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Random Energy Generator

S85530

Field of the Invention

- 5 The present invention relates to an energy generator for generating electrical energy, heat energy or a combination thereof from mechanical energy, such as a renewable energy resource. The present invention also provides for harnessing mechanical energy from a renewable energy resource and utilising it to drive a device.

10 **Background to the Invention**

- Renewable resources represent one of the most sustainable means through which energy can be generated. In particular, there is considerable interest in generating electrical energy from renewable energy resources such as wind energy, wave energy and tidal energy. Most schemes for generating electrical energy from a renewable energy
- 15 resources use an electrical generator of a conventional rotary type. A rotary electrical generator comprises a cylindrical stator and a rotor which rotates within the stator about an axis. One of the generator parts (typically the stator) has an array of permanent magnets or field windings which are energised to form a magnetic field. The other of the generator parts (typically the rotor) carries armature windings. A voltage is induced
- 20 in the armature windings as the rotor is turned within the magnetic field provided by the stator. The renewable energy source is harnessed in such a way that the rotary generator can be driven. In the case of wind energy or flowing water, the shaft of the rotor is driven by a set of turbine blades. In the case of wave energy, some form of mechanical conversion is required to convert the undulating motion of the water surface into a
- 25 rotational movement which can drive the rotor of a generator. The need to convert the energy source into a form in which a rotary generator can be driven can reduce the efficiency of the energy generation scheme.

- A further problem with conventional schemes for generating electrical energy from a
- 30 renewable energy source is that they operate most efficiently in the absence of turbulence. Indeed, excessive turbulence may damage the generator.

There have been some proposals to adapt, or replace the need for, a conventional rotary generator in electrical generation schemes which use a source of renewable energy. US 4,191,893 describes a natural turbulence electrical power generator with a rotary generator in which the rotor can also be moved longitudinally along the rotational axis of the rotor. The rotor is connected to a housing via a spring which converts longitudinal movement of the rotor into rotational movement of the rotor. GB 2,272,026A, WO 03/058055A1 and US 6,020,653 describe linear electrical generators which are driven by wave energy. The linear generator has a linear stator and a "rotor" which reciprocates along the longitudinal axis of the stator. This allows undulating movement of the water surface to directly drive the linear rotor, without the need to convert undulating motion of the water surface into rotary movement.

US 4,024,409 describes an Aeolian windmill comprising a conductor which oscillates between a set of magnets. DE 199 24 506A1 describes an arrangement for converting wind-driven movement of an object into electrical energy by use of a hydraulic piston which drives a rotary generator. WO 2007/03413 describes a kite power generator which converts varying forces exerted by wind on a kite into rotary movement of a crankshaft.

The present invention seeks to provide an alternative energy generator. For example, a generator capable of generating electrical, heat energy and combinations thereof. One aspect of the present invention seeks to provide an electrical generator which is more suited to being driven by a renewable energy source such as wind energy or wave energy, which is randomly directed.

Summary of the Invention

A first aspect of the present invention provides a generator as set out in the appended claims. The generator may be suitable for the generation of electrical energy, heat energy or combinations thereof.

The invention provides for an energy generator comprising:
a structure having a longitudinal axis:

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a drive shaft which is movable by an external force, the drive shaft being arranged to move in a first plane which is substantially perpendicular with respect to the longitudinal axis; and

5 means for generating energy in response to movement of the drive shaft in the first plane.

The drive shaft may be arranged to perform at least a reciprocating movement in the first plane and the means for generating energy is arranged to generate energy in response to the reciprocating movement of the drive shaft in the first plane. The drive shaft may be
10 arranged to move in any direction in the first plane and the means for generating energy is arranged to generate energy in response to movement of the drive shaft in any direction within the first plane. The drive shaft may also be movable in the direction of the longitudinal axis and the means for generating energy is also arranged to generate energy in response to movement of the drive shaft in the direction of the longitudinal axis.

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The generator may further comprise a mounting for the drive shaft which is arranged to permit pivotal movement of the drive shaft about the longitudinal axis. The mounting may be arranged such that the drive shaft has a rest position, in the absence of an external force, which is substantially aligned with the longitudinal axis.

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The generator may be for generating one of electrical energy, heat energy and combinations thereof. The generator may be for generating heat energy. The generator for generating heat energy may comprises a housing and the means for generating heat energy comprises a plurality of pistons connected between the drive shaft and the housing,

25 each piston comprising a rod and a sleeve for receiving a compressible fluid, wherein heat energy is generated by compression of a fluid in the piston sleeve in response to movement of the drive shaft.

The compressed fluid may be deliverable to at least one heat exchanger. The fluid may be
30 air. The generator may further comprise a housing and:

at least one set of conductors mounted on one of the housing and the drive shaft;

at least one magnetic field source mounted on the other of the housing and the drive shaft; wherein heat is generated in the conductors in response to movement of the drive shaft. The generator may further comprise a heat extracting means for harnessing the heat energy.

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The generator may be used for generating electrical energy. An electrical generator may have a structure comprising a tubular housing and the means for generating electrical energy comprises a plurality of pistons connected radially between the drive shaft and the tubular housing, each piston comprising a sleeve and a rod with a winding mounted on one
10 of the sleeve and the rod and at least one magnetic field source mounted on the other of the sleeve and the rod;

wherein electrical energy is generated in the windings in response to movement of the drive shaft in the first plane.

- 15 The electrical generator structure may comprise a stator and the means for generating electrical energy comprises:

at least one set of windings mounted on one of the stator and the drive shaft;

- at least one magnetic field source mounted on the other of the stator and the drive shaft; wherein electrical energy is generated in the windings in response to movement of
20 the drive shaft in the first plane. The stator may extend in the direction of the longitudinal axis and the generator further comprises a plurality of units spaced along the longitudinal axis which are connected to the drive shaft and which are arranged to follow movement of the drive shaft, each unit comprising

at least one set of windings mounted on one of the stator and the unit;

- 25 at least one magnetic field source mounted on the other of the stator and the unit;

wherein electrical energy is generated in each of the sets of windings in response to movement of the drive shaft in the first plane.

- The at least one magnetic field source may be mounted substantially perpendicular to the
30 drive shaft. There may be first and second magnetic field sources mounted substantially perpendicular to one another and perpendicularly to the drive shaft. The first and second

magnetic field sources may be mounted on the drive shaft and there are four sets of windings mounted on the stator.

- 5 The electrical generator structure may comprise a stator and a linkage mechanism connects the drive shaft to a plurality of arms which are each arranged to move along a first axis which is parallel to the longitudinal axis of the generator, the linkage mechanism being arranged to convert movement of the drive shaft in the first plane into linear movement of the arms along their respective first axis.

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The electrical generator may further comprise:

at least one set of windings mounted on one of the stator and an arm;

at least one magnetic field source mounted on the other of the stator and the arm;

wherein electrical energy is generated in the windings in response to movement of the arm.

- 15 The magnetic field source may comprise one of: a permanent magnet or a field winding which can be energised to generate a magnetic field.

The magnetic field may be variable during operation of the generator. The magnetic field may be varied based on velocity of the drive shaft. The magnetic field may be varied based on direction of movement of the drive shaft about a rest position. The magnetic field may be varied so as to suppress velocity of the drive shaft. The magnetic field source may comprise one of:

- 20 a field winding and the generator further comprises a controller which is arranged to apply a variable current to the field winding; and

- 25 a plurality of selectively energisable field windings which differ in their respective resistance

With reference to the electrical generator of the present invention, external mechanical energy may be transferred to oppose an alternating or pulsing counter magnetic force set up in the generator, via the drive shaft and where motion of the counter magnetic force opposes movement of the drive shaft. The electrical energy generated may be equal to the energy required to cause the relative motion between the counter magnetic force and the applied mechanical energy.

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Eddy currents may be generated in the windings in response to changes in the magnetic field. The eddy currents may generate heat in the windings and the generator may further
5 comprise a means for extracting said heat.

In a further aspect the present invention provides for an apparatus for generating electrical power from a renewable energy source comprising:

- a collector which is responsive to force exerted by a renewable energy source;
- 10 an electrical generator according to any one of the preceding claims: and,
- a linkage between the collector and the drive shaft of the electrical generator. The invention also provides for a method of generating electrical energy using an electrical generator according to the present invention.

- 15 A generator substantially as described herein and with reference to the accompanying drawings. An electrical generator substantially as described herein and with reference to the accompanying drawings.

- An advantage of the generator is that it can be driven by forces in a range of different
20 directions, such as naturally occurring, randomly directed, movements that arise in renewable sources of energy such as wind energy, wave energy or tidal energy. The

source of mechanical energy applied to the drive shaft can also be vibrational energy. The generator can avoid the need to convert mechanical energy into a form in which a rotary generator can be driven.

- 5 In a simple form, the movement of the drive shaft can be reciprocating movement in the first plane although, more advantageously, the drive shaft can be driven in any direction within the first plane. The drive shaft can be mounted in a manner which allows the drive shaft to pivot with respect to the longitudinal axis and this can be achieved by means such as a ball and socket connection.

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- The invention can be embodied at a range of different scales, both in terms of physical size of the generator and (electrical) power output of the generator. A large scale generator, or set of generators, can be used to supply electricity to the grid, or to a property, while a smaller scale generator can be used to generate an electrical supply for an appliance, such as charging a battery of a portable or stand-alone appliance.
- 15

Brief Description of the Drawings

Embodiments of the invention will be described, by way of example only, with reference to the accompanying drawings in which:

- 20 Figures 1A and 1B schematically shows an apparatus for generating energy from a source of renewable energy;

Figures 2A-2D show a range of possible movements of a drive shaft of a generator according to a first embodiment of the invention;

- Figure 3 shows components of a generator which can perform the movements shown in Figure 2;
- 25

Figures 4A-4E show the generator of Figure 3 in assembled form, in a range of different positions;

Figures 5-8 show an alternative form of the generator of Figures 3 and 4, with a stack of units;

- 30 Figure 9 shows a second embodiment of a generator with a set of pistons mounted radially around the drive shaft of the generator;

Figure 10 shows a single one of the pistons used in the generator of Figure 9;

Figure 11 shows an alternative form of the piston of Figure 10;

Figures 12-14 show a third embodiment of a generator;

Figures 15-18 show the generator of Figures 12-14 in operation, illustrating the range of possible movements;

Figure 19 shows an alternative form of the generator of Figures 12-18;

5 Figure 20 shows an embodiment of the generator configured for generating heat; and

Figure 21 shows a heat exchanger utilised in the embodiment of Figure 20.

Detailed Description of the Invention

10 The words “comprises/comprising” and the words “having/including” when used herein with reference to the present invention are used to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

15 It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable sub-combination.

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Figures 1A and 1B schematically show an apparatus for generating electrical and or heat energy from a renewable energy source. For generating energy the apparatus comprises a collector, an electrical generator and a linkage (drive shaft) between the collector and the generator. Figure 1A shows apparatus which can be driven by wave or tidal energy.

