(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
09 January 2020 (09.01.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/008236 A1

(51) International Patent Classification:
F03B 13/14 (2006.01)

(21) International Application Number:
PCT/IB2018/054988

(22) International Filing Date:
06 July 2018 (06.07.2018)

(25) Filing Language: English

(26) Publication Language: English

(72) Inventor; and
(71) Applicant: KABOODVANDY RAD, modjtaba [IR/IR]; fazel street, fazeli alley, Bijar 0098 (IR).

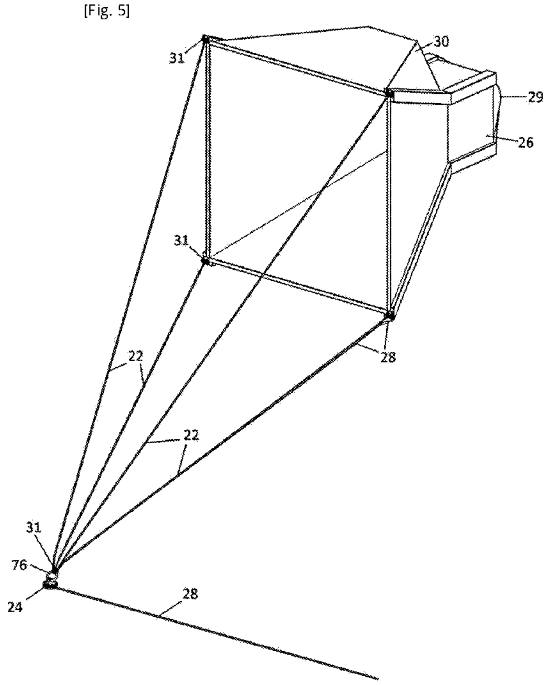
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) Title: SUBMERSIBLE CURRENT POWER PLANT

[Fig. 5]



(57) Abstract: Marine current energy is at an early stage of development. Air and water are fluids but both have a lot of differences in their properties. While ocean currents move slowly relative to typical wind speeds, they carry a great deal of energy because of the density of water. Submersible turbine with Buoyant Moored collector is different current technology concept, because direction of ocean currents continually are changed, in this embodiment duo to possibility of rotation on one point that apparatus tethered to that point, power plant always could operate in maximum efficiency, and collectors with large intake duo to incompressibility of water could extract kinetic and potential energy in efficient small turbines. This embodiment can be utilized successfully at a commercial scale because a number of engineering and technical challenges, including: avoidance of cavitation; prevention of marine growth buildup; reliability, are addressed.

WO 2020/008236 A1

Description

Title of Invention : Submersible Current Power Plant

Technical Field

[0001] This invention relates generally to water current power plants, and, more specifically to submersible turbine with buoyant moored collector that can extract ocean, tidal and river current energies.

Background Art

[0002] Growing global energy demand creates a dual challenge: providing energy to meet people's needs while managing the risks of climate change. Renewable energy is collected from renewable resources, which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat.

[0003] Marine energy could be a safe alternative to increasing energy demand. No standard ocean stream generator has emerged as the clear winner, among a large variety of designs. Six principal types of ocean current energy converter are recognize so far. They are horizontal axis turbines, vertical axis turbines, oscillating hydrofoils, venturi devices, Archimedes screws and tidal kites.

Summary of Invention

[0004] Energy and climate change are defining challenges of this century. Energy underpins economic growth. Modern energy and its path is shaped by countless forces. The challenge of providing the energy supplies that power the global economy is coupled with the need to do so in ways that reduce energy-related greenhouse gas emissions and mitigate the risk of climate change.

[0005] In general, progress on energy and climate goals requires practical solutions that are reliable, affordable, and cost-effective. Many opportunities exist to reduce CO2 emissions, and since the costs vary widely and can be substantial, societies should adopt policies targeting CO2 emissions that will minimize the related costs that are ultimately borne by consumers and tax-payers.

[0006] Renewables growth supported by policies to reduce CO2 emissions. Solar energy is about double the cost of wind for curbing emissions in the United States. These renewable energies such as solar and wind can't solve challenge. While ocean currents move slowly relative to typical wind speeds, they continuously carry a great deal of energy because of the density of water.

[0007] All fluids in two category liquids and gases are classifying. The main difference is in compressibility. Using collector has advantages on the basis of incompressibility feature. Volume of fluid in the collector can be considered as control volume, that applied force on one side will cause force on opposite side duo to incompressibility. In this case turbines can with high efficiency extract kinetic and potential energy. More energy can be extracted with larger collector.

