum assembly **50** includes an elongate pendulum arm **52** having an annular mounting boss **51** or hub formed or disposed at a center of the elongate pendulum arm **52**, the mounting boss **51** facilitating freely rotatable mounting of the pendulum arm **52** about the central axle **39**. A support plate **54** is disposed at opposite ends of the pendulum arm **52**. Each support plate **54** preferably carries a pair of dynamos **56**. Each dynamo **56** includes a rotor or follower **57**, the rotors extending in opposite directions with respect to each other. Each rotor **57** frictionally engages the inner surface **36***a* of its adjacent annular rail **36**, as can be seen in FIGS. **2**A and **2**B. Thus, the first pendulum assembly **50** can be referred to as an intermediate pendulum assembly due to the first pendulum assembly **50** being operationally disposed between adjacent annular rails **36**. The first pendulum assembly **50** can also be referred to as a "quad-dynamo pendulum" since the pendulum arm **52** carries four dynamos **56**. Due to the above arrangement of the dynamos **56**, the annular rail **36** is preferably wide enough to accommodate the rotors **57** and the reinforcement member **38** without potentially interfering with each other during travel of the rotors **57**.

In use, as the wave energy convertor **10** undulates on the water by the motion of the waves, the pendulum arm **52** reacts by oscillating about the central axle **39**. This causes the rotors **57** to rotate and roll along the respective inner surfaces **36***a* in an are. The rotation of the rotors **57** generates electrical current, which is transmitted to a current collection assembly **70** coupled to the mounting boss **51**. Each mounting boss **51** includes a watertight or waterproof frictionless bearing **71**, such as a thrust bearing, to facilitate free rotatable movement of the pendulum arm **52**. The dynamos **56** are preferably disposed on opposite ends of the pendulum arm **52** so that the pendulum arm **52** is balanced by acting as counterweights for each other. The balanced pendulum arm **52** and the frictionless bearing **71** allows the pendulum arm **52** to readily oscillate, even with minimal water wave activity, thereby facilitating relatively constant current generation.

As best seen in FIGS. **3**A and **3**B, another one of the pendulum assemblies is a second or end pendulum assembly **60**. Each second pendulum assembly **60** includes an elongate pendulum arm **62** having an annular mounting boss **61** or hub formed or disposed at a center of the elongate pendulum arm **62**, the mounting boss **61** facilitating freely rotatable mounting of the pendulum arm **62** about the central axle **39**. A support plate **64** is disposed at opposite ends of the pendulum arm **62**. Each support plate **64** preferably carries a single dynamo **66**. Each dynamo **66** includes a rotor or follower **67** facing in the same direction as the other. Each rotor **67** frictionally engages the inner surface **36***a* of an adjacent annular rail **36**. Unlike the first pendulum assembly **50**, the second pendulum assembly **60** is configured to be disposed at the ends of the water energy convertor **10**. Thus, the second pendulum assembly **60** can be referred to as an end pendulum assembly due to the second pendulum assembly **60** being operationally disposed adjacent to one of the rails **36** at opposite ends of the water energy convertor. The second pendulum assembly **60** can also be referred to as a "duo-dynamo pendulum" since the pendulum arm **62** carries two dynamos **66**. In all other respects, the second pendulum assembly **60** functions substantially the same as the first pendulum assembly **50** in that the rotation of the rotors **67** on the dynamos **66** as the rotors **67** roll along the inner surface **36***a* of the corresponding annular rail **36** generates electrical current that collects at the current collection assembly **70** for post transmission.

Referring to FIG. **4**, each pendulum arm **52**, **62** includes the current collection assembly **70** mounted inside the frictionless bearing **71**. The current collection assembly **70** includes current collector member or commutator **73** mounted inside a hollow cylindrical sleeve **74**. At least one pair of brushes **73***a* extend radially from the outer surface of the commutator **73**, and each brush **73***a* extends through respective brush insulation frames **74***a* on the cylindrical sleeve **74**. The brushes **73***a* are preferably disposed at different spaced locations on the surface of the commutator **73**. When assembled, the cylindrical shaft **74** extends through the opening of the frictionless bearing **71** with a brush **73***a* on either side of the opening.