25 The collector can be a hollow sphere, Fig1A, for use below the surface of the water, where small holes in the sphere ensure that the internal water pressure of the sphere is equal to the external water pressure or any other suitable structure which is adapted to be driven by the force of the water. Figure 1B shows apparatus which can be driven by wind energy. The collector can have a wider range of forms compared to conventional
30 collecting structures, and may comprise items such as a blade, aerofoil, dish or any other suitable structure which is adapted to be driven by the force of the wind. Figure 1B shows an artificial tree although the collector could be a rigid structure, a part of a fence, a roof panel or a fascia trim panel. The collector can be designed to be driven by

any other source of energy. The linkage can be a simple direct connection between the collector and a drive shaft within the generator, such as a rigid connecting rod or cable, or it can be a more complex mechanical arrangement to transmit movement of the collector to the drive shaft of the generator.

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Figure 2 shows the types of movement that can be applied to the drive shaft of a first embodiment of the generator to generate energy (heat or electrical). Parts of the generator are shown in simplified schematic form to more clearly illustrate the principles. Figure 2 shows only the end portion of the drive shaft 11. The apparatus has
10 a longitudinal axis 10. A drive shaft 11 is mounted in a manner which allows pivotal movement about the longitudinal axis 10. A plate 12 is fixed to the drive shaft 11, perpendicularly to the longitudinal axis of the shaft 11, and moves with the drive shaft. Together, drive shaft 11 and plate 12 form a kind of rotor although it will be seen that this rotor is capable of moving in a plane 5 which is perpendicular to the longitudinal
15 axis 10 of the generator. This contrasts with a conventional rotary generator where the drive shaft would be continually aligned with longitudinal axis 10. In this example, the drive shaft 11 is pivotably mounted by a ball 13 and socket 14 connection between the underside of plate 12 and a rod 15. As will be described in more detail below, plate 12 may carry magnets. A tubular stator (not shown in Figure 2) is aligned with the
20 longitudinal axis 10 and surrounds the drive shaft 11 and plate 12. Windings (coils) are mounted on the stator. In use, movement of the drive shaft 11 and plate 12 moves magnets relative to the windings and causes a voltage to be induced in the windings. The mount 13, 14 is also capable of movement in the direction of the longitudinal axis 10. A channel 16 in the support block 17 allows movement of the drive shaft 11. Plate
25 12 is shown here as a simple circular disc although it can take other shapes, and it does not need to be a solid structure.

Figures 2A-2D show the apparatus in a range of orientations with respect to the longitudinal axis 10. In Figure 2B the upper part of the drive shaft 11 has moved
30 radially 15 (to the right) with respect to the longitudinal axis 10. The movement is a pivotal movement about the mount 13, 14. Pivotal movement is possible in any radial direction. The sequence of drawings in Figures 2A-2D show that the drive shaft 11, unit 12 and mount 13, 14 can also move in the direction of the longitudinal axis 10. The

drive shaft is not limited to only performing radial movements, but can generally move in a plane 5 which is substantially perpendicular to the longitudinal axis 10 of the generator. The drive shaft 11 can also be driven in a circular motion about the longitudinal axis 10 in the plane 5 perpendicular to the longitudinal axis 10. The range of movement of the drive shaft 11 is "joystick-like". Thus, the shaft may move simultaneously in a first plane which is substantially perpendicular with respect to the longitudinal axis and in either direction of the longitudinal axis.

Figure 3 shows, in plan view, the main components of an electrical generator according to a first embodiment of the present invention. A stator 30 comprises a tubular housing 31 with windings 32 positioned on the housing, 90° apart. A movable unit 20 comprises a first magnet 21 and a second magnet 22 mounted in a cross-shaped form. In the centre of the unit 20 is a mount (e.g. bolting hole) for receiving and connecting to the drive shaft 25. Movable unit 20 is dimensioned such that, when assembled, it will fit inside the stator 30 and move within the stator in the manner shown in Figure 2. Although not shown in Figure 3, the apparatus can be pivotably mounted (e.g. by a ball and socket connection) in a similar manner as shown in Figure 2. Advantageously, the length of each magnet 21, 22 is only slightly smaller than the internal diameter of housing 31 to maximise the interaction between the magnets 21, 22 and the windings 24. Figure 3 shows the windings 32 mounted on the stator 30 and the magnets 21, 22 mounted on the movable unit 20 but the position can be swapped, with the windings 32 mounted on the movable unit 20 and the magnets 21, 22 mounted on the stator 30. The magnetic field can be achieved using permanent magnets or by using field windings which are powered by an electrical supply. Windings 32 can extend around a larger area of the stator housing 31 than shown in Figure 3. Two or more windings can be electrically connected together, or outputs from each winding can be separately applied to a power output stage. The connection of windings will depend on the type of movement that the generator is responsive to (joystick movement only or a combination of joystick movement and movement along the longitudinal axis.)

A voltage is induced in windings 32 in response to movement of the magnets 21, 22 carried by unit 20. Positioning windings 90 degrees apart ensures that a voltage will be induced in at least one of the windings, irrespective of direction of movement of the

drive shaft 11. In cases where “joystick-like” movement of movable unit 20 occurs in a straight line directly between two diametrically-opposed windings, current will be induced only in those diametrically-opposed windings, and no current will be induced in the windings positioned at 90 degrees to the line of movement. In other cases of “joystick-like” movement, movement of movable unit 20 will induce current in each of the four windings 32. Any movement through the longitudinal axis only will induce current in all windings, equally. Where movement of the drive shaft is perpendicular to longitudinal axis only, one set of opposite windings will generally induce more current than the other than the other opposite set.

Figure 4A shows a plan view of the components of Figure 3 in assembled form. Figures 4A-4E show, in plan view, a sequence of drawings to illustrate possible movement of the movable unit 20 with respect to the stator 30. In addition, an embodiment of the generator can permit movement along the longitudinal axis (directly into and out of the paper in Figure 4).

Figures 3 and 4 show a generator with a single movable unit 20 within a stator 30. A further embodiment of the generator provides a set of movable units 20 in a stacked configuration. This is shown in Figures 5 to 8. This configuration can increase the amount of generated electrical energy. Figure 5 shows eight movable units 20A-20H mounted within a stator assembly 130 although any other suitable number of units could be used. The movable units 20A-20H are connected together by a set of four connecting rods 122. Each connecting rod 122 connects between a connecting socket 26 (e.g. a ball socket) on a first movable unit 20 and a connecting socket 26 in the same position on an adjacent movable unit 20. The set of connecting rods maintain each adjacent pair of movable units 20 a fixed distance apart, while allowing each of the movable units 20B-20H to follow the same movement as the first unit 20A to which the drive shaft 11 is connected. A ball and socket connection 113, 114, or similar means, connects between the centre of unit 20H and a rod 115 and performs a similar function as shown in Figure 2 of allowing unit 20H to pivot and move longitudinally.

Pivotal movement of the drive shaft 11, and the set of units 20A-20H, is illustrated in Figure 8. Figure 5 shows an individual winding alongside each movable unit 20

although other embodiments of the generator can provide fewer windings, such as a single winding which extends the full length of the stator.

The drive shaft shown in Figures 5 to 8 can move in the longitudinal direction. A first return spring 124 is fitted within housing 130 between the movable unit 20H at the first end of the housing and a first end face 133 of the housing. A second return spring 125 is fitted within housing 130 between the movable unit 20A at the second end of the housing and a second end face 134 of the housing. Springs 124, 125 allow the set of units 20A-20H to move in the direction of the longitudinal axis 10 in response to an external force and return the set of units 20A-20H to a rest position within the housing in the absence of an external force. Longitudinal movement is shown in Figures 6 and 7. Longitudinal movement of the set of units 20A-20H causes electrical energy to be generated in windings 32.

The apparatus shown in Figures 5 to 8 can be adapted to include a larger, or a smaller, number of units (stacking) 20 and windings 24. The number of units will depend on factors such as: velocity of the external force which drives the drive shaft and voltage or power required from the generator. Voltage induced in a winding is defined by the relationship:

$$\text{Emf} = V \times B \times L \quad (\text{Eqn. 1})$$

where: Emf = induced voltage; V = velocity; B = magnetic field strength; L = length of conductor.

Increasing the length of the stator in the apparatus will increase the length of conductor (a larger value of L) which "cuts" the lines of the magnetic field. Increasing the number of units 20 which carry magnets increases the surface area of the exciting magnetic field which can interact with the conductors.

Figure 9 shows another embodiment of the generator which is also capable of generating electricity and or heat in response to movement of a drive shaft in a plane perpendicular to the longitudinal axis of the generator. In particular, Figure 9 shows a generator for generating electrical energy in cross-section. The generator comprises a

tubular housing 230 with a longitudinal axis 210. A drive shaft 211 is mounted centrally within the housing 230 and has a collar 212 mounted to around the shaft. A set of magnetic pistons are connected radially between the collar 212 and the housing 230. Each piston comprises a piston chamber 201 which is connected to the housing
5 230 via a connecting rod 207 and a ball joint 208. A piston is slideably movable within chamber 201. The piston comprises a drive rod 205 which is connected between a pivotal mounting 204 on the collar 212 and a piston head received within the piston chamber 201. A field winding 206 is wound around the piston head. A coil 202 is wound around the piston chamber 201.

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Figure 9 shows the coils 202 mounted on the piston chamber 30 and the magnets 21, 22 mounted on the piston head but the position can be swapped, with the coils 202 mounted on the piston head and the magnets 21, 22 mounted on the piston housing. The magnetic field can be achieved using permanent magnets or by using field windings
15 which are powered by an electrical supply. In a further alternative, the piston chamber 201 is connected to the collar 212 and the drive rod 205 is connected to the housing 230.

In operation, the drive shaft 211 is driven by external forces. The drive shaft 211 can
20 move radially from the rest position shown in Figure 9. Consider a radially-directed movement towards the left of Figure 9. This will compress pistons on the left-hand side of Figure 9 while the pistons on the right-hand side will extend. Relative movement of the field winding relative to the coil in each piston causes a voltage to be induced in each coil. Movement of the drive shaft is limited by the range of travel within each
25 piston. The drive shaft is not limited to radial movements, and can generally move in a plane which is substantially perpendicular to the longitudinal axis 210 of the housing 230.

Figure 10 shows a side view of one of the pistons in Figure 9. Figure 11 shows an
30 alternative design of the piston which increases field winding length and exciter magnetic field surface area.

The embodiment of the generator shown in Figures 9-11 can comprise a single ring - or layer - of pistons, as shown in Figure 9, or multiple layers of pistons can be provided in a stacked configuration, in a similar manner as shown in Figure 5. Each layer of pistons is located at a different position along the longitudinal axis of the tubular housing 230, with each layer being offset from the adjacent layer or layers. Collar 212 in each layer is connected to the collar 212 in neighbouring layers so as to transmit force of drive shaft 211 to other layers of the stacked structure.