[0008] The movement of water in the world's oceans creates a vast store of kinetic energy or energy in motion. This energy can be harnessed to generate electricity. Strong ocean currents are generated from a combination of temperature, wind, salinity, bathymetry, and the rotation of the Earth. Ocean stream generators draw energy from water currents in much of the same way as wind turbines draw energy from air currents. However, the potential for power generation by an individual ocean current or tidal turbine can be greater than that of similarly rated wind energy turbine. The higher density of water relative to air (water is about 800 times the density of air) means that a single generator can provide significant power at low tidal flow velocities compared with similar wind speed.

[0009] Relative to wind, wave, and tidal resources, the energy resource potential for ocean current power is the least understood, and its technology is the least mature. Ocean-current-generated energy technologies have many favorable characteristics, including the following:

Water currents have a relatively high energy density.

Some ocean currents are relatively constant in location and velocity, leading to a large capacity factor (fraction of time actively generating energy) for the turbines.

They are installed beneath the water's surface, water turbines have minimal visual impact.

[0010] There are only small fluctuations in current speed and stream location with no changes in direction, ocean currents may be suitable locations for deploying energy extraction devices such as turbines.

[0011] There are a number of different current technology concepts under development. Several types of open-flow devices can be used in marine-current-power applications; many of them are modern descendants of the waterwheel or similar. However, the more technically sophisticated designs, derived from wind-power rotors, are the most likely to achieve enough cost-effectiveness and reliability to be practical in a massive marine-current-power future scenario. Even though there is no generally accepted term for these open-flow hydro-turbines, some sources refer to them as water-current turbines. There are two main types of water current turbines that might be considered: axial-flow horizontal-axis propellers, and cross-flow vertical-axis Darrieus rotors. Both rotor types may be combined with any of the three main methods for supporting water-current turbines: floating moored systems, sea-bed mounted systems, and intermediate systems. Sea-bed-mounted mono-pile structures constitute the first-generation marine current power systems. They have the advantage of using existing and reliable engineering know-how, but they are limited to relatively shallow waters.

[0012] In accordance with one embodiment a submersible power plant comprises a tethered buoyant collector seamlessly coupled to an energy extraction unit that said energy extraction unit configured to extract energy from the flow of water provided by said tethered buoyant collector.

Advantageous Effects of Invention

[0013] Accordingly several advantages of one or more aspects are as follows: to embody submersible current power plant that there is no difficulty in generating large quantity of electricity ; that are more reliable, that they do not lead to the growing global warming problem; that the ultimate solution to the energy problems is the balance on many various power sources and current turbine's technology is the least mature; that ocean currents are relatively constant and flow in different direction, in contrast to tidal currents along the shore when turbines fixed to a point, energy can extracted in all direction; that are solely relies in the weather and that are consistent and predictable. Other advantages of one or more aspects will be apparent from a consideration of the drawings and ensuing description.

Brief Description of Drawings

[0014] The accompanying drawings, which are incorporated into and form a part of the specification, illustrate embodiments of the present invention and, together with the description, serve to explain the principles of the invention. In the drawings:

Fig.1

[0015] [fig.1] is a perspective view of a submersible turbine with buoyant collector that tethered to two or more fixed point.

Fig.2A

[0016] [fig.2A] is a perspective view of an external watertight casing (shroud) that covered shaft-less turbine.

Fig.2B

[0017] [fig.2B] is a perspective view of an internal casing that covered shaft-less turbine.

Fig.2C

[0018] [fig.2C] is a perspective view of a shaft-less turbine.

Fig.2D

[0019] [fig.2D] is an exploded perspective view of a shaft-less turbine.

Fig.3A

[0020] [fig.3A] is a perspective view of an internal watertight casing of a turbine.

Fig.3B

[0021] [fig.3B] is a perspective view of the turbine.

Fig.3C

[0022] [fig.3C] is a sectional side view of the turbine.

Fig.4

[0023] [fig.4] is a side view of the submersible turbine with buoyant tethered collector.

Fig.5

[0024] [fig.5] is a perspective view of the submersible turbine with buoyant collector that tethered to one point (in order to possibility of rotation and using current energy in all directions).

Fig.6A

[0025] [fig.6A] is a top side view of the submersible turbine with buoyant collector (that operate in ocean current).

Fig.6B

[0026] [fig.6B] is a top side view of the submersible turbine with buoyant collector (that tethered to one point and could operate in all direction of currents).

Fig.7

[0027] [fig.7] is a perspective view of the submersible turbine with buoyant collector that tethered by a chain and anchor.

