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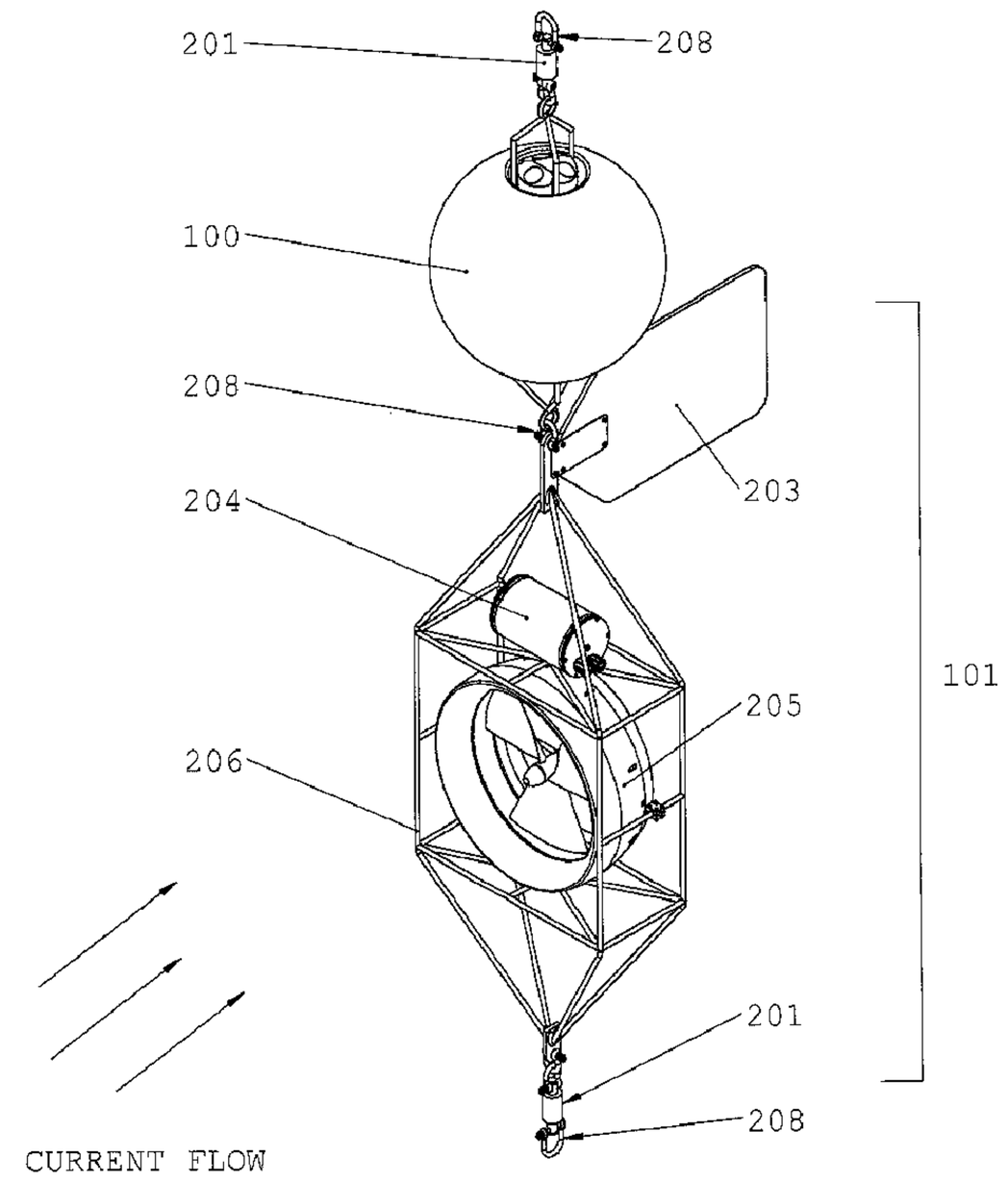
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(54) Titre : MODULE DE GENERATION D'ENERGIE DESTINE A DES AMARRES DE CAPTEUR OCEANOGRAPHIQUE
(54) Title: POWER GENERATION UNIT FOR OCEANOGRAPHIC SENSOR MOORINGS



(57) Abrégé/Abstract:
An oceanographic sensor mooring section for use with standard oceanographic moorings comprising: mooring oceanographic equipment, such as floatation devices and sensors; and a subsurface power generation unit connected to the mooring

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(57) Abrégé(suite)/Abstract(continued):
oceanographic equipment, wherein the mooring section has connective swivels at opposing ends thereof for attachment of the mooring section to standard oceanographic moorings, mooring lines, or mooring anchors, to allow the mooring section to independently orient in the direction of current flow. The subsurface power generation unit comprises a battery and power management / tracking electronics and a rim turbine generating unit that harnesses the power of underwater currents to power any sensors and related electronics equipment.

ABSTRACT

An oceanographic sensor mooring section for use with standard oceanographic moorings comprising: mooring oceanographic equipment, such as floatation devices and sensors; and a subsurface power generation unit connected to the mooring oceanographic equipment, wherein the mooring section has connective swivels at opposing ends thereof for attachment of the mooring section to standard oceanographic moorings, mooring lines, or mooring anchors, to allow the mooring section to independently orient in the direction of current flow. The subsurface power generation unit comprises a battery and power management / tracking electronics and a rim turbine generating unit that harnesses the power of underwater currents to power any sensors and related electronics equipment.

POWER GENERATION UNIT FOR OCEANOGRAPHIC SENSOR MOORINGS

FIELD OF THE INVENTION

This invention relates to oceanographic moorings. In particular, the present invention relates to power generation units that can supply power to oceanographic sensor moorings, and more particularly to power generation units that can supply power from ocean currents to standard oceanographic sensor moorings.

BACKGROUND OF THE INVENTION

A mooring in oceanography is a collection of devices, connected to a wire and anchored on the seabed/sea floor, lake bed, river bed, or bed of other waterway. Typically, the mooring is held up in the water column by a variety of subsurface or surface floatation devices (steel floats, glass floats, plastic floats, etc.), and held in place on the waterway bed with a heavy anchor. Devices attached to the mooring often comprise sensors of various types that are designed to measure various conditions or things found in the ocean. For example, the sensors could include devices such as current meters, conductivity / temperature / depth sensors, and other biological sensors.

Unfortunately, because of the impracticability of directly connecting these sensors to typical power generation plants, these sensors are very often powered via one or more batteries or battery packs, all of which have a limited lifespan once deployed. There is thus a significant cost to maintaining oceanographic moorings. For one, these batteries require periodic changing, some on relatively short intervals, such as every six or twelve months. To replace the batteries, a crew and vessel are required to travel to the mooring to replace the

battery or battery pack. Vessel and crew costs can be extremely high. To minimize this cost and to achieve deployments of longer duration, electricity use may be minimized in order to try to prolong the lifespan of the battery or battery pack. One way of accomplishing this is to reduce the sampling rate of the sensors so as to lower their average power consumption and thereby reduce the amount of power drawn from the battery or battery pack. Naturally, this results in the sensors capturing less data over a given time period, which is not ideal for research or the like. If, however, real time data is desired or a necessity, because acoustic or inductive telemetry systems that allow for the capture and transmission of real time data require a lot of power, this drains the battery or battery pack quickly, thereby increasing maintenance costs for such applications.

There are a variety of known methods of providing power to traditional moorings, including two methods that are surface mounted. The first is solar based, drawing power from the sun through panels located at the water surface. The second is a wave power harvesting system, which generates power from ocean waves, again at the surface of the water. The latter type of systems are disclosed in, for example, U.S. Patent No. 6,791,205 B2 (Woodbridge), U.S. Patent No. 6,647,716 B2 (Boyd), and U.S. Patent No. 7,535,117 B2 (Montgomery). The power in both the solar and wave powered cases is transmitted from the water's surface where it was generated down to instruments in the mooring through a power cable. However, because this distance can be considerable in a deep water mooring, a lengthy cable must be used at significant cost.

It is also known to convert the mechanical energy from subsurface ocean currents into electrical energy, and a great deal of effort has been expended commercially to develop large scale tidal turbine systems, including those for grid-tied applications. For example, U.S. Patent No. 4,026,587 (Hultman and Hultman) discloses an underwater turbine to be mounted on a seabed by way of a large concrete base, upon which is rotatably mounted a large electric generator. However, such a system is not suitable for mounting on moorings to provide power to sensor systems. Indeed, there are few existing small-scale power generation systems for oceanographic applications, even though there is an ever increasing number of reasons for taking ocean measurements, and a greater need for small-scale power generation systems that can support sensor arrays to take these measurements. Historically, for example, most of the measurement programs being conducted in the ocean have been sponsored by governments and operated and managed by scientists and engineers from international ocean research institutions and scientific agencies. There have also been a number of specialized ocean measurement programs that have been sponsored and carried out by the navies of the world for defense-related purposes. Today, however, there are a substantial and ever increasing number of commercial organizations that are starting to appreciate the need to collect and analyze information, including real-time information, about the physical, chemical, and biological processes that are occurring in various undersea locations around the world. Whether it be for the advancement of pure science, for health and human safety reasons, for military protection purposes, or for commercial exploitation, ocean observation and measurement is an emerging and growing market.