Figures 12-19 show a further embodiment of the generator. The generator comprises a housing 330 having a longitudinal axis 310. A drive shaft 311 is movable in a plane 305 which is perpendicular to the longitudinal axis 310 of the apparatus. An arrangement of rods 312, joints 313 and arms 314 translate movement of the drive shaft 311 in the plane 305 into linear movement 321 in the direction parallel to the longitudinal axis 310. Drive shaft 311 has two bores 308, 309 mounted perpendicularly to one another for receiving a respective rod 312. A joint 313 at each end of the rods 312 connects to an arm 314 which is aligned parallel to the longitudinal axis. A magnet 315 is connected to each rod 314. In use, movement of the drive shaft 311 in the plane 305 moves rods 312 and applies a force to the uppermost ends of arms 314 which causes the arms 314, and magnets 315, to move in direction 321. Magnets are constrained to move only along a path 321 which is parallel the longitudinal axis 310. This can be achieved by rails which guide the path of the magnets 315. A pair of longitudinally aligned rails (not shown) can be positioned, one on each side, of the path of the magnet 315, or a pair of longitudinally aligned rods can pass through a bore hole in each magnet 315.

Structure 330 serves as a stator of the generator. A winding 325 is mounted on each face of the stator. Each of the windings 325 can be mounted around the linear path along which the magnet 315 will move, in use. Other forms of winding can be used which do not encircle the path of the magnet 315 but which, instead, are mounted on one of the faces of the housing alongside the linear path along which the magnet will move, in use. Permanent magnets 315 can be used on arms 314 or, alternatively, field windings can be mounted around a core of ferrous material.

Figure 13 shows the assembly of Figure 12 mounted inside the stator 330. The stator structure 330 of the generator can be any suitable dimensions, and can have a height which is greater than the width of each face of the stator. Figure 15 shows an assembled generator of increased height.

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Figure 14 shows other parts of the structure of the generator. An upper plate 331 mounts to one end of the stator 330 and a lower plate 332 mounts to the opposite end of the stator 330. A base plate 334 and support pillars 333 can support the lower plate on a surface. The generator is shown mounted in a vertical orientation although other, non-
10 vertical orientations are possible and the parts 333, 334 may not be used in other orientations.

Figures 16-18 show the generator in use. Firstly, Figure 16 shows the drive shaft 311 at rest, aligned with the longitudinal axis 310. In Figure 17, the drive shaft 311 has been
15 pivoted with respect to the longitudinal axis 310, causing one arm 314A to rise higher than the arm 314B on the other side. Each arm 314A, 314B pulls a magnet 315A, 315B through a respective coil 325A, 325B. In Figure 18 the drive shaft is pivoted from the longitudinal axis, exactly as in Figure 17, but the drive shaft 311 is also displaced along the longitudinal axis.

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Figures 12-18 show a generator having a stator 330 with four faces although the number of faces can be as small as two, or three, or greater than four. Providing magnets and coils on a larger number of faces allows the generator to generate a voltage in response to movements of the drive shaft in a range of different directions.

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Figure 19 shows a further enhancement of the apparatus in which multiple sets of magnets and coils are arranged concentrically (when viewed in plan). Rods 312 are longer than previously shown. A further set of joints 313 and arms 314 are mounted on each rod 312. Each arm 314 supports an additional magnet and a further winding 325 is
30 provided on the stator. In use, the set of magnets are moved through windings 325 as the drive shaft is moved about the longitudinal axis 310.

In the embodiments of the invention shown in Figures 12-19 the generator is shown with a tubular stator housing having a face 330 on each side. An alternative structure for the stator (not illustrated) provides a separate part for each face of the stator, the separate parts being mounted on a base plate (e.g. plate 332 in Figure 14).

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In each of the embodiments described, electrical energy generated in windings of the generator can be stored, for future use, or directly transmitted to a load. Advantageously, some form of regulation/conditioning circuitry is used to condition the outputs of the windings. In one advantageous embodiment, an output of each winding
10 is first rectified (converted to dc form), the set of rectified outputs are combined, and the combined supply is regulated to a particular output voltage (e.g. to charge a battery) or converted to ac form (e.g. via an inverter) required by a load or distribution network.

Another feature of the generator, which can be applied to any of the embodiments
15 described above, is to vary the strength of the magnetic field during operation. The variation in field strength can be achieved in a number of different ways. In a first way, multiple (at least two) sets of windings are provided in each location where a magnetic field is required. The windings are selectively energised. In a second way, a single winding is provided at each position where a magnetic field is required and the current
20 through the winding is varied depending on the required magnetic field strength. Advantageously, a monitoring device is arranged to monitor movement of the drive shaft 11, 211, 311 and vary the magnetic field strength dependent upon the current. Controlling the magnetic field in this manner can help to compensate for a reduction in induced voltage (see eqn. 1 above) which occurs when the drive shaft slows down. This
25 can be useful, for example, if the generator is required to provide a constant, or near-constant, output voltage to a load, furthermore, movement of the collector can be manipulated to a degree in varying conditions.

The energy generator of the present invention may be utilised to generate heat energy.
30 Figure 20 illustrates an embodiment of the invention configured for generating heat. A piston drive rod 412 is connectable to a central drive shaft according to the present invention (not shown). The piston is responsive to movement in the drive shaft as described in the embodiment illustrated in Figure 9. It will be appreciated by a skilled

person that any of the embodiments disclosed in Figures 5 to 19 may be modified to include a piston arrangement as disclosed in Figure 20.

Fluid in the reservoir 410 is distributed in pipe 405 to one-way inlet valves 401 so as to
5 permit passage of the fluid into the piston chamber 404. The fluid may be a gas such as air. The piston chamber has stop rings 407 to prevent movement of the piston head 408 beyond the stop rings 407. One-way outlet valves 402 allow exit of the fluid from the piston chamber 404 for return to the reservoir 410 in pipe 403. A flow regulator valve 416 regulates return of the fluid to the reservoir 410 in pipe 403. Flow regulator valve
10 416 regulates the extent of fluid compression in the chamber 404. Reservoir 410 may further act as an expansion reservoir, allowing the compressed fluid in pipe 403 to decompress or expand, thus recommencing the compression cycle.

Heat exchangers 406 are utilised to harness heat energy from a compressed fluid. The
15 heat exchanger pipe circuit 409 comprises a refrigerant or any other fluid suitable for heat transfer. The refrigerant is pumped around the pipe circuit 409 using pump 413. In this embodiment the circuit 409 has a radiating means 411 for radiating heat harnessed from heat exchangers 406. The heat exchanger pipe circuit 409 comprises a thermostat 414 and an expansion vessel 415. The thermostat 414 controls operation of
20 the pump 413, such that only refrigerant having reached predetermined temperature is permitted to flow from the heat exchanger 406 around circuit 409. The expansion vessel expands in response to the increasing temperature and volume of the refrigerant within circuit 409. The expansion vessel may be an elastomeric diaphragm forming an interface between the refrigerant in the circuit 409 and air in the atmosphere.

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In operation, the drive shaft (not shown) connected to piston drive rod 412 is driven by external forces. Movement of the piston drive shaft 412 and piston head 408 will compress fluid in the chamber 404. The extent of compression can be regulated by flow regulator valve 416. For example, when valve 416 is closed the extent of compression
30 in piston chamber 404 is increased. Opening valve 416 will decrease the extent of compression as the fluid is allowed to flow through the valve. As the fluid is compressed, its kinetic energy increases and so its temperature rises. Heat from the compressed fluid is transferred to a refrigerant/coolant in heat exchanger 406. The

heated refrigerant is pumped around circuit 409 by pump 413. Heat may be lost through radiating means 411. Once heat has been lost through the radiating means, the cooled fluid is pumped back to heat exchangers 406 to begin the cycle once again.

- 5 An embodiment of a heat exchanger having a folded, high surface area structure is illustrated in Figure 21.

The energy generator of the present invention may allow for harnessing heat energy derived from eddy currents in the windings. The eddy currents are generated in the
10 windings in response to a changing magnetic field. Heat generated in the windings may be harnessed or extracted by any suitable means, for example by circulating a coolant fluid around the heated windings. There may be at least two windings. Desirably, the windings are offset by 90 degrees.

- 15 Eddy currents may result in the generation of heat in the windings in any of the embodiments of the electrical generator discussed above and illustrated in Figures 5 to 19. The heat may be harnessed or extracted by any suitable means, for example by circulating a coolant fluid around the heated windings.

- 20 As will be appreciated by a person skilled in the art, the electrical generator in each of the embodiments discussed above and illustrated in Figures 5 to 19 may be converted into a generator solely for generating heat. The windings in each of the above embodiments may be replaced with conductors, such as conducting metals, for example aluminium or copper. Varying the magnetic field experienced by the conductor, for
25 example a metal, will result in the generation of eddy currents in the conductor. The eddy currents will generate heat in the conductor. The heat may be harnessed by any suitable means, for example by circulating a coolant fluid around the heated windings.

- For example, in one embodiment the generator may comprise a housing and a drive
30 shaft as described in preceding embodiments and:

at least one set of conductors mounted on one of the housing and the drive shaft;

at least one magnetic field source mounted on the other of the housing and the drive shaft;

wherein heat energy is generated in the conductors in response to movement of the drive shaft.

There may be at least two windings. Desirably, the windings are offset by 90 degrees.

5

The drive shaft may be arranged to perform at least a reciprocating movement in the first plane. The drive shaft may be arranged to move in any direction in the first plane. The drive shaft may also be movable in either direction of the longitudinal axis of the drive shaft. The generator may comprise a mounting for the drive shaft which is
10 arranged to permit pivotal movement of the drive shaft about the longitudinal axis. The mounting may be arranged such that the drive shaft has a rest position, in the absence of an external force, which is substantially aligned with the longitudinal axis.

The conductor will most likely be a metal, such as aluminium or copper. Heat may be
15 harnessed or extracted from the conductors and utilized in other applications. Accordingly, the generator may further comprise a means for extracting said heat from said conductor.

In a further aspect the present invention provides for a device comprising:

20

a structure having a longitudinal axis;

a drive shaft which is movable by an external force, the drive shaft being arranged to move in a first plane which is substantially perpendicular with respect to the longitudinal axis,

wherein the drive shaft is also movable in either direction of the longitudinal
25 axis and the drive shaft has a rest position, in the absence of an external force, which is substantially aligned with the longitudinal axis, and

further wherein the drive shaft is couplable to a second mechanical device, such that the second mechanical device is operable in response to movement of the drive shaft.

30

In yet a further aspect the present invention provides for a system comprising:

a first structure having a longitudinal axis; and

a drive shaft which is movable by an external force, the drive shaft being arranged to move in a first plane which is substantially perpendicular with respect to the longitudinal axis,

5 wherein the drive shaft is also movable in either direction of the longitudinal axis and the drive shaft has a rest position, in the absence of an external force, which is substantially aligned with the longitudinal axis, and

a second device coupled to the shaft,
such that the second device is operable in response to movement of the drive shaft.

10 Movement in either direction of the longitudinal axis refers to linear motion of the shaft in either direction parallel to the longitudinal axis, i.e. upward or downward motion. Thus the shaft may move simultaneously in a first plane which is substantially perpendicular with respect to the longitudinal axis and in either direction of the longitudinal axis.