Conductor wires, such as the positive conductor wire **78** and negative conductor wire **79**, transmit the generated current from the dynamos **56**, **66** to respective contacts **71***a* inside the mounting bosses **51**, **61**. Both the positive conductor wire **78** and the negative conductor wire **79** are preferably covered by an insulated sleeve **80**. Each mounting boss **51**, **61** includes another contact **71***a* diametrically opposite on the other side of the frictionless bearing **71**. A copper sleeve **72** is mounted to one side of the opening of the frictionless bearing **71**, and a copper conductor sleeve **76** is mounted to the other side such that opposite ends of the commutator **73** are respectively enclosed by the copper sleeve **72** and copper conductor sleeve **76**. The copper sleeve **72** and the copper conductor sleeve **76** are in contact or communication with the respective contacts **71***a* to permit current to flow therein. When assembled, the brushes **73***a* extend out of the respective insulation frames **74***a* a certain distance to contact the copper sleeve **72** and the copper conductor sleeve **76**, respectively.

By this construction, conductive contact between the current collection assembly **70** and the contacts **71***a* is maintained throughout the oscillating motion of the pendulum arms **52**, **62**. The current transmitted to the commutator **73** from the dynamos **56**, **66** is transmitted to the output line **41** via the transmission cables **73***b* extending from one end of the commutator **73**. An insulation ring **77** caps opposite ends of the collection assembly **70** to seal the same onto the mounting boss **51**, **61**.

Thus, the wave energy convertor **10** provides a relative compact floating power plant capable of generating electrical power with minimal expense and effort in operating the dynamos **56**, **66**. Compared to conventional hydropower systems, the wave energy convertor **10** occupies much less space and costs less to manufacture and maintain.

It is to be understood that the present invention is not limited to the embodiments described above, but encompasses any and all embodiments within the scope of the following claims.

We claim:

1. A wave energy convertor using oscillating pendulums, comprising:
- a buoyant base adapted to float on a body of water and ride on waves;
- a support frame mounted to the buoyant base, the support frame having:
  - at least one annular rail, the at least one annular rail having an inner surface;
  - a reinforcement member extending diametrically across the at least one annular rail; and
  - a central axle extending concentrically through the at least one annular rail, the central axle being rigidly mounted on and extending through the reinforcement member; and
- a power generating assembly coupled to the support frame, the power generating assembly having:
  - at least one pendulum assembly rotatably mounted on the central axle; and
  - at least one dynamo mounted on the at least one pendulum assembly, the dynamo having a rotor extending therefrom, the rotor frictionally engaging the inner surface of the at least one annular rail to roll thereon and generate current;
- wherein undulating motion of the buoyant base from passing water waves causes the at least one pendulum assembly to oscillate, whereby the rotor rolls along the inner surface of the at least one annular rail to generate current for subsequent collection and distribution.

2. The wave energy convertor according to claim **1**, further comprising an output line extending from the central axle, the output line being adapted for transmitting current collected from the at least one dynamo to an onshore facility for subsequent distribution.

3. The wave energy convertor according to claim **1**, wherein said buoyant base comprises at least one pair of spaced floats.

4. The wave energy convertor according to claim **3**, wherein said at least one pair of spaced floating bodies comprises a plurality of pairs of spaced floating bodies coupled together to form a pair of elongate pontoons.

5. The wave energy convertor according to claim **3**, wherein said support frame comprises:
- a cross member spanning between said at least one pair of spaced floats; and
- an upright support member extending upward from atop of each of the floats, respectively, a pair of the upright support members supporting said at least one annular rail thereon at an elevated position above the corresponding cross member.

6. The wave energy convertor according to claim **5**, wherein said cross member has a length smaller than the diameter of said at least one annular rail, and wherein said upright support member has a length greater than the radius of said at least one annular rail.

7. The wave energy convertor according to claim **1**, further comprising an output line extending from the central axle, said at least one pendulum assembly including:
- a plurality of pendulum assemblies including a pair of end pendulum assemblies disposed at opposite ends of said central axle and at least one intermediate pendulum assembly mounted on said central axle between the end pendulum assemblies; and
- a current collection assembly coupled to the at least one intermediate pendulum assembly to collect and transmit generated current to the output line.