It would be desirable to employ a small-scale subsurface power generation system that can augment traditional oceanographic mooring designs by harvesting power from ocean currents and providing it to sensors in the mooring itself, with the potential benefits of allowing the sensors to operate and be powered for longer periods of time (i.e. increased deployment duration), whether in shallow or deep water, while maintaining or increasing the amount of data that may be captured as a result thereof (including the option of real-time data collection), as well as reducing maintenance costs.

It would further be desirable to use such a subsurface power generation system with traditional oceanographic moorings and their associated sensors in order to extend the lifespan and/or increase the usability of these moorings and sensors by allowing them to be recycled or re-used, thereby avoiding or minimizing replacement and upgrade costs.

SUMMARY OF THE INVENTION

The present invention provides a subsurface apparatus for supplying power to sensors / systems mounted on traditional oceanographic moorings that allows those sensors / systems to operate unattended for relatively long periods of time in shallow or deep water environments. In particular, the present invention provides a subsurface mooring power generation unit that can be used to augment existing mooring designs, harvest power from ocean currents and provide the power to sensors / instruments in the mooring. The power generation unit is generally comprised of: a rim turbine generating unit, and batteries and power management / tracking electronics, each of which is attached to a stainless steel frame, and swivels at

opposing ends of the unit for attachment to typical mooring equipment to allow the entire unit to orient itself into the ocean current flow to maintain power supply.

More particularly, in one embodiment, the present invention provides an oceanographic sensor mooring section for use with standard oceanographic moorings comprising: mooring oceanographic equipment; and a subsurface power generation unit connected to said mooring oceanographic equipment, wherein said mooring section has connective swivels at opposing ends thereof for attachment of said mooring section to standard oceanographic moorings, mooring lines, or mooring anchors, to allow said mooring section to independently orient in the direction of current flow. The mooring oceanographic equipment may comprise a floatation device, and may further comprise a sensor for measuring one or more of physical, chemical or biological processes in an undersea environment. The subsurface power generation unit harnesses power from underwater currents. The subsurface power generation unit generally comprises a battery and power management / tracking electronics, and a rim turbine generating unit, each connected to a frame. The battery and power management / tracking electronics may comprise a lithium battery pack and associated electronics housed in a pressure housing. The rim turbine generating unit comprises a blade and rotor assembly rotatably connected to and within a venturi cowling and stator assembly by means of a shaft connected to said stator assembly that passes through the centre of said blade and rotor assembly. The blade and rotor assembly comprises at least three turbine blades the distal ends of which are attached to a cylindrical rotor thereof comprising magnets arranged in a Halbach array configuration, wherein said blade and rotor assembly is capable of rotating on the shaft that

passes through the centre of said blade and rotor assembly on bearings. The rim turbine generating unit may further comprise a venturi cowling cap releasably connected to the venturi cowling and stator assembly and a nose cone releasably connected to a free end of the shaft of the venturi cowling and stator assembly. The venturi cowling and stator assembly comprises coils, a venturi cowling mount and at least 3 venturi cowling support rods. The coils may comprise at least 36 coils, each of said coils comprising 55 turns of 18awg magnet wire and configured for 3 phase power output. The venturi cowling cap increases flow speed near the tips of the turbine blades and provides drag to orient the rim turbine generating unit in the direction of current flow. The rim turbine generating unit may also be associated with an alignment fin that assists in keeping said unit aligned in the direction of current flow. In addition, the rim turbine generating unit and alignment fin may pivot about a pivot point to allow the rim turbine generating unit to be self-compensating for mooring inclination.

In another embodiment, the present invention provides a subsurface power generation unit that harnesses power from underwater currents for use with standard oceanographic moorings comprising: a battery and power management / tracking electronics; and a rim turbine generating unit, wherein each of said battery and power management / tracking electronics and rim turbine generating unit is connected to a perpendicular frame, and wherein said frame has connective swivels at opposing ends thereof for attachment of said subsurface power generation unit to mooring oceanographic equipment, standard oceanographic moorings, mooring lines, or mooring anchors, to allow said subsurface power generation unit to independently orient in the direction of current flow. The battery and power management /

tracking electronics may comprise a lithium battery pack and associated electronics housed in a pressure housing. The rim turbine generating unit comprises a blade and rotor assembly connected to a venturi cowling and stator assembly by means of a shaft connected to said venturi cowling and stator assembly that passes through the centre of said blade and rotor assembly. The blade and rotor assembly comprises at least three turbine blades the distal ends of which are attached to a cylindrical rotor thereof comprising magnets arranged in a Halbach array configuration, wherein said blade and rotor assembly rotates on the shaft that passes through the centre of said blade and rotor assembly on bearings. The rim turbine generating unit may further comprise a venturi cowling cap releasably connected to the venturi cowling and stator assembly and a nose cone releasably connected to a free end of the shaft of the venturi cowling and stator assembly. The venturi cowling and stator assembly comprises coils, a venturi cowling mount and at least 3 venturi cowling support rods. The coils comprise at least 36 coils, each of said coils comprising 55 turns of 18awg magnet wire and configured for 3 phase power output. The venturi cowling cap increases flow speed near the tips of the turbine blades and provides drag to orient the rim turbine generating unit in the direction of current flow. The rim turbine generating unit may also be associated with an alignment fin that assists in keeping said generating unit aligned in the direction of current flow. The rim turbine generating unit and alignment fin may pivot about a pivot point to allow the rim turbine generating unit to be self-compensating for mooring inclination.

In yet another embodiment, the present invention provides an underwater rim turbine generating unit for use with standard

oceanographic moorings that is capable of harnessing power from underwater currents comprising a blade and rotor assembly connected to a venturi cowling and stator assembly by means of a shaft connected to said venturi cowling and stator assembly and that passes through the centre of said blade and rotor assembly. The blade and rotor assembly comprises at least three turbine blades the distal ends of which are attached to a cylindrical rotor thereof comprising magnets arranged in a Halbach array configuration, wherein said blade and rotor assembly rotates on the shaft that passes through the centre of said blade and rotor assembly on bearings. The rim turbine generating unit may further comprise a venturi cowling cap releasably connected to the venturi cowling and stator assembly and a nose cone releasably connected to a free end of the shaft of the venturi cowling and stator assembly. The venturi cowling and stator assembly comprises coils, a venturi cowling mount, and at least 3 venturi cowling support rods. The coils comprise at least 36 coils, each of said coils comprising 55 turns of 18awg magnet wire and configured for 3 phase power output. The venturi cowling cap increases flow speed near the tips of the turbine blades and provides drag to orient the rim turbine generating unit in the direction of current flow.

BRIEF DESCRIPTION OF THE DRAWINGS

In the detailed description which follows, reference will be made to the following drawings which illustrate embodiments of the present invention and, together with the description, serve to explain the principles and advantages of the present invention:

FIGURE 1 is a profile view showing a typical oceanographic mooring on the left alongside one augmented with an embodiment of a power generation unit of the present invention.

FIGURE 2a is a perspective view of a power generation unit attached to typical mooring oceanographic equipment in accordance with one embodiment of the present invention.

Figure 2b is a perspective view of a power generation unit attached to typical mooring oceanographic equipment in accordance with a second embodiment of the present invention.

Figure 2c is a perspective view of a power generation unit attached to typical mooring oceanographic equipment in accordance with a third embodiment of the present invention.

FIGURE 3 is a perspective view showing an embodiment of the rim turbine generating unit of the present invention, as fully assembled and with indication of water current flow.

FIGURE 4 is an exploded perspective view of the general components of a rim turbine generating unit, in accordance with one embodiment of the present invention.

FIGURE 5 is a perspective view of the blade and rotor assembly of an embodiment of the rim turbine generating unit of the present invention, with a cutaway portion showing the magnets therein.

FIGURE 6 is a perspective view of an embodiment of a rim turbine generating unit of the present invention, with a cutaway portion showing the coils of the venturi cowling and stator assembly.

DETAILED DESCRIPTION OF THE INVENTION

Various non-limiting embodiments of the invention will now be described. Variants of these embodiments will be apparent to those skilled in the art.