15

The terms "couplable to" and "coupled to" are intended to indicate a mechanical linkage to the second device. For example, the drive shaft may be a component of a mechanical linkage for conversion of energy input into mechanical output suitable for driving the second mechanical device.

20

The drive shaft may be arranged to perform at least a reciprocating movement in the first plane. The drive shaft may be arranged to move in any direction in the first plane. The device or system may comprise a mounting for the drive shaft which is arranged to permit pivotal movement of the drive shaft about the longitudinal axis.

25

The invention is not limited to the embodiments described herein, which may be modified or varied without departing from the scope of the invention.

Claims

1. An energy generator comprising:
 - a structure having a longitudinal axis;
 - a drive shaft which is movable by an external force, the drive shaft being arranged to move in a first plane which is substantially perpendicular with respect to the longitudinal axis; and
 - means for generating energy in response to movement of the drive shaft in the first plane.

2. An energy generator according to Claim 1 wherein the drive shaft is arranged to perform at least a reciprocating movement in the first plane and the means for generating energy is arranged to generate energy in response to the reciprocating movement of the drive shaft in the first plane; and optionally
 - wherein the drive shaft is arranged to move in any direction in the first plane and the means for generating energy is arranged to generate energy in response to movement of the drive shaft in any direction within the first plane; and optionally
 - wherein the drive shaft is also movable in the direction of the longitudinal axis and the means for generating energy is also arranged to generate energy in response to movement of the drive shaft in the direction of the longitudinal axis; and optionally
 - further comprising a mounting for the drive shaft which is arranged to permit pivotal movement of the drive shaft about the longitudinal axis; and optionally
 - wherein the mounting is arranged such that the drive shaft has a rest position, in the absence of an external force, which is substantially aligned with the longitudinal axis; and optionally
 - for generating one of electrical energy, heat energy and combinations thereof.

3. An apparatus for generating electrical power from a renewable energy source comprising:
 - a collector which is responsive to force exerted by a renewable energy source;
 - a generator according to any one of the preceding claims; and
 - a linkage between the collector and the drive shaft of the generator.

4. A device comprising:
 - a structure having a longitudinal axis;
 - a drive shaft which is movable by an external force, the drive shaft being arranged to move in a first plane which is substantially perpendicular with respect to the longitudinal axis,
 - wherein the drive shaft is also movable in either direction of the longitudinal axis and the drive shaft has a rest position, in the absence of an external force, which is substantially aligned with the longitudinal axis, and
 - further wherein the drive shaft is couplable to a second mechanical device, such that the second mechanical device is operable in response to movement of the drive shaft.
5. A generator, heat generator, electrical generator or device substantially as described herein and with reference to the accompanying drawings.