Fig.8

[0028] [fig.8] is a perspective view of the submersible turbine with buoyant tethered flexible collector (with buoyant intake and a set of turbine that connected to intake by collector and cables for withstand in high pressure).

Fig.9

[0029] [fig.9] is a perspective view of the submersible turbine with buoyant tethered collector in tidal current.

Fig.10

[0030] [fig.10] is a perspective view of the submersible turbine with tethered collector and without buoyancy tanks in tidal current that fixed on river-bed or seabed.

[0031] Drawings are for purposes of illustrating the concepts of the invention and, except for the graphical illustration, are not to scale.

Description of Embodiments

[0032] Following description and the accompanying drawings provide examples for the purposes of illustration. However, these embodiments should not be construed in a limiting sense as they are not intended to provide an exhaustive list of all possible implementations. In other instances, certain structures and devices are omitted or simplified in order to avoid obscuring the details of the various embodiments. Various other components may be included and called upon for providing for aspects of the teachings herein. For example, additional materials, combinations of materials and/or omission of materials may be used to provide for added embodiments that are within the scope of the teachings herein. In the present application a variety of variables are described, including but not limited to components and conditions. It is to be understood that any combination of any of these variables can define an embodiment of the disclosure. Other combinations of articles, components, conditions, and/or methods can also be specifically selected from among variables listed herein to define other embodiments, as would be apparent to those of ordinary skill in the art.

[0033] When introducing elements of the present disclosure or the embodiment(s) thereof, the articles "a," "an," and "the" are intended to mean that there are one or more of the elements. Similarly, the adjective "another," when used to introduce an element, is intended to mean one or more elements. The terms "including" and "having" are intended to be inclusive such that there may be additional elements other than the listed elements.

[0034] As shown in Figs. 1 through 6, a submersible turbine with buoyant collector 20 that tethered to anchor 24 on seabed. One embodiment of the submersible turbine with buoyant collector 20 is illustrated in Fig.1. The submersible turbine has a collector 20 consisting of a stiffened plate of material which can be durable and supportive for turbine generator. In one embodiment, the wall of collector 20 is a metallic stiffened structure, such as steel, aluminum, etc. However, the wall of collector 20 can consist of any other flexible or inflexible material such as plastic, composite, etc.

[0035] There is a concern about how the creation of EMF and acoustic outputs may affect marine organisms. It should be noted that because these devices are in the water, the acoustic output can be greater than those created with offshore wind energy. Depending on the frequency and amplitude of sound generated by the ocean current or tidal energy devices, this acoustic output can have varying effects on marine mammals, particularly those who echolocate to communicate and navigate in the marine environment such as dolphins and whales. Since adding collector has advantages over traditional large blades ocean current devices. Ducted and shaft-less turbine have low acoustic outputs than traditional tidal turbines.

[0036] Fig. 1 shows a submersible turbine with buoyant collector 20 that it is positioned by a series of downwardly extending anchor cables 22 between anchors 24 and intake 27 of collector 20. Collector 20 can have any forms and sections. Said tethered buoyant collector could be made from light and buoyant material with or without buoyancy tanks. Said anchor cables is disposed between the inlet and sides of said buoyant collector and a plurality of said anchors, in order to tolerate all strong forces and operate in one direction. Based on current specification in any depth like near seabed, middle depth, near sea surface. The submersible turbine is preferably positioned a desired distance down the water's surface to maintain the equipment out of the reach of waves, ocean spray, etc. and avoid occupied space in sea surface and cause trouble for ships traffic. Thus, each turbine is provided as shown with a plurality of cable 22 with thimble eye machine swaged 31 or other kind of end termination on cables, which are judiciously disposed in front of collector 20, bottom the casing of turbine generator 26, etc. Turbines will support by the necessary buoyancy tank 30. This buoyancy tank 30 can be seamless with power plant or with cables joined to the submersible turbine (not shown).

[0037] At first buoyancy tanks 30 can be flooded or ballasted by opening the flood valves which are attached to each tank 30. The submersible turbine is free to guidably descend to the ocean floor. Each support anchor cable 22, is provided with a hold down cable assembly which extends from the cable winching equipment, downward to anchor 24. Basically, each anchor cable 22 is connected to an anchor 24 in such manner that when tension is applied to the cables through cable winching mechanism, the respective cables will be pulled uniformly tighter.