With reference to **Figure 1**, on the left side of this Figure is shown a traditional oceanographic mooring, comprising typical mooring oceanographic equipment **100** (in this example, generally floatation devices), each connected by wire / line **102**, and attached to an anchor means **103** to anchor the mooring to a specific location above the seabed. Of course, anchor means **103** may be any means of anchoring the mooring oceanographic equipment **100** in a manner sufficient to hold such in place above a specific location on the seabed, in both reversible or irreversible manner, including typical anchors of all types. Sensors may be attached to any point of this oceanographic mooring, including, for example above, below or within the mooring oceanographic equipment **100**, so that the sensor is correctly positioned to take measurements at the depth required. The term "wire / line **102**" is used as a descriptive term only, this element being the link(s) that conjoin the various mooring oceanographic equipment **100** in the mooring as well as to the anchor means **103**. It will be understood that while normally a wire is used in wire / line **102**, and preferably a wire composed of metal and preferably a metal that does not rust on contact with water or salt water, the term wire / line can also comprise fabric materials such as ropes or cords, or even a multiplicity of solid rods, as the case and conditions warrant.

On the right side of **Figure 1** is shown an embodiment of the present invention, including mooring oceanographic equipment **100** (again, in this example, generally including floatation devices), anchor means **103**, wire / line **102**, but also augmented with power generation units **101** of the present invention. In the case of the embodiment shown in **Figure 1**, two power generation units **101** are depicted attached below two of the mooring oceanographic equipment **100**. It should be understood that more or fewer links in the oceanographic mooring can be added / removed to increase or decrease its length, as required. Also, it should be understood that more or fewer power generation units **101** can be added to the mooring, even conjoined together, both above or below the mooring oceanographic equipment **100**, as desired.

Figure 2a shows an enlarged perspective view of one of the mooring oceanographic equipment **100** mounted above power generation unit **101**, as shown in **Figure 1**. In the embodiment shown in **Figure 2a**, power generation unit **101** comprises at least one rim turbine generating unit **205**, and battery and power management / tracking electronics **204**, each of which is mounted to a frame **206**. Specifically, in this embodiment, rim turbine generating unit **205** is mounted to and within frame **206**, such that frame **206** protects and surrounds the rim turbine generating unit **205** without blocking water flow through it. More specifically, frame **206** is shown in **Figure 2a** as a cage generally surrounding the rim turbine generating unit **205** and battery and power management / tracking electronics **204**. However, the exact shape of frame **206** is not important to the function of the invention as shown in this embodiment provided it does not significantly block or negatively affect water flow to the rim turbine generating unit **205**. Frame **206** can therefore

be made in almost any shape and therefore may depend on the level of protection desired. In this respect, in another embodiment where protection of rim turbine generating unit **205** and battery and power management / tracking electronics **204** is of lesser concern, frame **206** may simply comprise a long vertical rod on which is mounted battery and power management / tracking electronics **204**, and from which may extend perpendicularly thereto a secondary horizontal rod on which the rim turbine generating unit **205** may be mounted, as shown in **Figure 2b**. In such an embodiment, the rim turbine generating unit **205** is capable of orienting itself downstream of the water current flow by action of water drag. Such an embodiment thereby allows the power generation unit **101** to maximize power generating capacity. Frame **206** can be made of any material that can support and optionally protect the rim turbine generating unit **205** and battery and power management / tracking electronics **204**, and is preferably comprised of lightweight, strong, and corrosion resistant material such as stainless steel or aluminum. In this respect, frame **206** is more preferably made from stainless steel, but can be any material suitable for long term underwater use, and having the necessary strength to reliably hold the components of the present invention.

Power generation unit **101** (and mooring oceanographic equipment **100**) are generally optionally but preferably rotatably connected to another power generation unit **101**, wire / line **102**, mooring oceanographic equipment **102**, or the like, as shown in **Figure 2a**, via a connector **208**, which in **Figure 2a** is shown as two interlocking rings, but can be any attachment means thought suitable including rigid connecting means. Power generation unit **101** (and mooring oceanographic equipment **102**) can also be attached to those devices / parts and the like noted above by a

swivel **201** (also shown in **Figure 2a**), which more readily allows the power generation unit **101** or mooring oceanographic equipment **100**, or the like, to freely rotate in the water current. Allowing the power generation unit **101** to independently and naturally orient itself allows for maximal power generation by allowing the unit to orient into water flow, while also minimizing torsional and rotational strain and stress on the mooring oceanographic equipment **100** and power generation unit **101**.

As shown in **Figure 2a**, power generation unit **101** may also have an optional alignment fin **203** associated therewith, which serves to assist in keeping the power generation unit **101** aligned into current flow for more efficient power generation. Alignment fin **203** is preferably coupled with frame **206** such that any movement of fin **203** will also move the frame **206** as desired. Thus, if the rim turbine generating unit **205** is placed within frame **206** with its axis perpendicular to the axis of alignment of fin **203**, as shown in **Figure 2a**, this will assist to maximize generating capacity out of rim turbine generating unit **205**. In particular, the subsurface water current will push on alignment fin **203**, thereby orienting the frame **206** and coupled rim turbine generating unit **205** so that it is perpendicular to the current flow direction. The current then drives rim turbine generating unit **205**, generating power that is fed to batteries and power management / tracking electronics **204**, which in turn feeds the electricity to any sensors (not shown) that may be mounted on frame **206**, or above, below or within mooring oceanographic equipment **100**. Another embodiment of a power generation unit **101** with a fin **203** that is winged, and with a pivot point **209** is shown in **Figure 2c**. This embodiment is similar to that shown in **Figure 2a** in terms of operation, but the pivot point **209** further

enables the rim turbine generating unit **205** to be self-compensating for mooring inclination as well as flow direction because the moments due to gravity and buoyancy acting on either side of the pivot point **209** are equal.

Batteries and power management / tracking electronics **204** can comprise any battery pack system suitable for accepting power from the rim turbine generating unit **205** and supplying it to the sensors desired to be used in connection with the oceanographic mooring system of the present invention. In one preferred embodiment, the batteries and power management / tracking electronics **204** can, for instance, comprise a 12.8V to 25.6V lithium battery pack and associated electronics housed in a pressure housing. The batteries may be recharged by a power tracking unit (not shown) and the battery power is then fed through a subsea connector to the sensor(s) attached to the oceanographic mooring (not shown). Such tracking unit is preferably capable of rectifying the three-phase AC to get a large DC voltage (which is usable from 14 to 500V). This voltage is then stepped down preferably using a buck converter to a voltage close to the battery voltage. The tracking unit measures the power that is going into the battery pack, and constantly adjusts the voltage to maintain the maximum amount of power. The batteries and power management / tracking electronics **204** should have safeguards in place to shut down the buck converter when the battery is fully charged to prevent overcharging and to not decrease the lifespan of the battery. As well, the batteries and power management / tracking electronics **204** should be capable of balancing the individual battery cells. This improves battery pack performance and lifespan. The foregoing would be well known to persons skilled

in the art and further details are therefore unnecessary in this regard.

Rim turbine generating unit **205** contains no gearbox, and has few rotating mechanical components when compared to those turbines and generators known in the art, which improves low speed flow startup. A preferred embodiment of rim turbine generating unit **205** in fully assembled form is shown in **Figure 3** with an indication of water current flow. **Figure 4** shows an exploded perspective view of a preferred embodiment of those parts / components that make up the rim turbine generating unit **205** of the present invention (i.e. in disassembled form), thereby allowing a person skilled in the art to readily understand how to make said rim turbine generating unit **205**.

Shown as the middle component in **Figure 4** is blade and rotor assembly **401**, which is essentially the component of the rim turbine generating unit **205** that rotates from water currents to generate power. Assembly **401** rotatably mounts on the shaft **405** of venturi cowling and stator assembly **402** (the rightmost component shown in **Figure 4**) preferably with the use of bearings **503** (see **Figure 5**) to reduce friction between moving parts. In this respect, as the blade and rotor assembly **401** is mounted on shaft **405**, the outer circumference of blade and rotor assembly **401** rotatably fits within the inner circumference of the venturi cowling and stator assembly **402**. The blade and rotor assembly **401** is further shown by itself in **Figure 5**, and comprises a number of turbine blades **501** (shown with three blades but the number of blades can be adjusted from upwards of 2 as necessary) that are, for instance, NACA5420 flared blades having a pitch of around 3.7". As shown in **Figure 5**, the entire outer circumference of blade and rotor assembly **401** comprises magnets

502 embedded there within. For instance, the entire outer circumference of blade and rotor assembly **401** could comprise 48 grade N52 neodymium magnets **502** arranged preferably in a Halbach array configuration embedded there within.