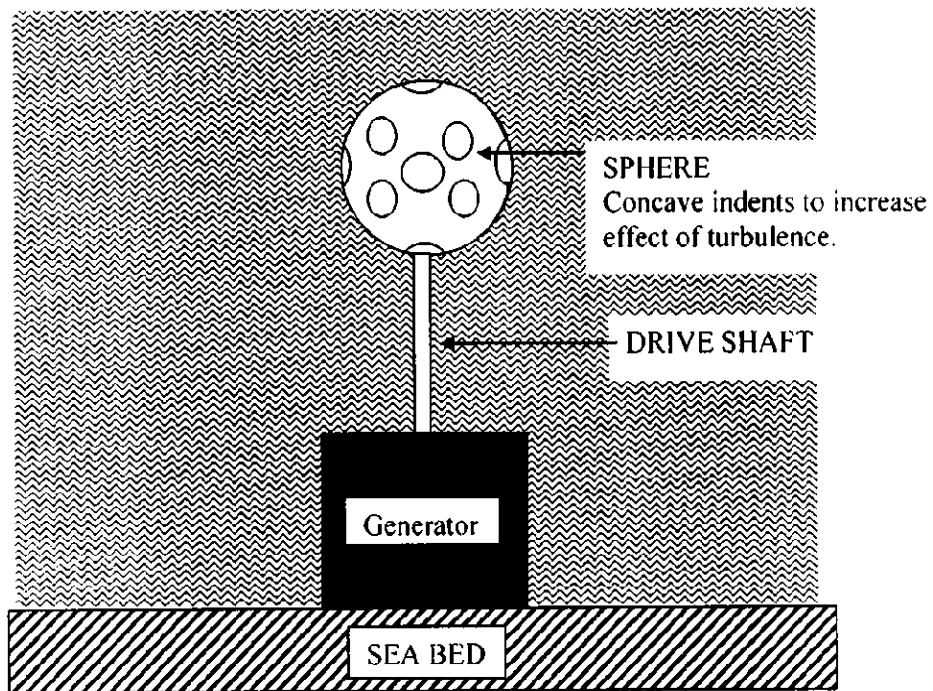


Fig. 1A

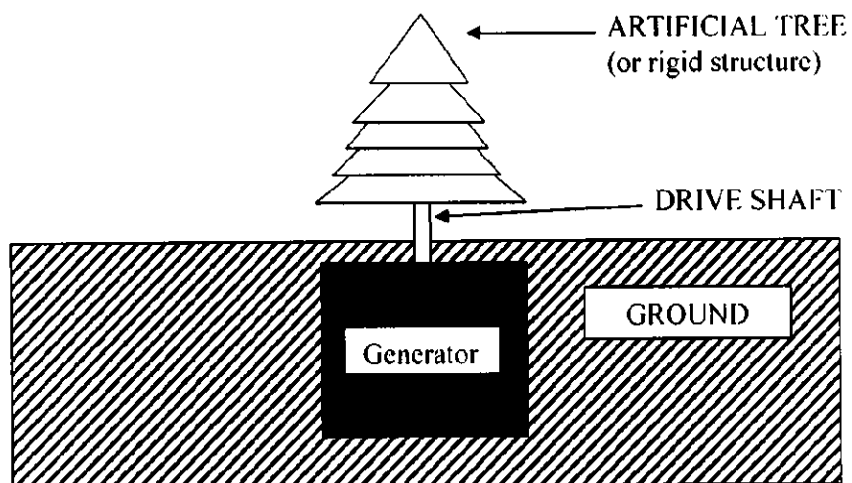


Fig. 1B

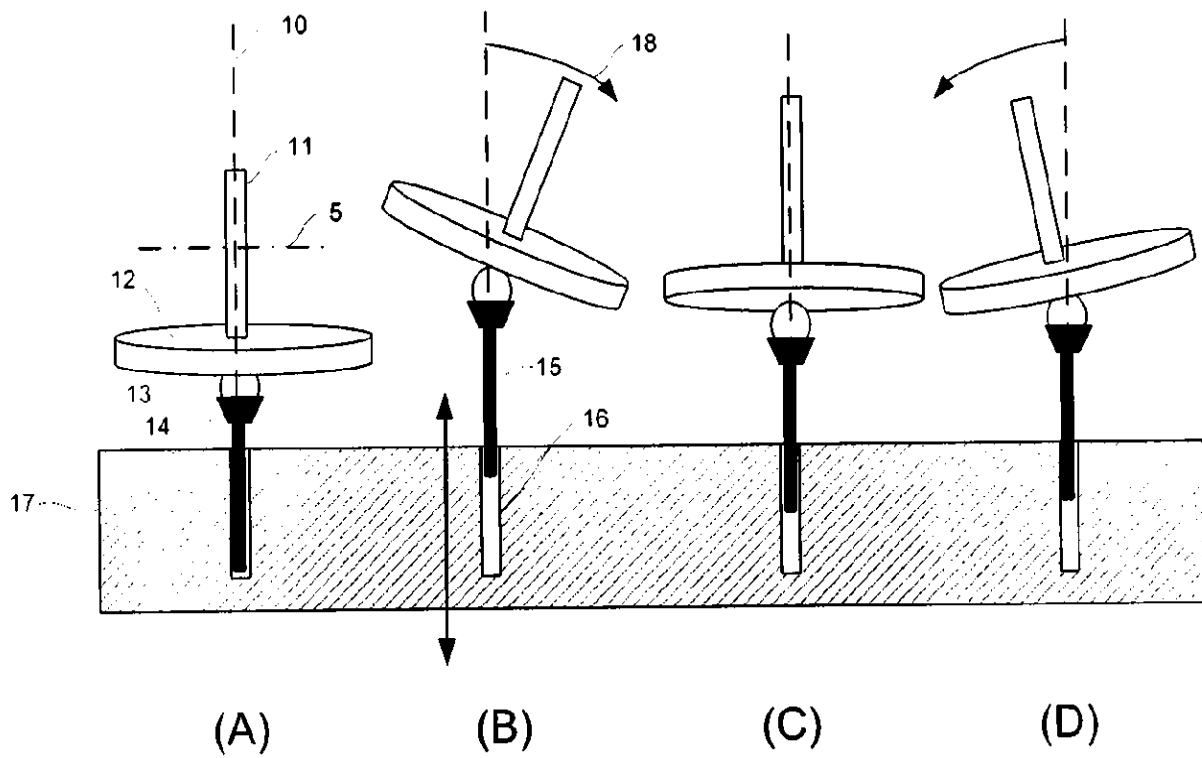


Fig. 2

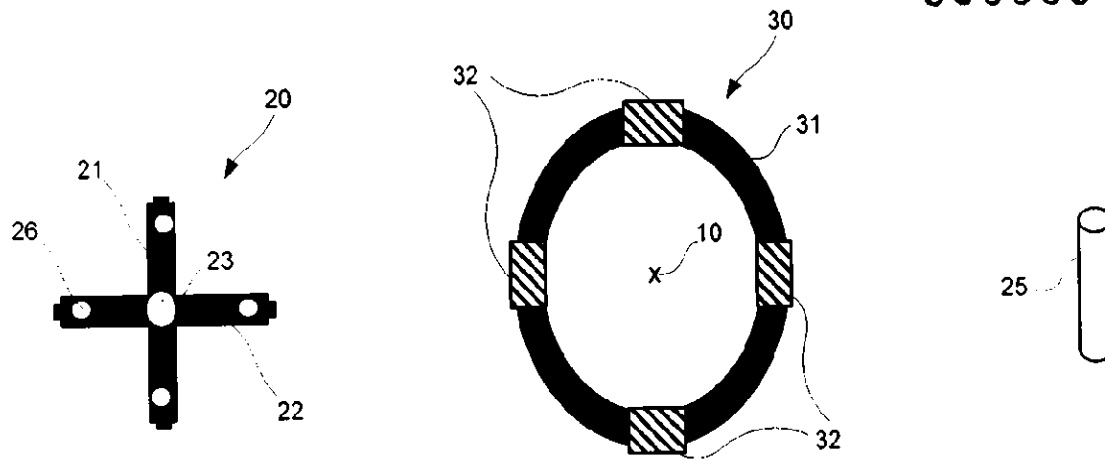


Fig. 3

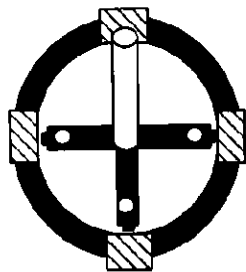


Fig. 4A

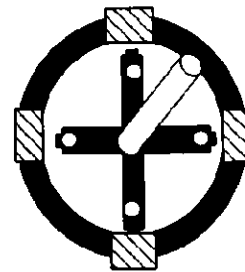


Fig. 4B

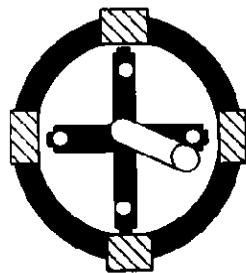


Fig. 4C

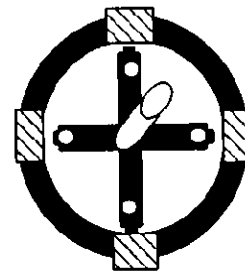


Fig. 4D

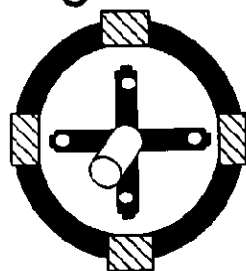
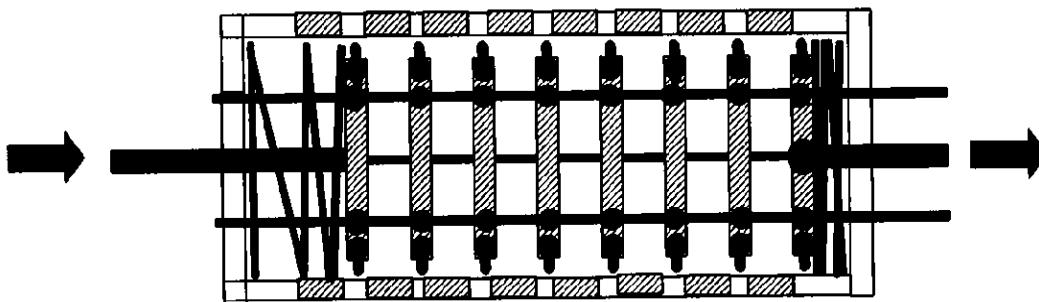
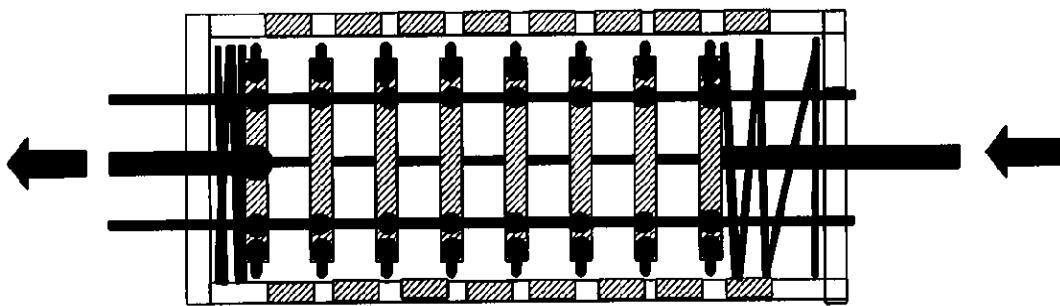
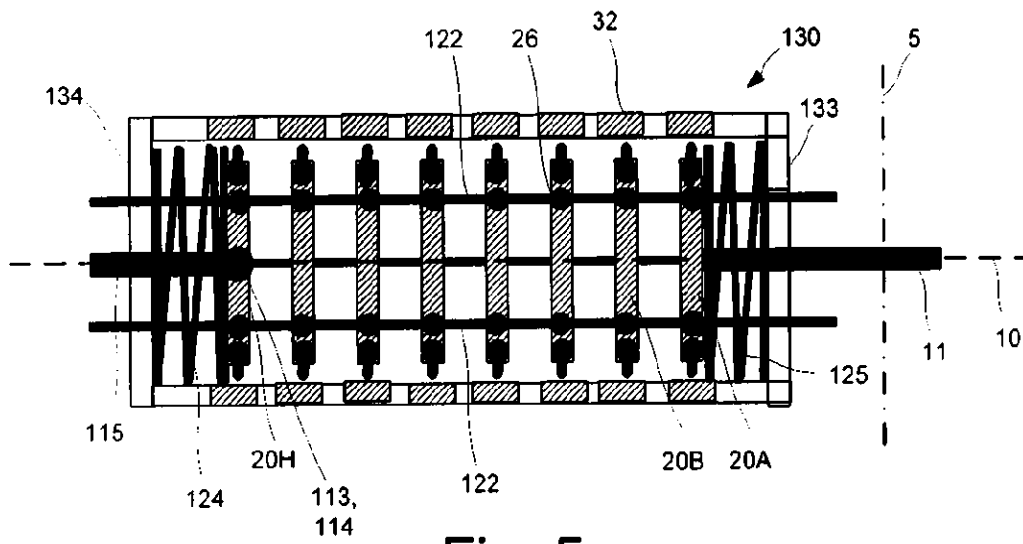