[0038] Ballast water is discharged by a suction pump and the flood valves are closed. When so released, the hull will slide to its place, because length of each cable and volume of buoyancy tank are designed and calculated. The hull will thereby be buoyed to its position at near of water's surface. As the submersible turbine pulled progressively downward into the water overcoming its own buoyancy by virtue of the tensioned hold down cables, the submersible turbine will become horizontal and more closely aligned in front of ocean current.

[0039] Anchors 24 rests on the seabed. Power cable 28 is attached to anchor cable 22 from the underside of the submersible turbine to the anchor 24. Also, Power cables 28 run from anchor 24 to destination that carries generated energy by the submersible turbine for consumption.

[0040] Ocean currents flow in complex patterns affected by wind, water salinity, temperature, topography of the ocean floor, and the earth's rotation. The Sun acts as the primary driving force, causing winds and temperature differences. Water is more than 800 times denser than air. So for the same surface area, water moving 12 miles per hour exerts the same amount of force as a constant 110 mph wind. Because of this physical property, ocean currents contain an enormous amount of energy that can be captured and converted to a usable form.

[0041] A turbine generator (or more) is disposed in the collector such that fluid moving through the collector motivates the turbine generator. Although turbine generator is disposed near outlet 29, turbine generator may be disposed at any position within collector 20. As shown in Figs. 2A through 2D, a shaft-less turbine that rest inside of watertight walls 34. Watertight walls 34 seamlessly joined to wall of collector 20. Although a turbine generator is used in this embodiment to generate energy or electricity, any device could be disposed in the fluid path to take advantage (e.g., mechanically or electrically) of the moving fluid. Fig. 2B shows watertight external casing 38 of turbine generator that rest inside watertight walls 34 with stiffener 36 and bolts 41 that inlet 33 of turbine generator join to collector 20 by bolts and nuts 40.

[0042] As shown in Fig. 2c, a shaft-less turbine generator includes a Main casing 46; long bolts and nuts 42; and Separable casing 44. Shaft-less turbine could have stationary guide vanes 32 to direct the working fluid at the appropriate angle towards the propeller. The distance between the downstream edges of the guide vanes 32 and the leading edges of the propeller will have a bearing on the size of fish that can safely pass through the turbine, and prevent from large fish, sharks, etc. to inter and injured by blades 52 of propellers. Fig. 2D shows a shaft-less turbine generator which includes a shaft-less propeller 50 supported by the ball bearing 48. Shaft-less propeller 50 have blades 52 fixed therein so that water will rotate the propeller 50 and thereby the shroud 54. A stator 58 which in use is fixed to the main casing 46, and a rotor 56 which is constrained for rotation within the stator 58 thereby and generate power.

[0043] As shown in Figs. 3A through 3C, a turbine that rest inside of watertight walls 34. Watertight walls 34 seamlessly joined to wall of collector 20. Fig. 3A shows watertight duct 61 of turbine generator that rest inside of watertight walls 34 with stiffener 36 and bolts 41 that inlet 33 of turbine generator join to collector 20 by bolts and nuts 40. Watertight duct 61 around the blades contains and controls the working fluid.

[0044] As shown in Fig. 3B, a turbine generator includes a blades 62; hub 64; fixed casing 68 of generator 72; strut 66; power cable 28; and conduit 60. Turbine could have stationary guide vanes to direct the working fluid at the appropriate angle towards the propeller (not shown). Fig. 3C shows a sectional view of turbine generator which includes a generator 72; blades 62; and hub 64 supported by struts 66. Fixed casing 68 of generator 72 will joined to shaft 70 by tiltable pad 74. Turbine have blades 62 fixed therein so that water will rotate the hub 64 and thereby the shaft 70. A generator 72 which in use is mounted on the fixed casing of generator 68, and a shaft 70 which is constrained for rotation within the generator 72 thereby and generate power.

[0045] Figs. 4 through 6, show the submersible turbine with buoyant tethered collector 20 that joined to single anchor 24. Fig 4 shows cables are joined to the bottom side of submersible turbine that turbine can be fixed horizontally. Fig 5 shows submersible turbines can be adapted to the variation in directions of ocean currents by utilize a single anchor 24 and/or a master-link 76. In this case (change in current direction) submersible turbines could change direction and stand in front of current and operate with maximum efficiency. Power cable 28 could along anchor cable 22 is transferred to seabed and then to shore.

[0046] Said anchor cables can be disposed between said buoyant collector and a master-link, that a plurality of said anchor cables is disposed between said master-link and said anchors for make possibility to rotation in order to operate in all current directions if single anchor can't tolerate forces (not shown).