The venturi cowling and stator assembly **402** is preferably fabricated without iron (i.e. no iron laminations as might be utilized in a typical motor / generator apparatus) in order to eliminate the effects of cogging (or "no-current") torque. As shown in **Figure 4**, venturi cowling support rods **407** are mounted at peripheral ends thereof to the inner surface of the solid outer shell circumference (cowling) of venturi cowling and stator assembly **402**, and attach at inner opposing ends thereof to a venturi cowling mount **408** that is located in the centre of venturi cowling and stator assembly **402**. Support rods **407** can be of any number and shape as deemed necessary, so long as they do not significantly interfere with or obstruct the flow of water through assembly **402**. While the venturi cowling support rods **407** provide structural support to the cowling and mount **408**, the mount **408** prevents rotation of the venturi cowling and stator assembly **402** relative to the blade and rotor assembly **401** when assembly **401** is rotating and generating power. Tail cone **404** is releasably attached to mount **408** and is shaped to reduce turbulence as water passes through the rim turbine generating unit **205**. The solid shell (outer circumference or cowling) of assembly **402** houses coils preferably of enamel coated magnet wire **601** configured for 3 phase output. For instance, the device could be fabricated with 36 coils **601** of wire embedded throughout the entire circumference there within, each preferably with 55 turns of 18awg magnet wire(12 coils per phase). In this respect, **Figure 6** shows a perspective view of a fully assembled rim turbine generating unit **205** of the present

invention, with a cutaway portion showing the coils **601** that are contained and embedded within the entire outer circumference (cowling) of the venturi cowling and stator assembly **402**. When the blade and rotor assembly **401** is spinning as a result of water currents pushing against turbine blades **501**, the flux from the spinning magnets **502** in the blade and rotor assembly **401** induces a current in the embedded coils **601** in the cowling of the venturi cowling and stator assembly **402**. It is this current that is then managed by the battery and power management / tracking electronics **204** to power sensors in the mooring oceanographic equipment **100**.

Leftmost in **Figure 4** is the venturi cowling cap **406**, which preferably is capable of releasably coupling with venturi cowling and stator assembly **402** (the rightmost component in **Figure 4**) when rim turbine generating unit **205** is fully assembled. Similarly, when fully assembled, nose cone **403** is releasably mounted on the free end of shaft **405**. The venturi cowling cap **406** and nose cone **403** are preferably shaped so as to reduce turbulence and increase the water flow speed near the tips of turbine blades **501** (see **Figure 5**) on blade and rotor assembly **401** and improve overall turbine performance, as well as provide the drag required to orient the turbine downstream of the flow, but this element is not essential to the basic functioning of the rim turbine generating unit **205**.

Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alternations can be made herein without departing from the spirit and scope of the invention as defined by the appended claims. The invention achieves multiple objectives and because the invention can be used in different

applications for different purposes, not every embodiment falling within the scope of the attached claims will achieve every objective.

Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the disclosure of the present invention, processes, machines, manufactures, compositions of matter, means, methods or steps, presenting existing or later to be developed that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present invention. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

CLAIMS:

We claim:

1. An oceanographic sensor mooring section for use with standard oceanographic moorings comprising:

mooring oceanographic equipment; and

a subsurface power generation unit connected to said mooring oceanographic equipment,

wherein said mooring section has connective swivels at opposing ends thereof for attachment of said mooring section to standard oceanographic moorings, mooring lines, or mooring anchors, to allow said mooring section to independently orient in the direction of current flow.

2. An oceanographic sensor mooring section as claimed in claim 1 wherein the mooring oceanographic equipment comprises a floatation device.

3. An oceanographic sensor mooring section as claimed in claim 2 wherein the mooring oceanographic equipment further comprises a sensor for measuring one or more of physical, chemical or biological processes in an undersea environment.

4. An oceanographic sensor mooring section as claimed in any one of claims 1 to 3 wherein said subsurface power generation unit harnesses power from underwater currents.

5. An oceanographic sensor mooring section as claimed in claim 4 wherein said subsurface power generation unit

comprises a battery and power management / tracking electronics, and a rim turbine generating unit, each connected to a frame.

6. An oceanographic sensor mooring section as claimed in claim 5 wherein said battery and power management / tracking electronics comprises a lithium battery pack and associated electronics housed in a pressure housing.

7. An oceanographic sensor mooring section as claimed in any one of claims 5 or 6 wherein said rim turbine generating unit comprises a blade and rotor assembly rotatably connected to and within a venturi cowling and stator assembly by means of a shaft connected to said stator assembly that passes through the centre of said blade and rotor assembly.

8. An oceanographic sensor mooring section as claimed in claim 7 wherein said blade and rotor assembly comprises at least three turbine blades the distal ends of which are attached to a cylindrical rotor thereof comprising magnets arranged in a Halbach array configuration, wherein said blade and rotor assembly is capable of rotating on the shaft that passes through the centre of said blade and rotor assembly on bearings.

9. An oceanographic sensor mooring section as claimed in claim 8 wherein said rim turbine generating unit further comprises a venturi cowling cap releasably connected to the venturi cowling and stator assembly and a nose cone releasably connected to a free end of the shaft of the venturi cowling and stator assembly.

10. An oceanographic sensor mooring section as claimed in any one of claims 7 to 9 wherein said venturi cowling and stator assembly comprises coils, a venturi cowling mount and at least 3 venturi cowling support rods.

11. An oceanographic sensor mooring section as claimed in claim 10 wherein said coils comprises at least 36 coils, each of said coils comprising 55 turns of 18awg magnet wire and configured for 3 phase power output.

12. An oceanographic sensor mooring section as claimed in claim 9 wherein said venturi cowling cap increases flow speed near the tips of the turbine blades and provides drag to orient the rim turbine generating unit in the direction of current flow.

13. An oceanographic sensor mooring section as claimed in any one of claims 5 to 12 wherein said rim turbine generating unit is associated with an alignment fin that assists in keeping said unit aligned in the direction of current flow.

14. An oceanographic sensor mooring section as claimed in claim 13 wherein said rim turbine generating unit and said alignment fin pivot about a pivot point to allow the rim turbine generating unit to be self-compensating for mooring inclination.

15. A subsurface power generation unit that harnesses power from underwater currents for use with standard oceanographic moorings comprising:

a battery and power management / tracking electronics; and

a rim turbine generating unit,

wherein each of said battery and power management / tracking electronics and rim turbine generating unit is connected to a perpendicular frame,

and wherein said frame has connective swivels at opposing ends thereof for attachment of said subsurface power generation unit to mooring oceanographic equipment, standard oceanographic moorings, mooring lines, or mooring anchors, to allow said subsurface power generation unit to independently orient in the direction of current flow.

16. A subsurface power generation unit as claimed in claim 15 wherein said battery and power management / tracking electronics comprises a lithium battery pack and associated electronics housed in a pressure housing.

17. A subsurface power generation unit as claimed in any one of claims 15 or 16 wherein said rim turbine generating unit comprises a blade and rotor assembly connected to a venturi cowling and stator assembly by means of a shaft connected to said venturi cowling and stator assembly that passes through the centre of said blade and rotor assembly.

18. A subsurface power generation unit as claimed in claim 17 wherein said blade and rotor assembly comprises at least

three turbine blades the distal ends of which are attached to a cylindrical rotor thereof comprising magnets arranged in a Halbach array configuration, wherein said blade and rotor assembly rotates on the shaft that passes through the centre of said blade and rotor assembly on bearings.

19. A subsurface power generation unit as claimed in claim 18 wherein said rim turbine generating unit further comprises a venturi cowling cap releasably connected to the venturi cowling and stator assembly and a nose cone releasably connected to a free end of the shaft of the venturi cowling and stator assembly.

20. A subsurface power generation unit as claimed in any one of claims 17 to 19 wherein said venturi cowling and stator assembly comprises coils, a venturi cowling mount and at least 3 venturi cowling support rods.

21. A subsurface power generation as claimed in claim 20 wherein said coils comprise at least 36 coils, each of said coils comprising 55 turns of 18awg magnet wire and configured for 3 phase power output.

22. A subsurface power generation unit as claimed in claim 19 wherein said venturi cowling cap increases flow speed near the tips of the turbine blades and provides drag to orient the rim turbine generating unit in the direction of current flow.

23. A subsurface power generation unit as claimed in any one of claims 15 to 22 wherein said rim turbine generating unit is associated with an alignment fin that assists in

keeping said generating unit aligned in the direction of current flow.

24. A subsurface power generation unit as claimed in claim 23 wherein said rim turbine generating unit and said alignment fin pivot about a pivot point to allow the rim turbine generating unit to be self-compensating for mooring inclination.

25. An underwater rim turbine generating unit for use with standard oceanographic moorings that is capable of harnessing power from underwater currents comprising a blade and rotor assembly connected to a venturi cowling and stator assembly by means of a shaft connected to said venturi cowling and stator assembly and that passes through the centre of said blade and rotor assembly.

26. An underwater turbine unit as claimed in claim 25 wherein said blade and rotor assembly comprises at least three turbine blades the distal ends of which are attached to a cylindrical rotor thereof comprising magnets arranged in a Halbach array configuration, wherein said blade and rotor assembly rotates on the shaft that passes through the centre of said blade and rotor assembly on bearings.