Fig. 4E



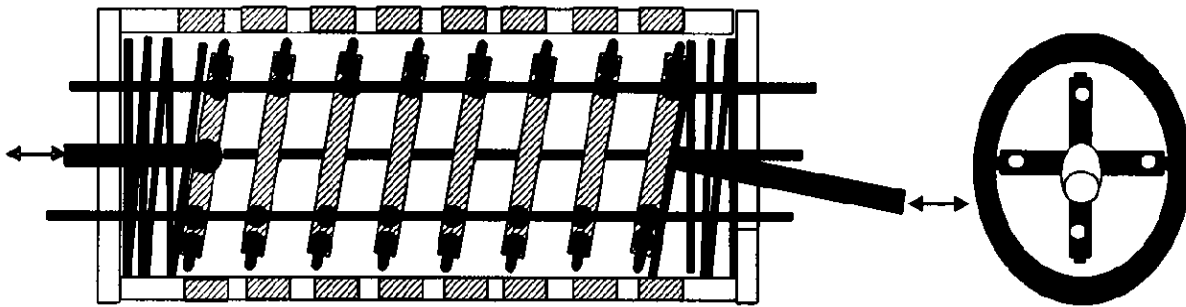


Fig. 8

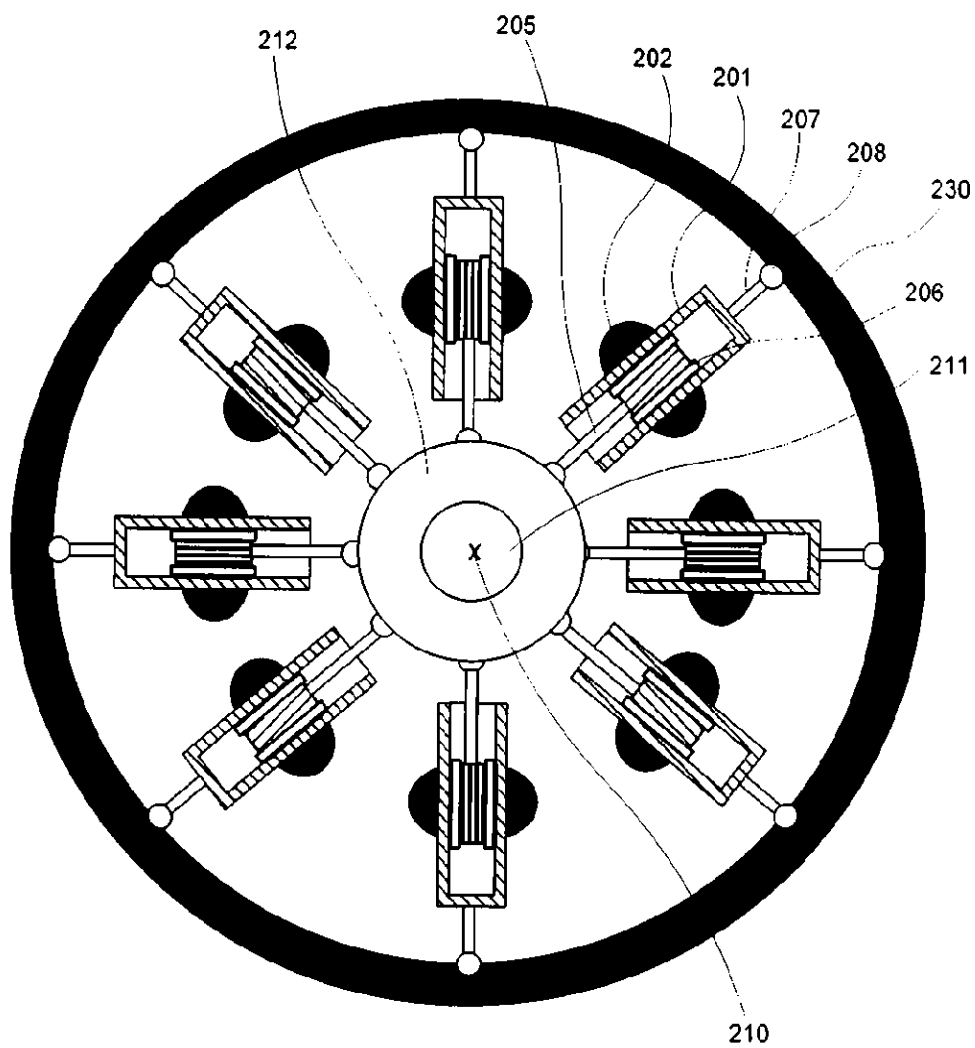


Fig. 9

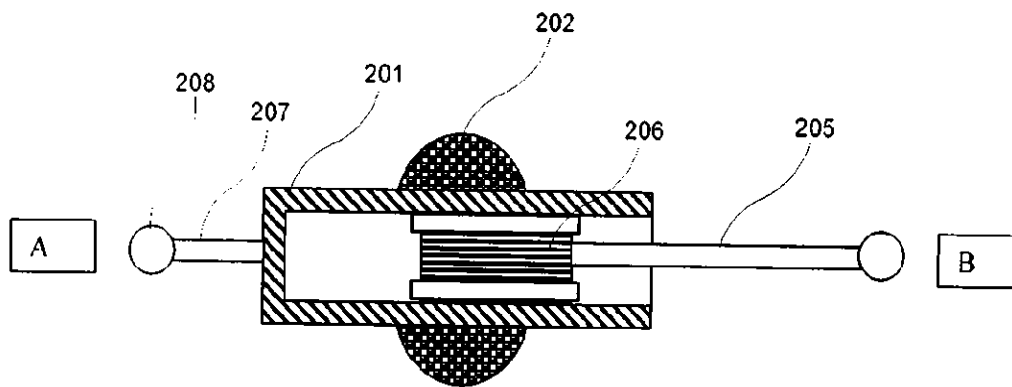


Fig. 10

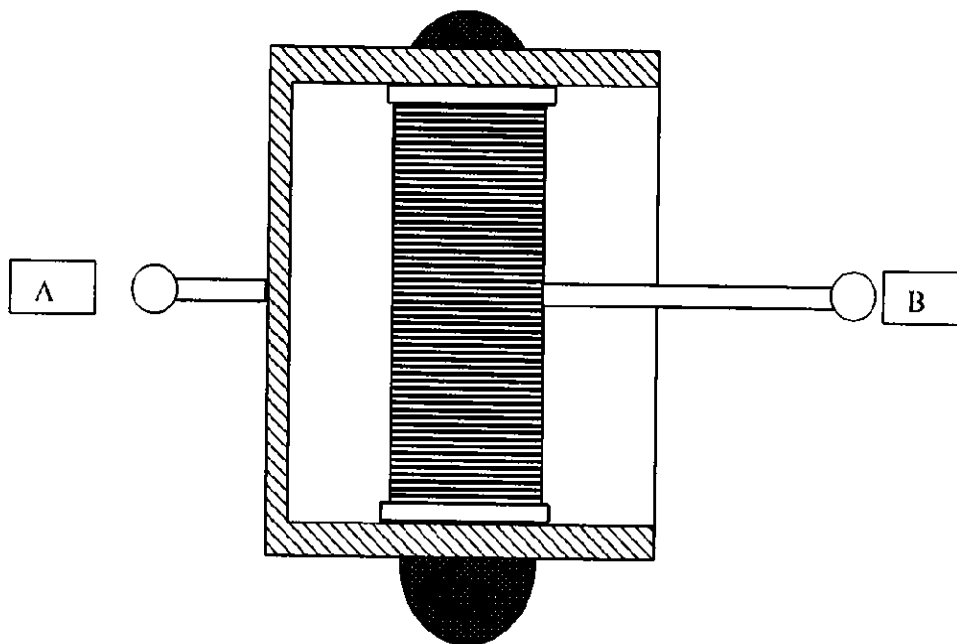
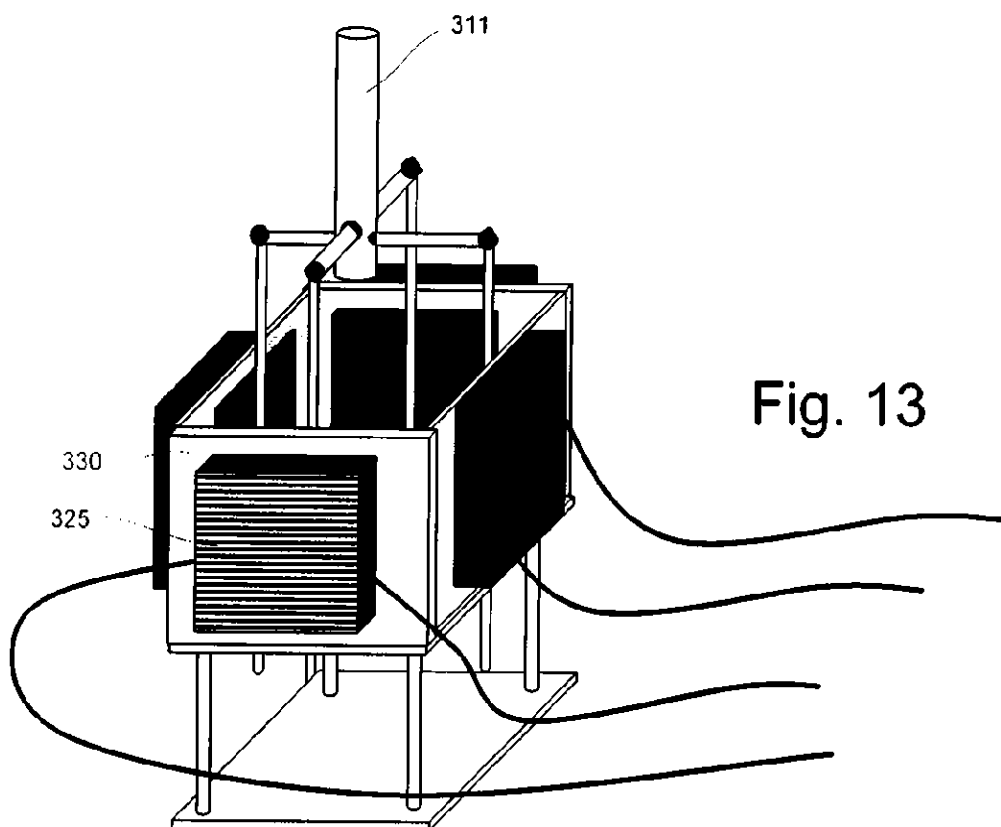
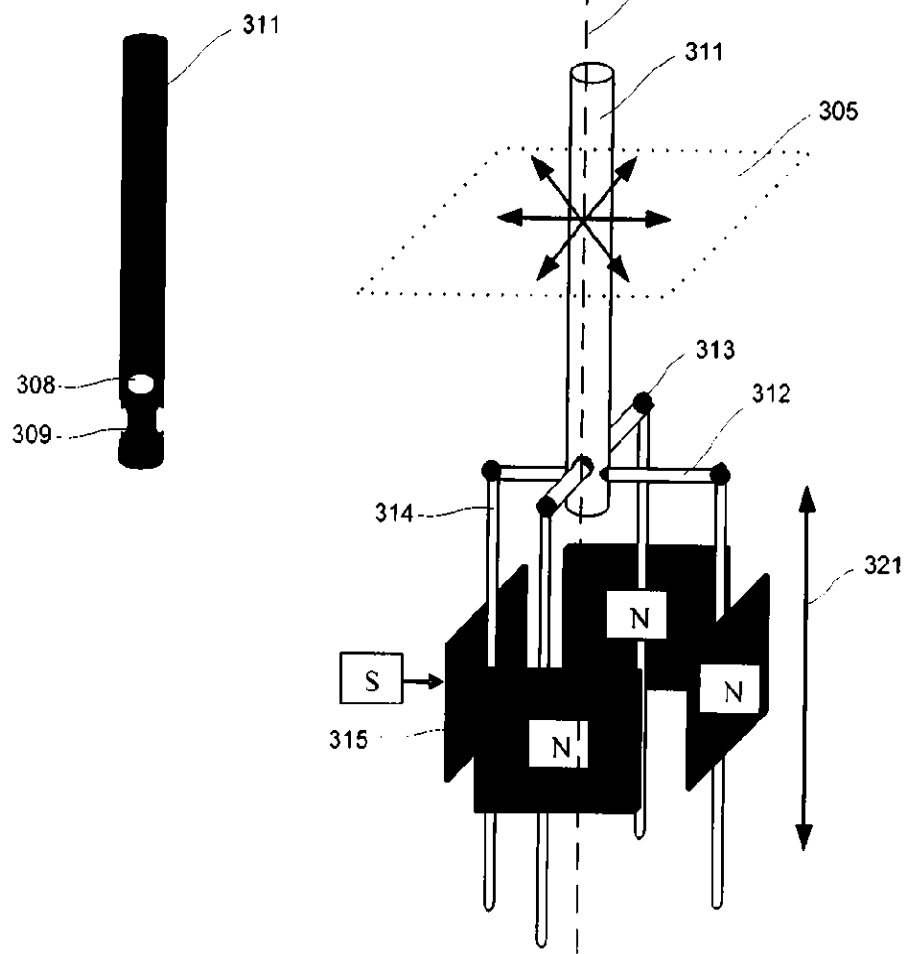


Fig. 11



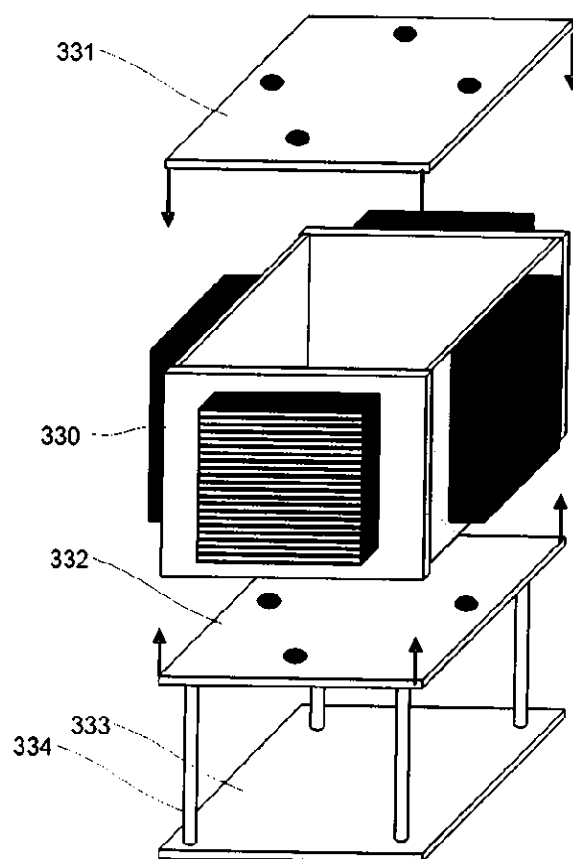


Fig. 14

Assembled Generator
(without top plate).