8. The wave energy convertor according to claim **7**, wherein said at least one intermediate pendulum assembly comprises:
- an elongate pendulum arm having a center and an annular mounting boss formed at the center of the elongate pendulum arm;
- a bearing disposed in the mounting boss, the bearing being mounted on said central axle to facilitate free rotation of the pendulum arm, the current collection assembly being coupled to the bearing; and
- a support plate disposed at opposite ends of the pendulum arm, the at least one dynamo comprising a pair of dynamos mounted on each of the support plates, the rotors of the dynamos in each pair of the dynamos extending in opposite directions.

9. The wave energy convertor according to claim **8**, wherein said current collection assembly comprises:
- at least one pair of electrical contacts inside said bearing, each of the contacts being disposed at different positions;
- conductor wires extending from said dynamos towards a respective one of the electrical contacts to facilitate transmission of the generated current;
- a hollow cylindrical sleeve extending through said bearing, the cylindrical sleeve having at least one pair of insulation frames thereon;
- a commutator mounted inside the cylindrical sleeve, the commutator having at least one pair of brushes radially extending from an outer surface of the commutator and at least one pair of transmission cables extending from

one end of the commutator, each of the brushes extending partially through a respective one of the insulation frames;

a copper sleeve enclosing one end of the commutator, the copper sleeve intermittently contacting one of the electrical contacts and one of the brushes;

a copper conductor sleeve enclosing the opposite end of the commutator, the copper conductor sleeve intermittently contacting the other of the electrical contacts and the other of the brushes; and

an insulation ring capping opposite ends of the collection assembly to seal the collection assembly onto the mounting boss;

wherein the brushes collect and transmit the generated current, via contact with the copper sleeve and the copper conductor sleeve, through the transmission cables towards said output line when the pendulum arm oscillates.

10. The wave energy convertor according to claim **7**, wherein each said end pendulum assembly has a current collection assembly coupled thereto to collect and transmit the generated current to said output line.

11. The wave energy convertor according to claim **10**, wherein each said end pendulum assembly comprises:

an elongate pendulum arm having a center and an annular mounting boss formed at the center of the elongate pendulum arm;

a bearing disposed in the mounting boss, the bearing being mounted on said central axle to facilitate free rotation of the pendulum arm, the current collection assembly being coupled to the bearing; and

a support plate disposed at opposite ends of the pendulum arm, said at least one dynamo comprising a single dynamo mounted on each of the support plates, the rotors of the dynamos extending parallel to each other.

12. The wave energy convertor according to claim **11**, wherein said current collection assembly comprises:

at least one pair of electrical contacts inside said bearing, each of the contacts being disposed at different positions;

conductor wires extending from said dynamos towards a respective one of the electrical contacts to facilitate transmission of the generated current;

a hollow cylindrical sleeve extending through said bearing, the cylindrical sleeve having at least one pair of insulation frames thereon;

a commutator mounted inside the cylindrical sleeve, the commutator having at least to one pair of brushes radially extending from an outer surface of the commutator and at least one pair of transmission cables extending from one end of the commutator, each of the brushes extending partially through a respective one of the insulation frames;

a copper sleeve enclosing one end of the commutator, the copper sleeve intermittently contacting one of the electrical contacts and one of the brushes;

a copper conductor sleeve enclosing the opposite end of the commutator, the copper conductor sleeve intermittently contacting the other of the electrical contacts and the other of the brushes; and

an insulation ring capping opposite ends of the collection assembly to seal the collection assembly onto the mounting boss;

wherein the brushes collect and transmit the generated current, via contact with the copper sleeve and the copper conductor sleeve, through the transmission cables towards said output line when the pendulum arm oscillates.

13. The wave energy convertor according to claim **1**, wherein said support frame is constructed from durable, corrosion-resistant material.

14. The wave energy convertor according to claim **13**, wherein said durable corrosion-resistant material comprises at least one material selected from the group consisting of carbon-fiber reinforced plastic, stainless steel, fiberglass, and composites.

15. The wave energy convertor according to claim **1**, further comprising an anchor cable and anchor assembly coupled to the buoyant base to selectively maintain relative position of the wave energy convertor at a select location on the body of water.

* * * * *