27. An underwater turbine unit as claimed in claim 26 wherein said rim turbine generating unit further comprises a venturi cowling cap releasably connected to the venturi cowling and stator assembly and a nose cone releasably connected to a free end of the shaft of the venturi cowling and stator assembly.

28. An underwater turbine unit as claimed in any one of claims 25 to 27 wherein said venturi cowling and stator assembly comprises coils, a venturi cowling mount, and at least 3 venturi cowling support rods.

29. An underwater turbine unit as claimed in claim 28 wherein said coils comprise at least 36 coils, each of said coils comprising 55 turns of 18awg magnet wire and configured for 3 phase power output.

30. An underwater turbine unit as claimed in claim 27 wherein said venturi cowling cap increases flow speed near the tips of the turbine blades and provides drag to orient the rim turbine generating unit in the direction of current flow.

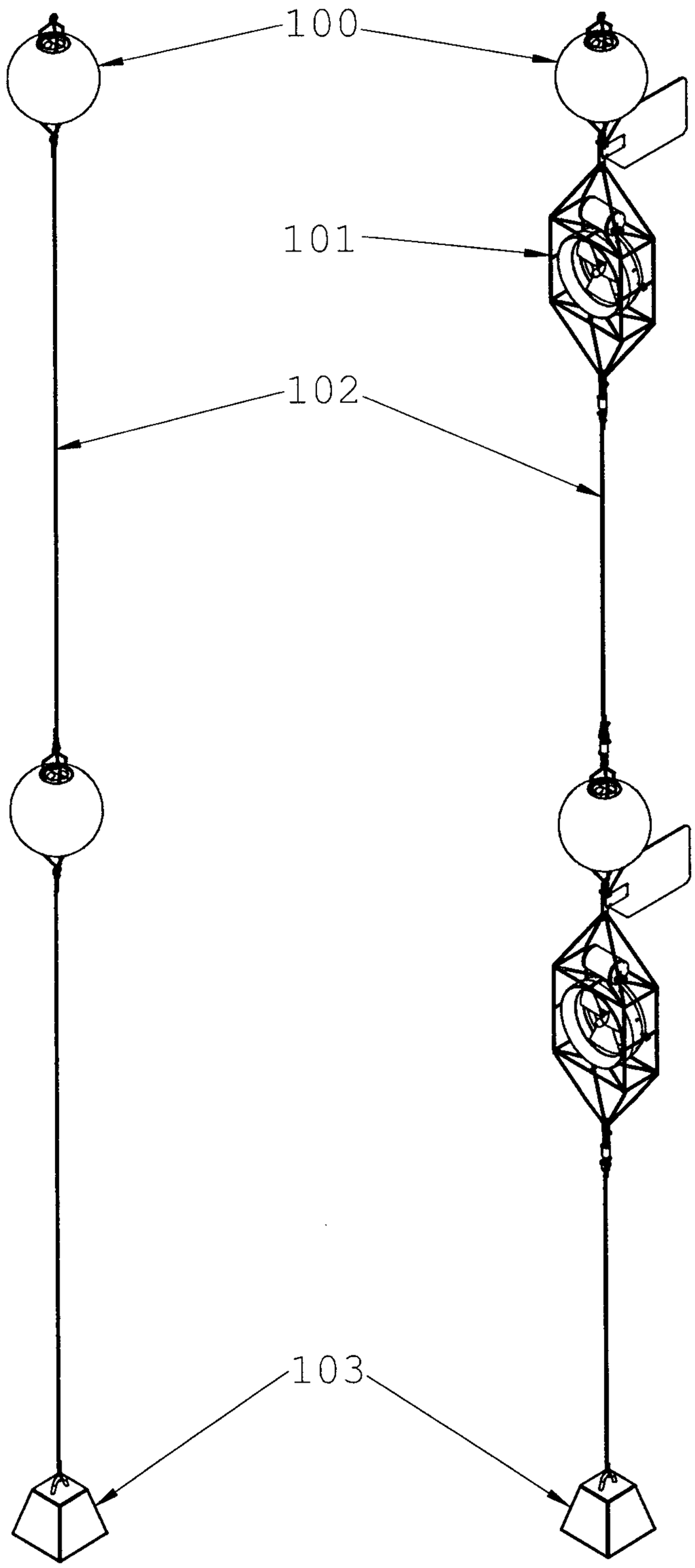


Figure 1

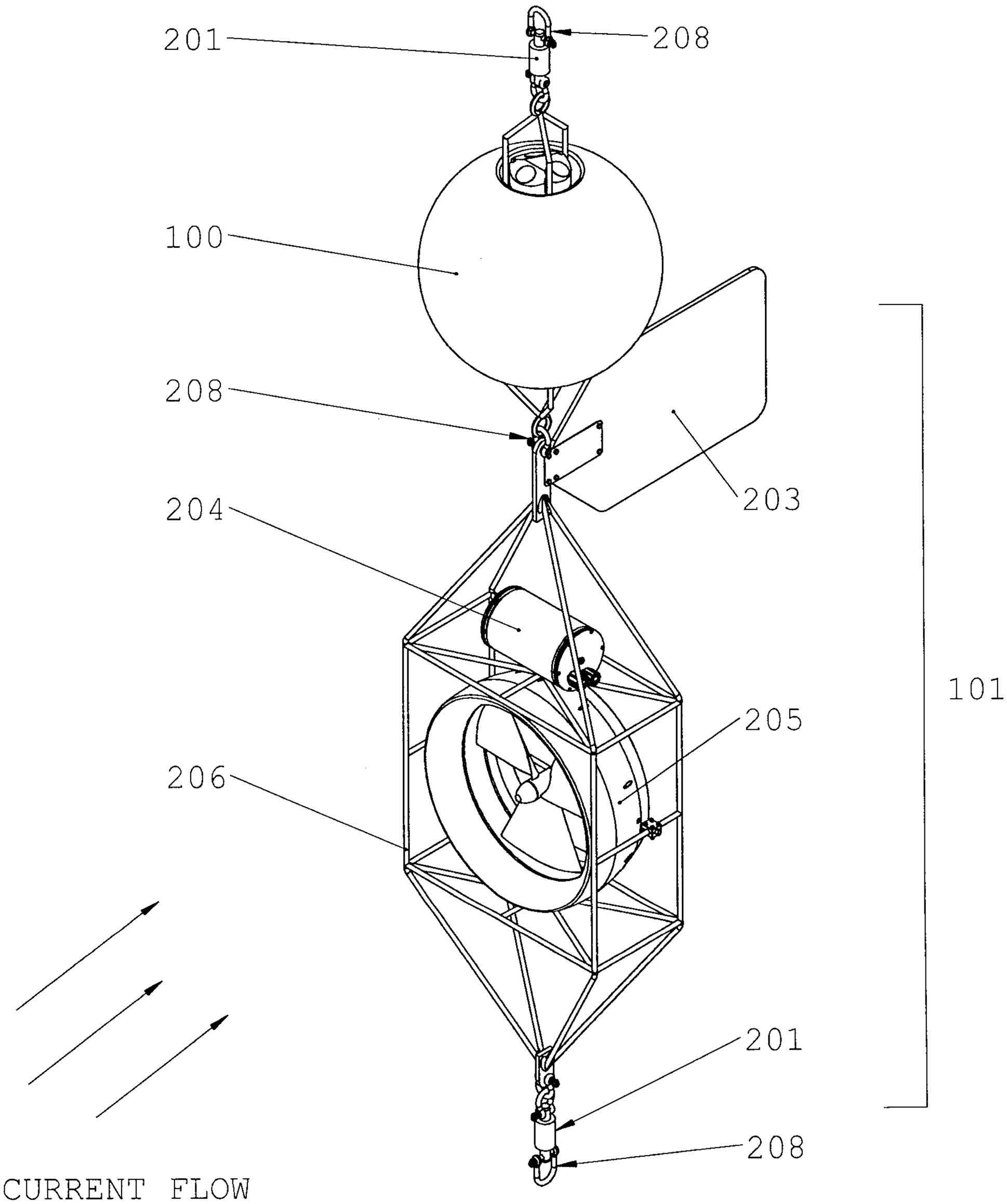


Figure 2a

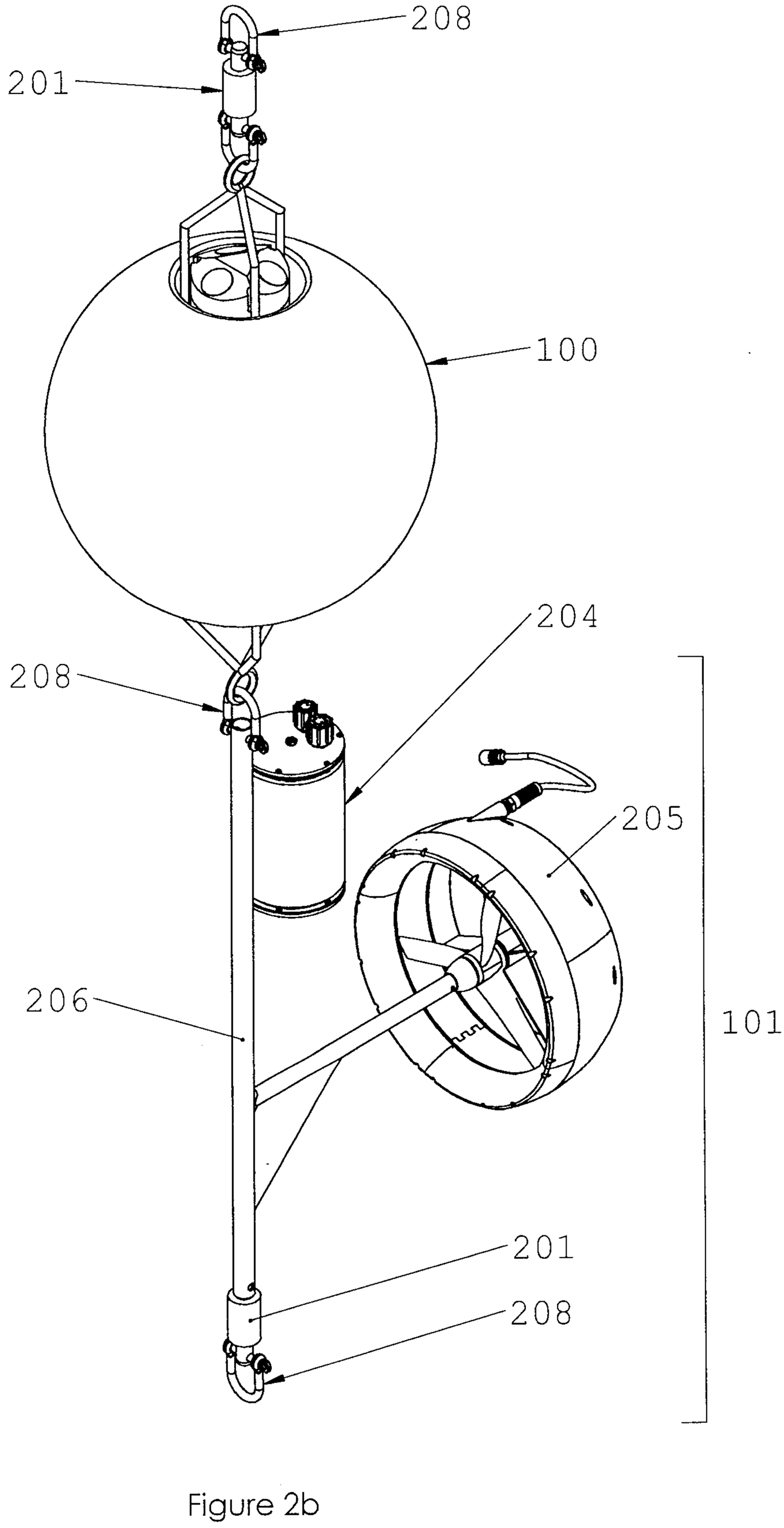


Figure 2b