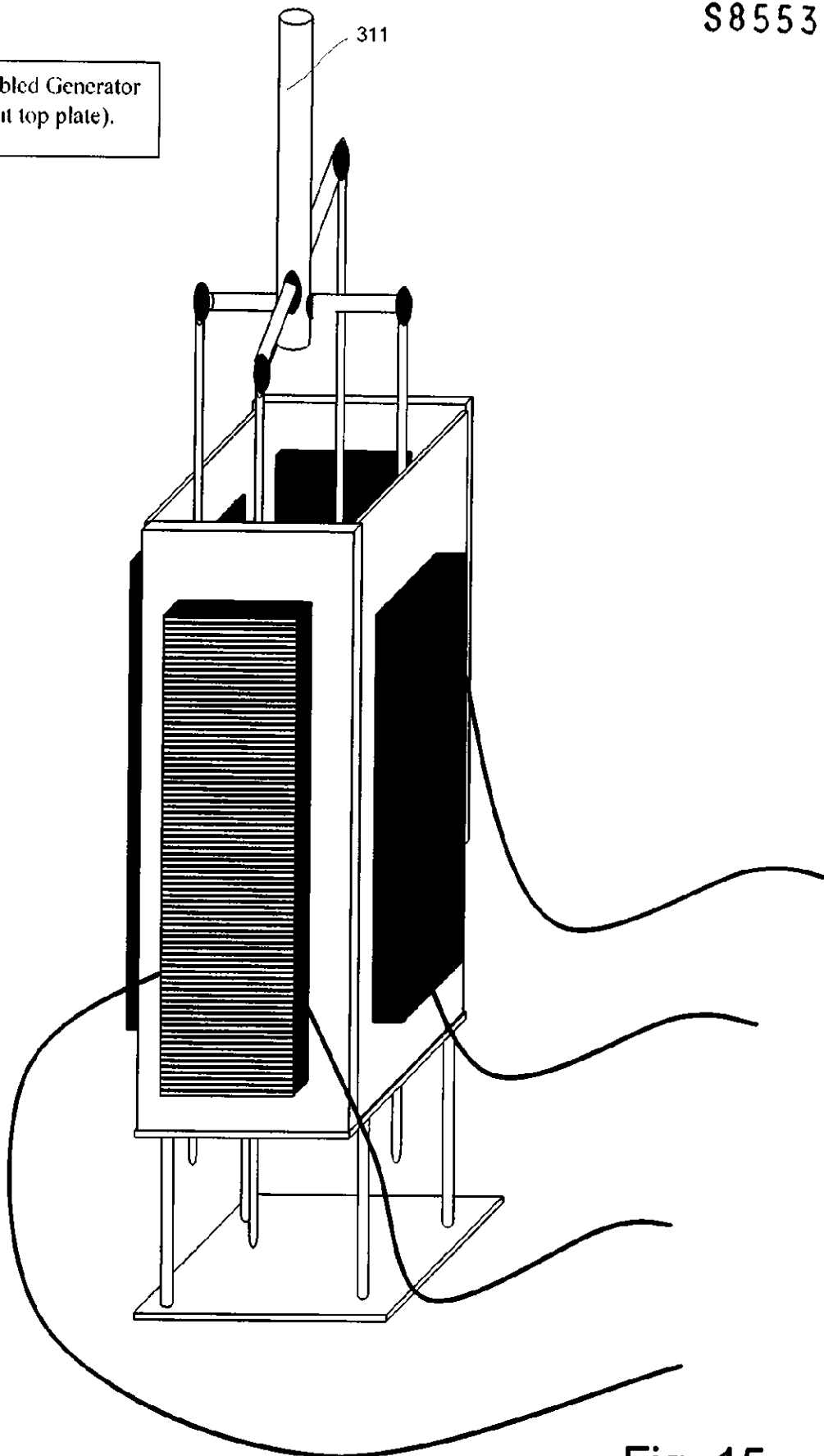


Fig. 15

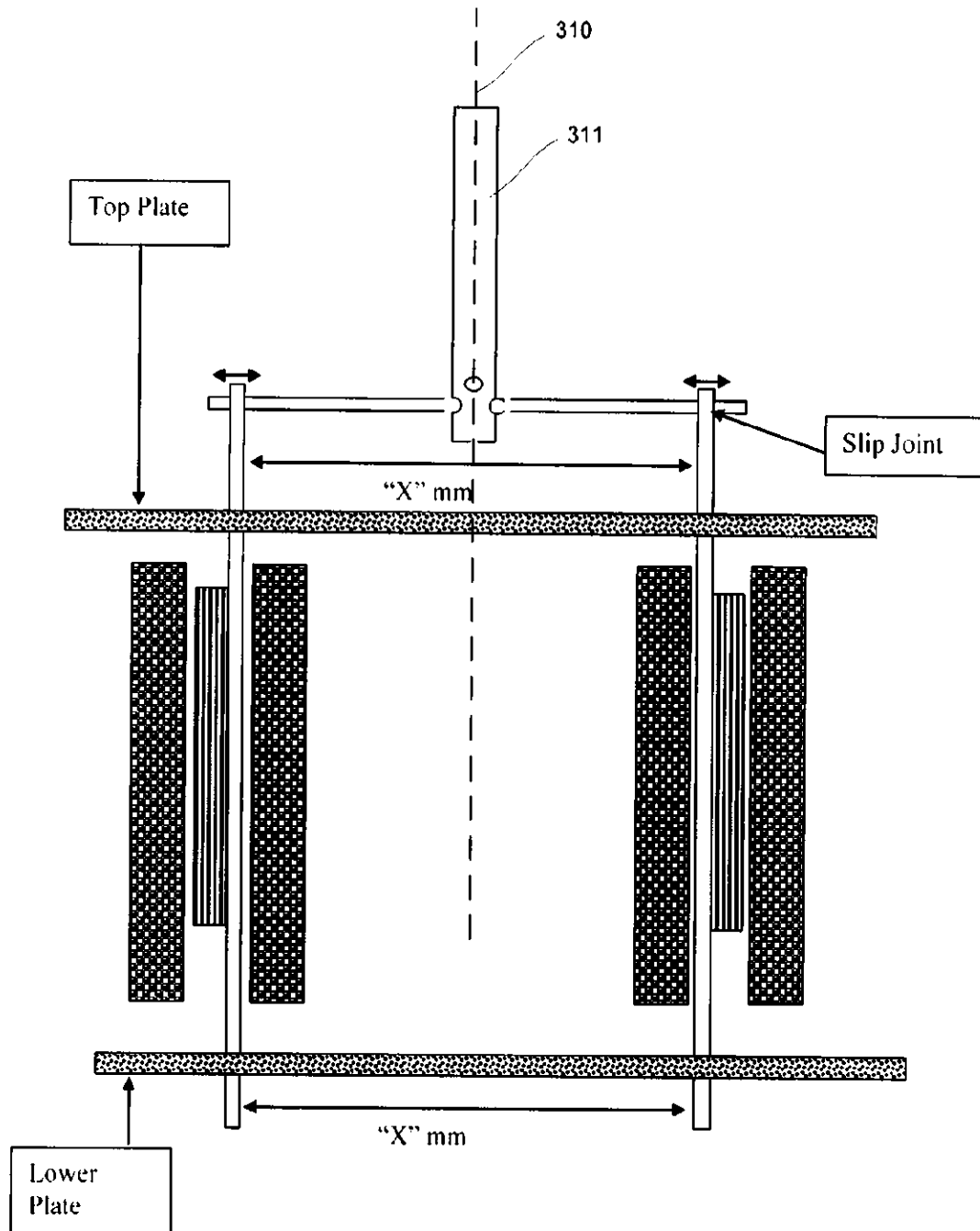


Fig. 16

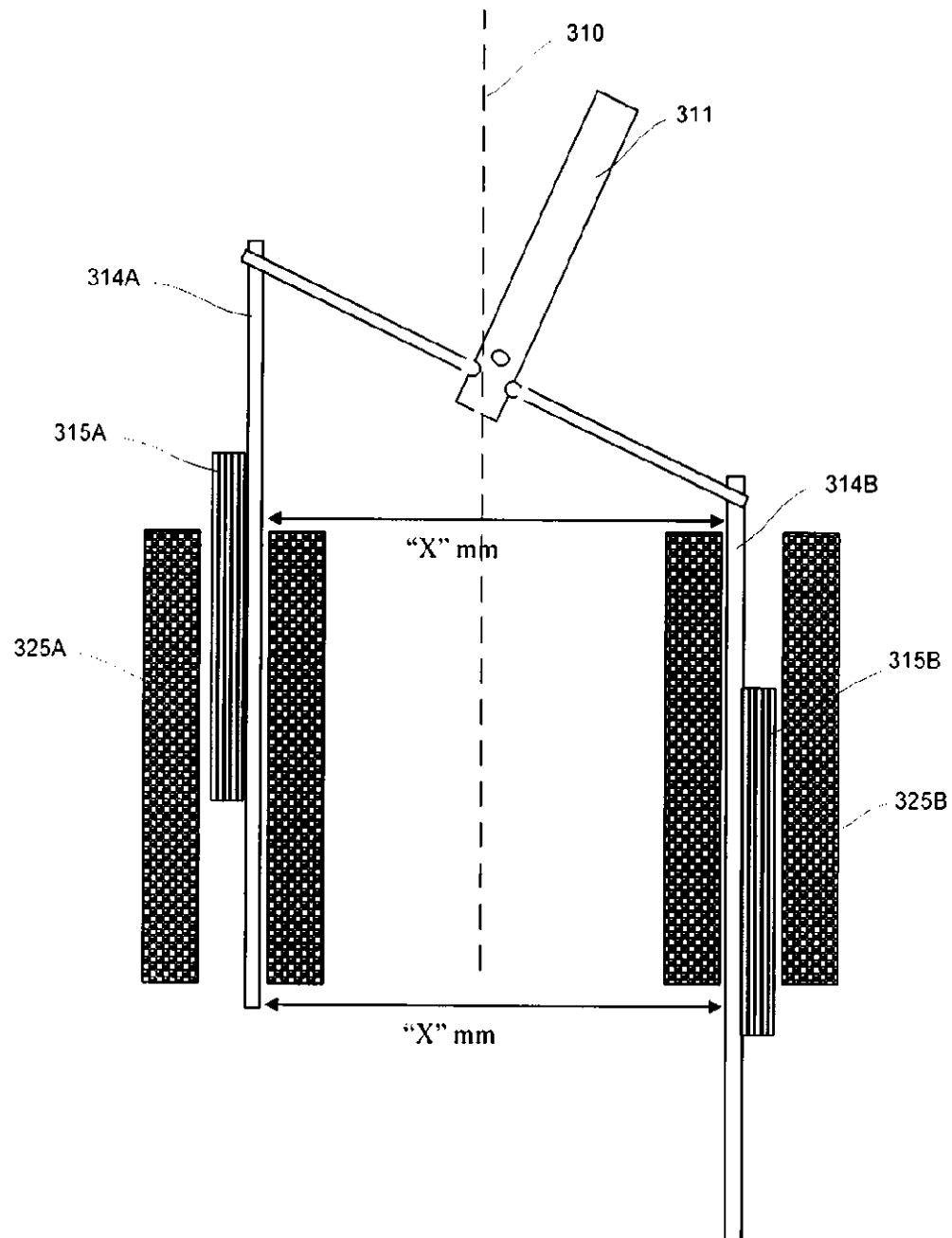


Fig. 17