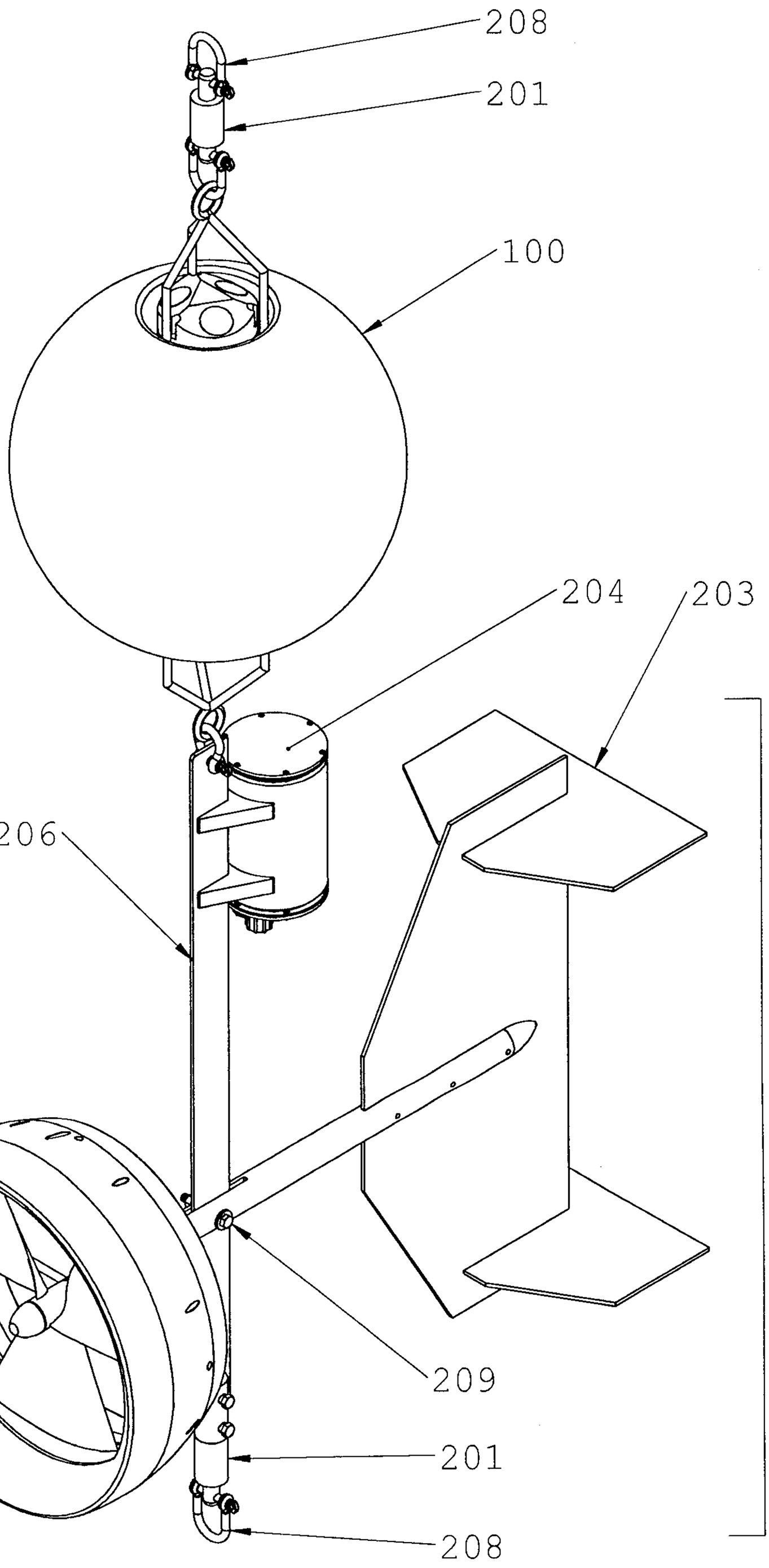


Figure 2c

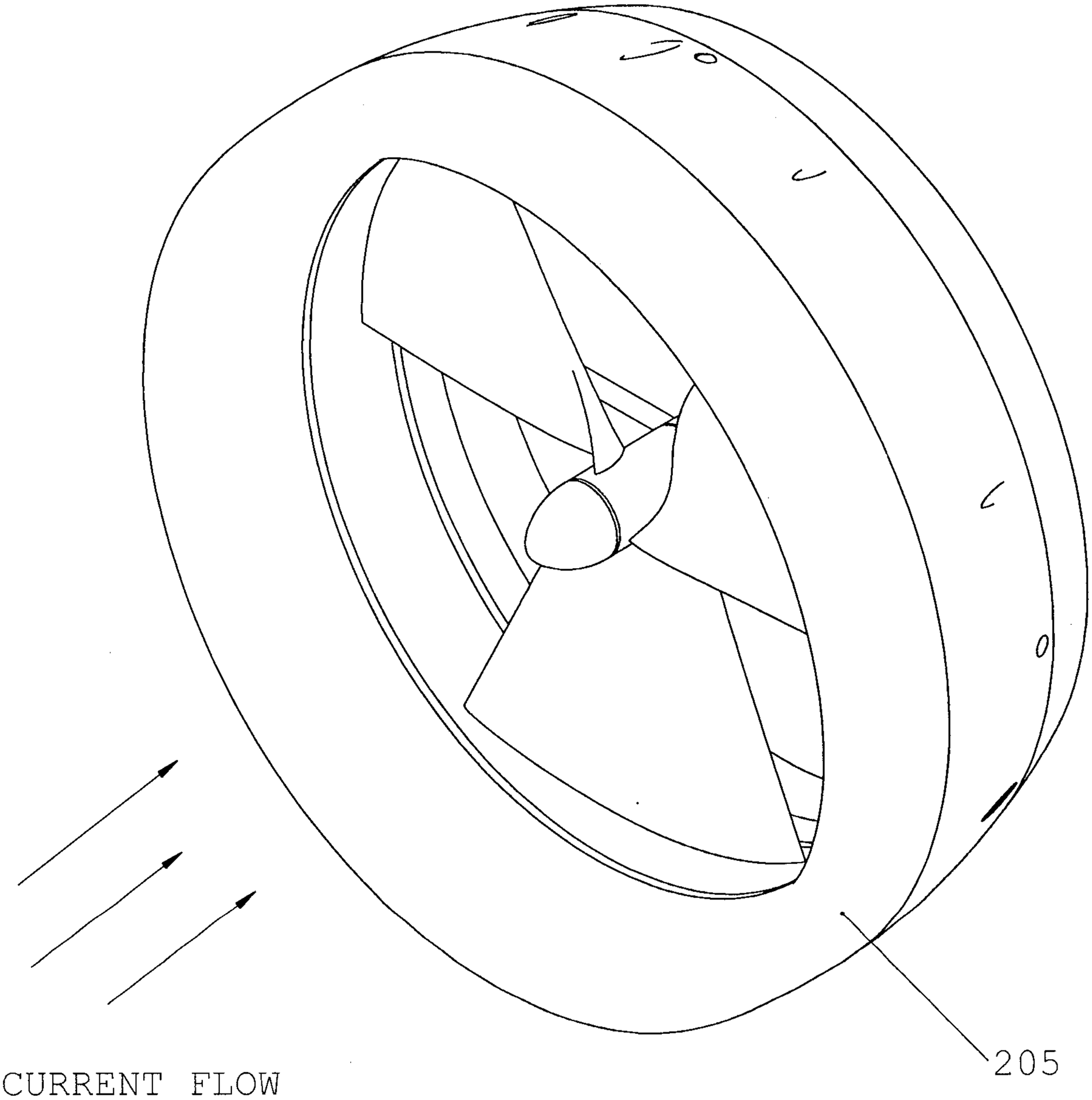


Figure 3

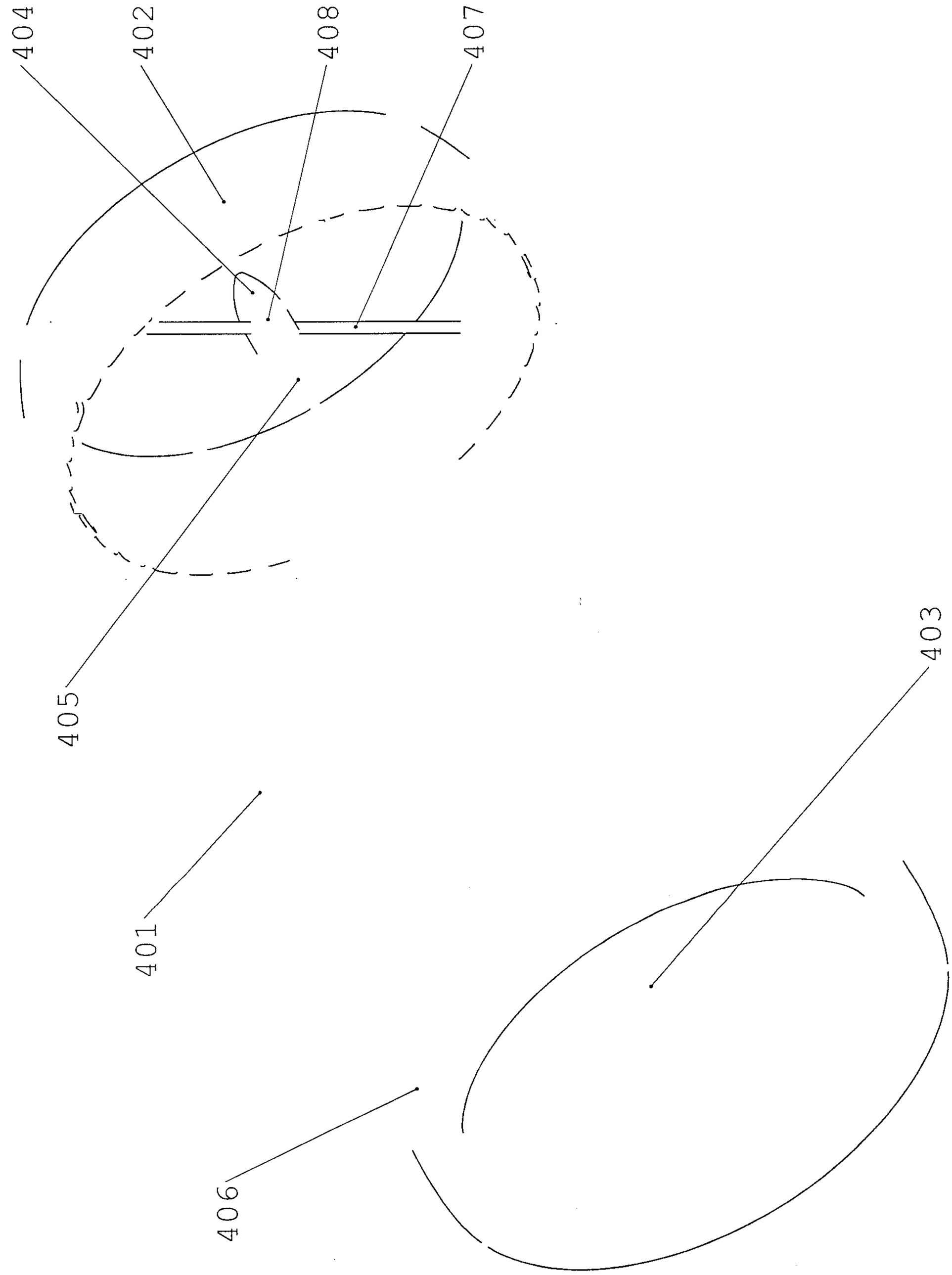


Figure 4

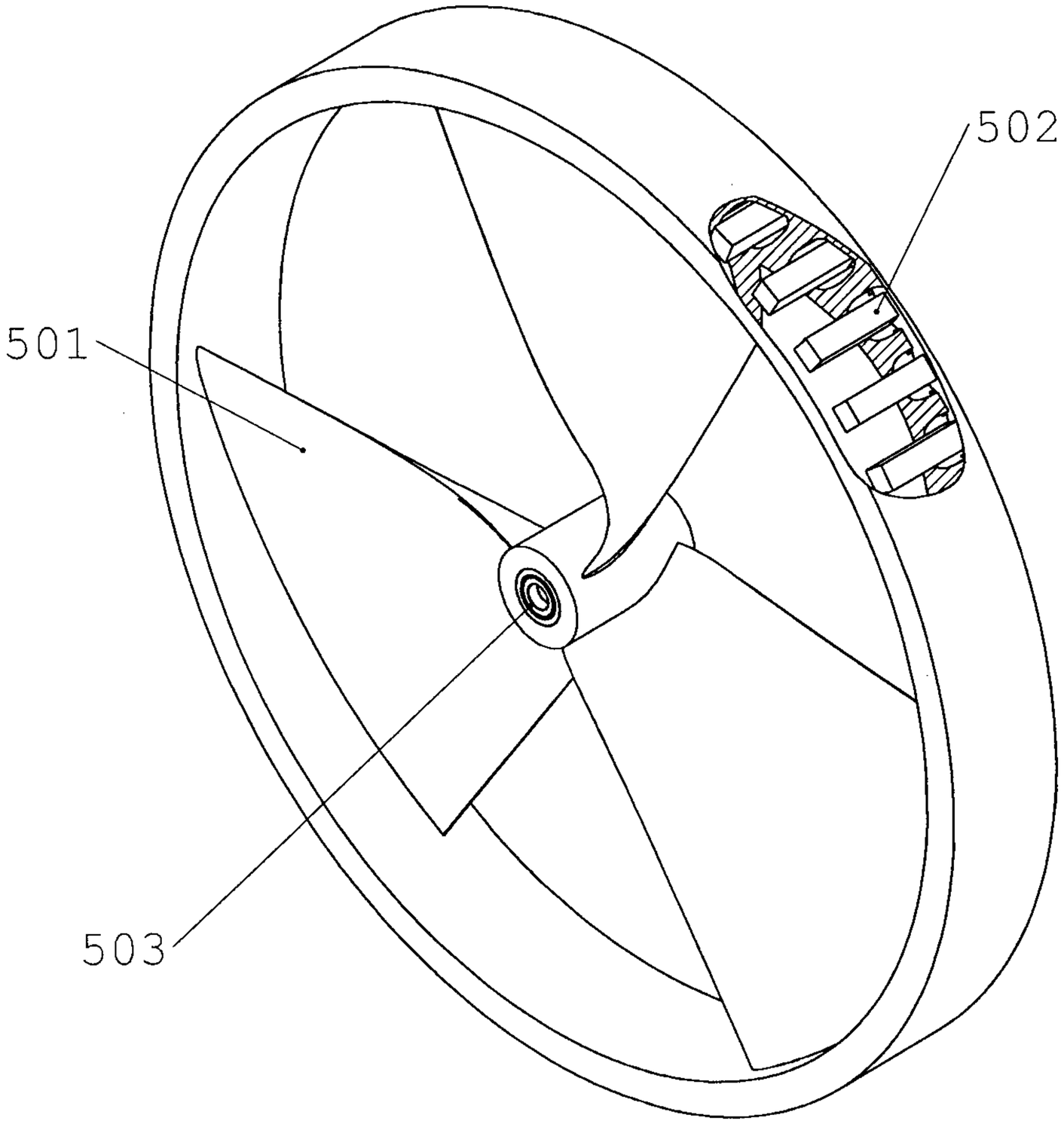


Figure 5

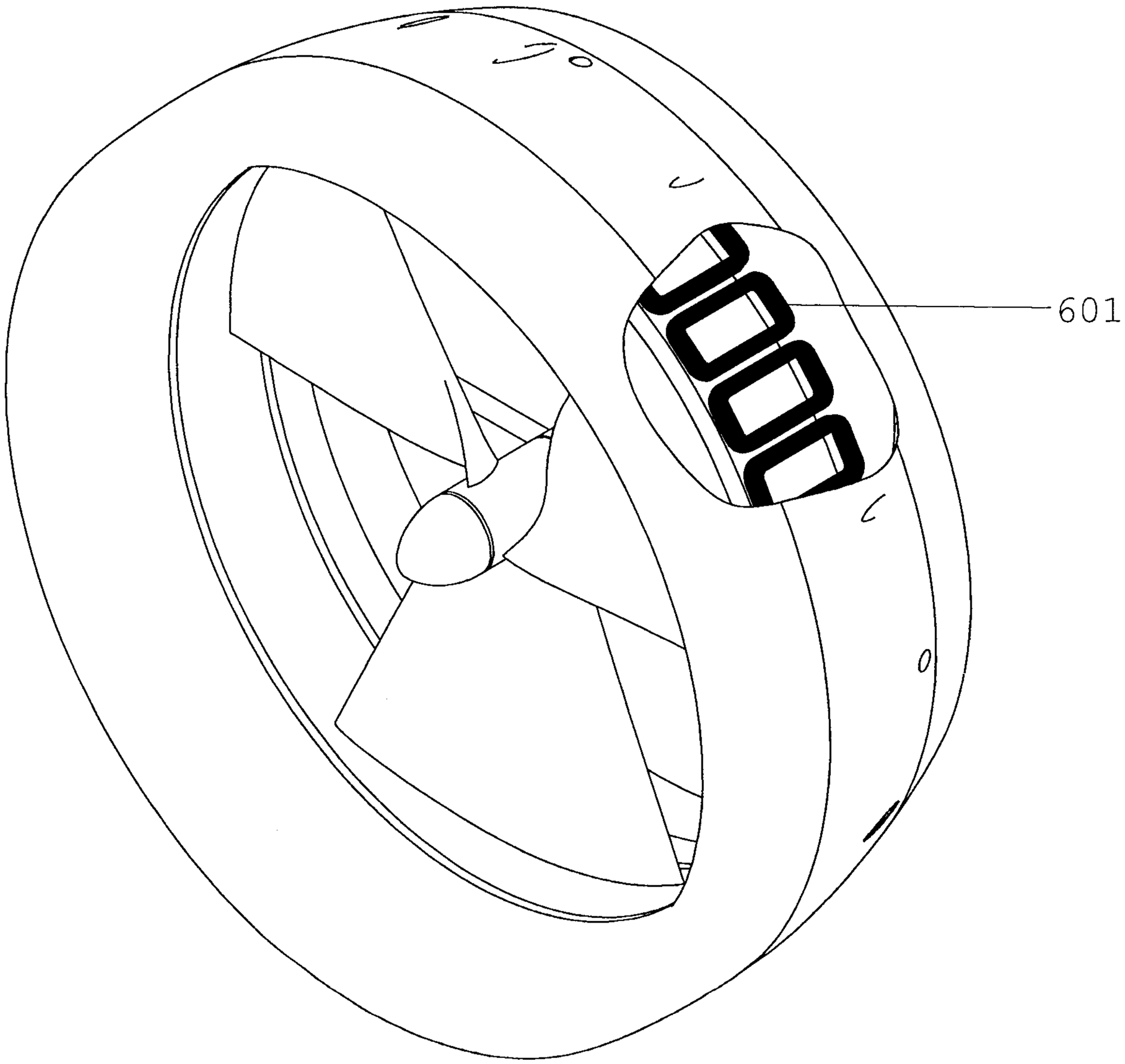
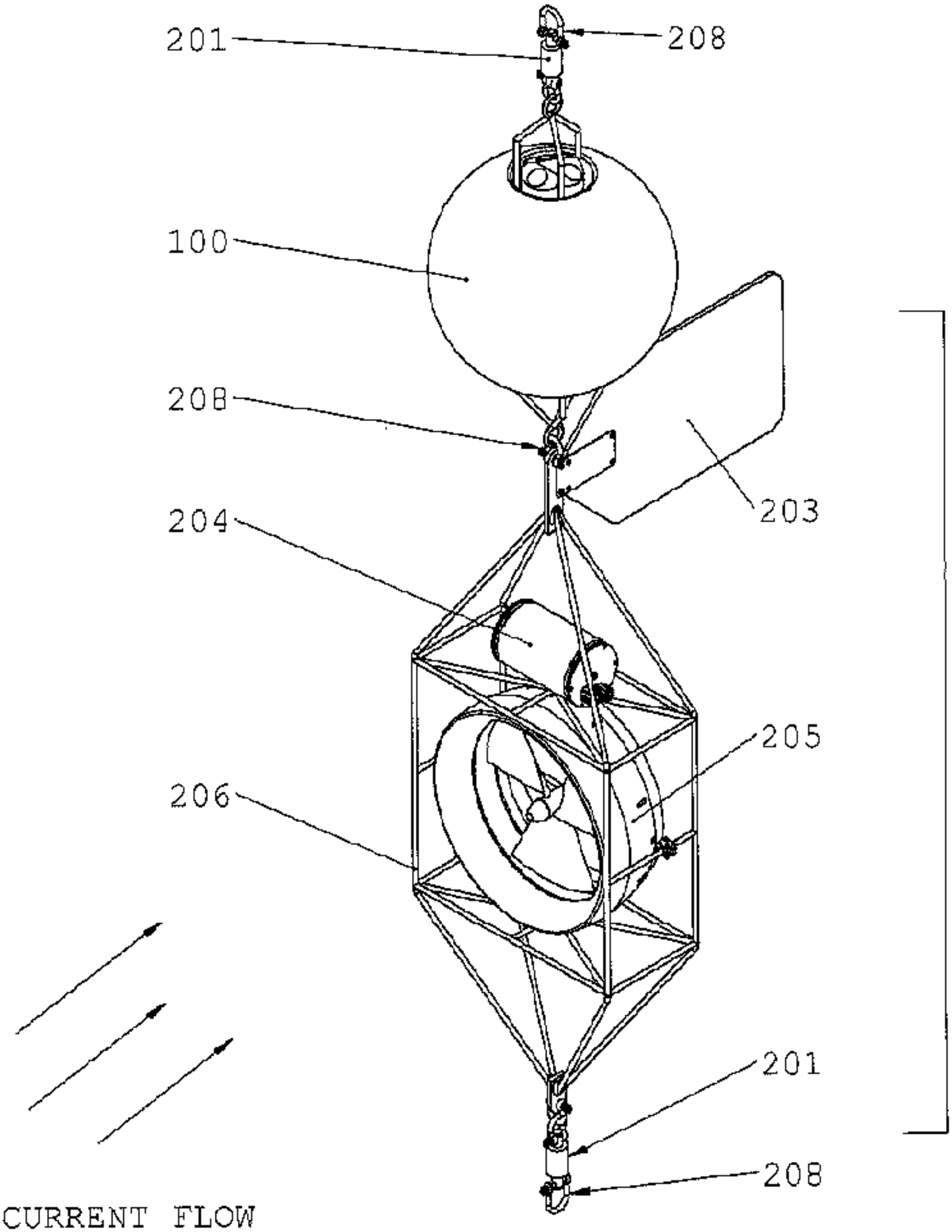


Figure 6


201
208
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CURRENT FLOW