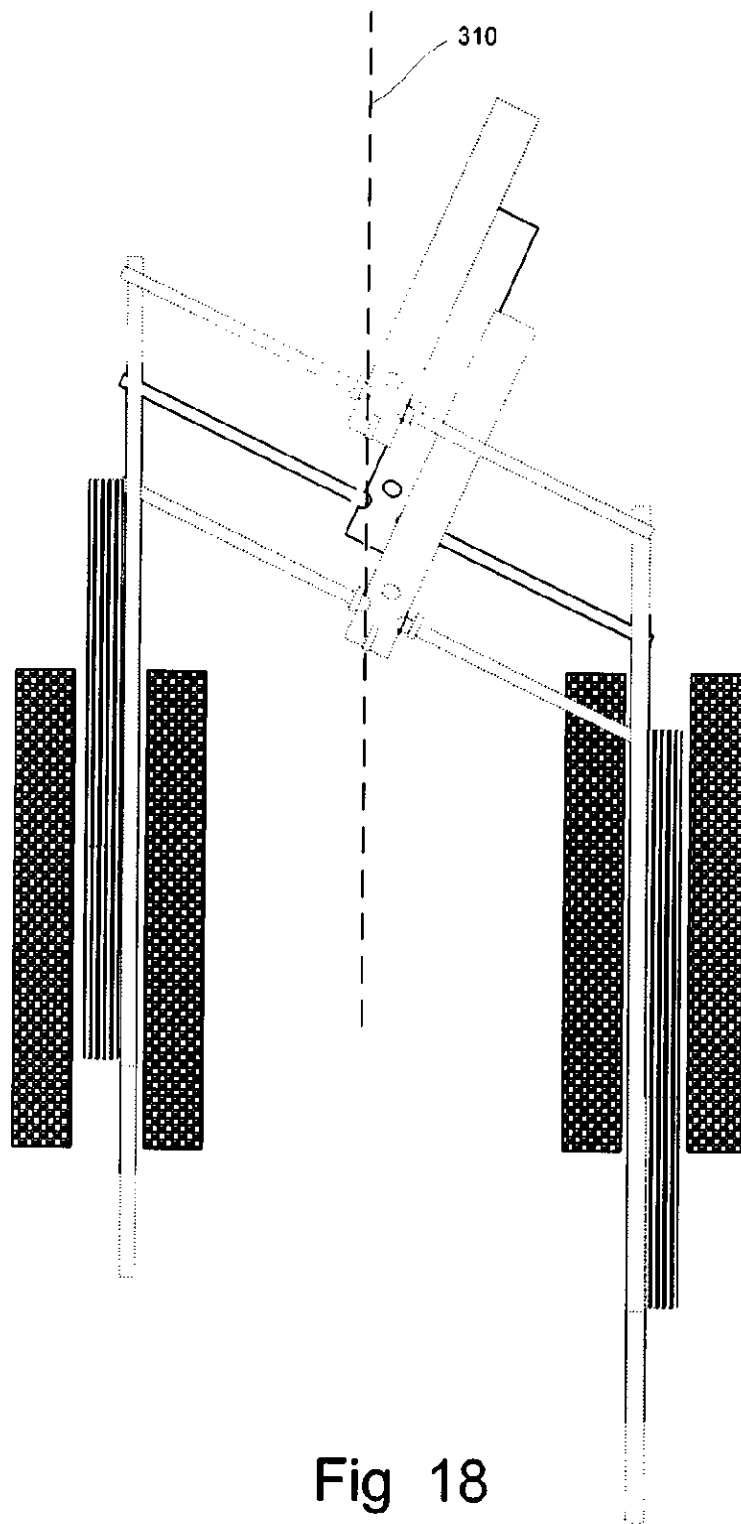


Fig 18

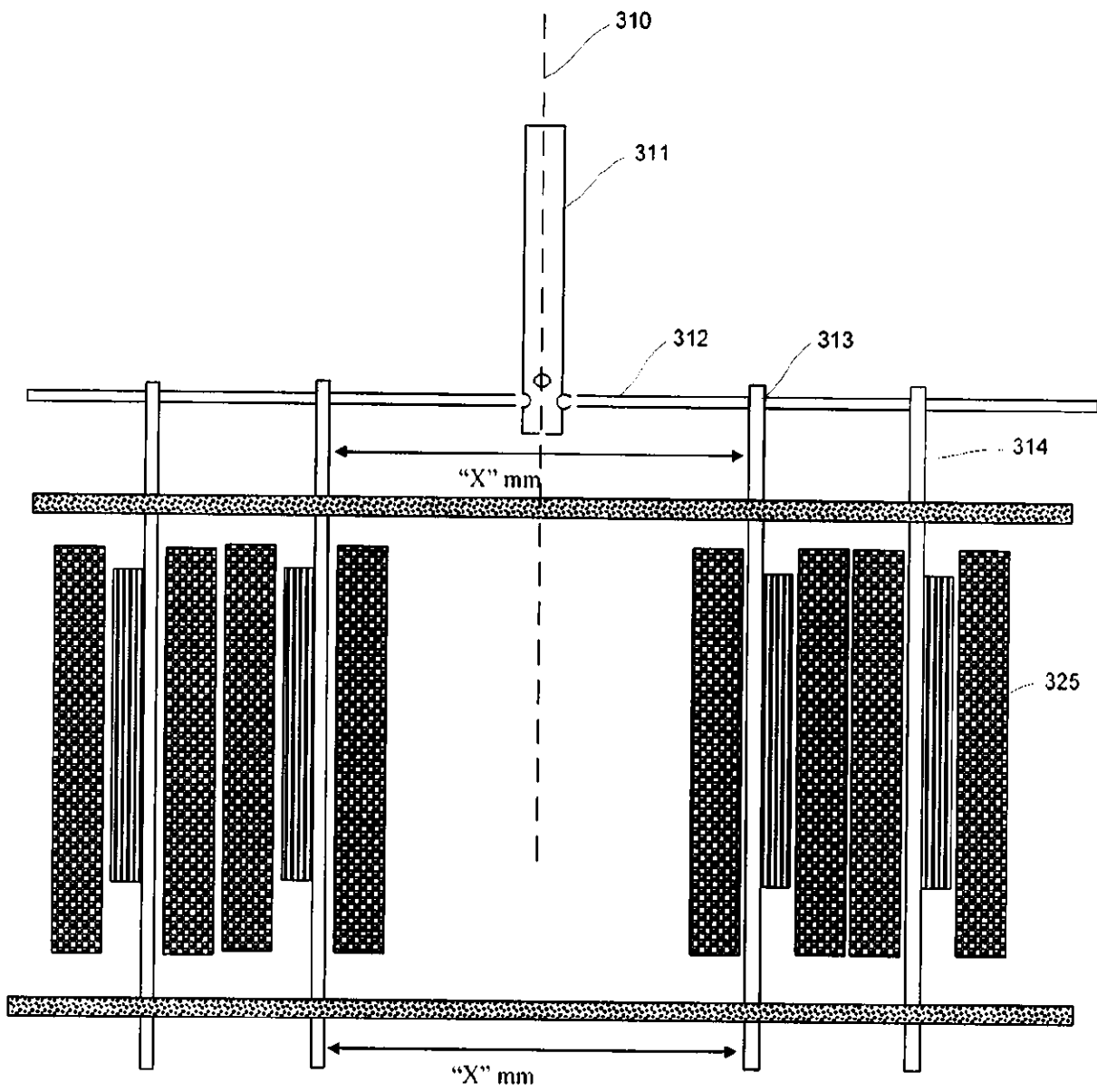
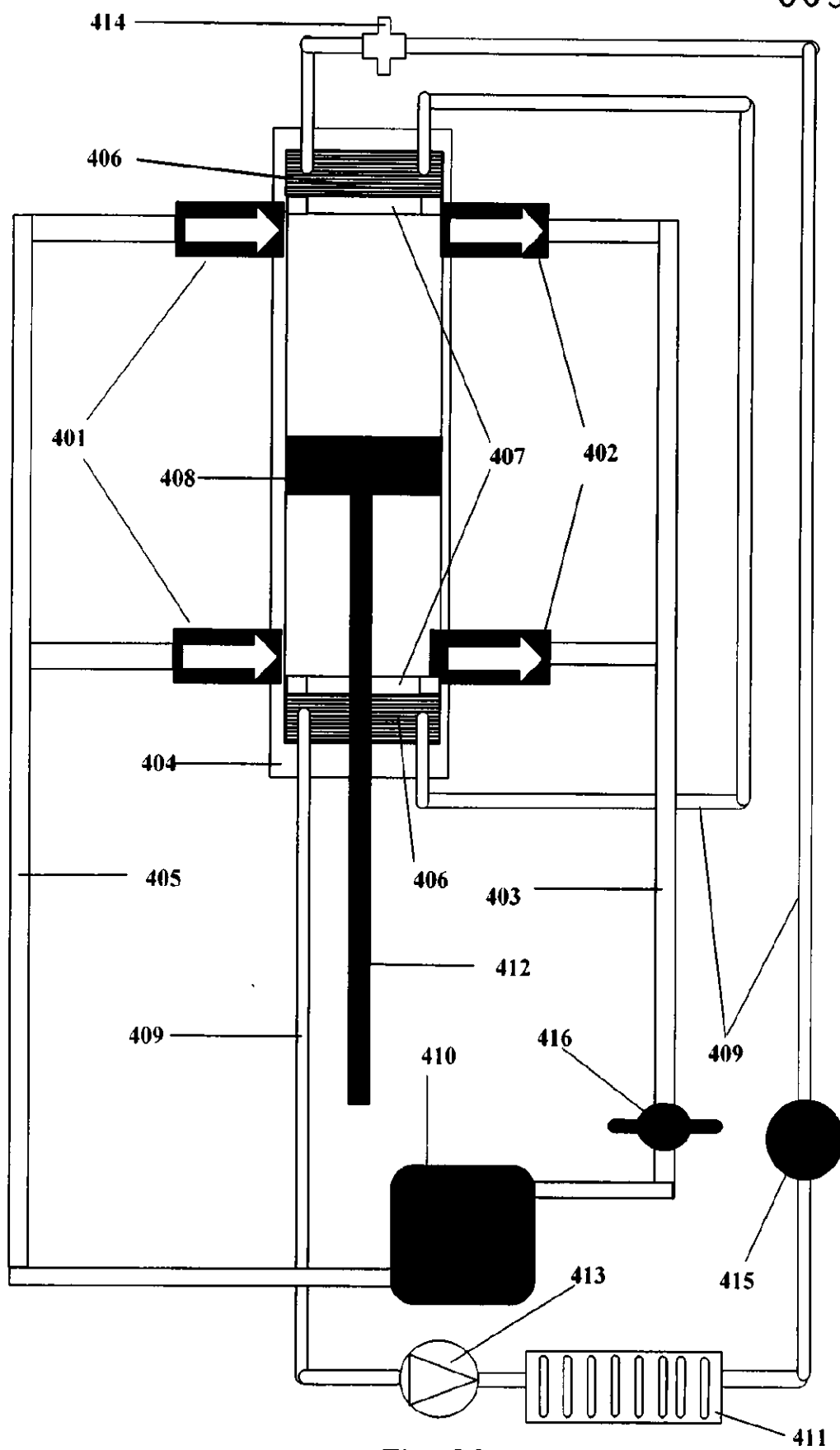


Fig. 19



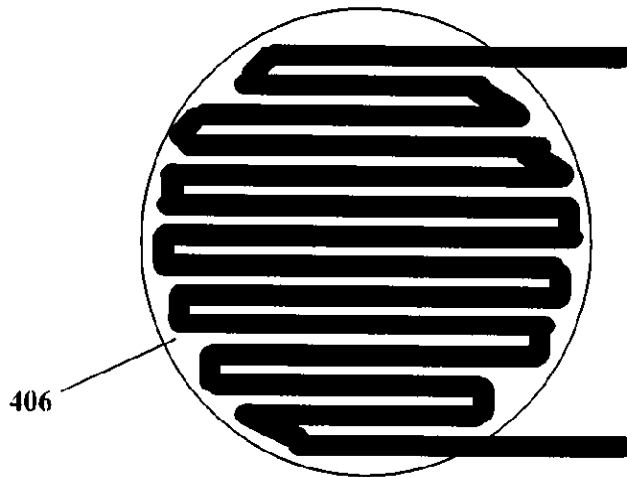


Fig. 21