[0047] As shown in Fig. 6A and 6B, the submersible turbine with buoyant collector 20 that tethered to one point and could operate in all direction of currents 79. In order to possibility of rotation and using current energy in all directions, whenever direction of ocean current is changed, apparatus can turn and placed against current automatically. In this case apparatus always can use current energy in all directions.

[0048] It has become necessary to go further offshore in search of adequate powerful ocean currents. However, the further offshore that one goes, the deeper the water will be. As a consequence, strong currents are being flowed regularly in greater than one thousand feet of water. While much technology is available regarding the safe and controlled operating of offshore power plants, the problems which arise in conjunction with the deeper waters are becoming increasingly complex. Further, with the greater depths of water in which it becomes necessary to operate, fixed power plants utilized for producing (generating) such current turbines involves enormous costs.

[0049] As shown in Fig. 7, the submersible turbine with buoyant collector that tethered by a chain 80 and anchor 82. In this case the submersible turbine could tethered with many cables to end of one heavy chain that is on seabed and frictional force between chain 80 and seabed could fix submersible turbines. Size of said anchor cables are determined before fix in water to operate. In another cases, only chain without anchor may be used.

[0050] In the cases that one anchor can't endure large force, and in other side we want power plant have possibility for rotation. A master link can be added that cable join to master link, afterward master link join to anchors on seabed (not shown).

[0051] As shown in Fig. 8, the submersible turbine with flexible collector 88 and buoyant intake 84 that buoyant turbine generator 86 is join to intake by flexible collector 88 and cables 85 to withstand in high tension (a composite structure can be used that fibers can withstand forces).

[0052] A combination of said collectors and said energy extraction units (turbines) may be used in said submersible power plant (not shown). A plurality of said energy extraction units (turbines) may be used in a single said collector (not shown).

[0053] As shown in Fig. 9, the submersible turbine with buoyant tethered collector in tidal current includes a reciprocating collector 90; cases 26 of turbine generators; buoyant tanks 30; anchor cables 22; power cable 28; and anchors 24. Of course instead of adding buoyant tanks 30, light materials could be used. Tidal currents have reciprocating nature. This apparatus in two sides fixed to a number of point by anchor cables. Cables can fixed on riverbed, bridge truss, tree trunk, etc. Said tethered reciprocating power plant is used in coastal waves as breakwater, or any other reciprocating currents.

[0054] As shown in Fig. 10, the submersible turbine with tethered collector and without buoyancy tanks in tidal current that fixed on river-bed or seabed includes a base 92; a reciprocating collector 90; cases 26 of turbine generators; anchor cables 22; power cable 28; and anchors 24. Rigid and stiffened components such as rods and joints, truss, etc. can be used in shallow water instead of cables, ropes, etc.

[0055] The collector of the submersible turbine can used every section and shape such as circular, rectangular, etc. The submersible turbine can be made with a number of separate inlets or outputs. Energy is increased with increase in dimensions of collector that can have varied dimensions and formations

[0056] While the disclosure refers to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the disclosure. In addition, many modifications will be appreciated by those skilled in the art to adapt a particular instrument, situation or material to the teachings of the disclosure without departing from the spirit thereof. Therefore, it is intended that the disclosure not be limited to the particular embodiments disclosed.

Claims

[Claim 1] A submersible current power plant for extracting energy stored in water current, comprising:

at least one tethered buoyant collector seamlessly coupled to at least one energy extraction unit, said energy extraction unit configured to extract energy from the flow of water provided by said tethered buoyant collector;

at least one anchor cables is disposed between said submersible current power plant and an anchor; and

wherein said tethered buoyant collector is configured so as to permit intensify the potential and kinetic energy of water current before reaching said energy extraction unit.

[Claim 2] The power plant of claim 1, further comprising at least one buoyant tank adding to said tethered collector.

[Claim 3] The power plant of claim 1, wherein said tethered collector made from light and buoyant material.

[Claim 4] The power plant of claim 1, further comprising master link, or any other means for perform rotating possibility, in order to said power plant rotate and operate in all current directions

[Claim 5] The power plant of claim 1, further comprising said anchor cables is disposed between the inlet and sides of said buoyant collector and a plurality of said anchor, in order to tolerate all strong forces and operate in one direction.

[Claim 6] The power plant of claim 1, wherein said anchor cables is disposed between said buoyant collector and a master-link, that a plurality of said anchor cables is disposed between said master-link and said anchors for make possibility to rotation in order to operate in all current directions if single anchor can't tolerate forces.

[Claim 7] The power plant of claim 1, wherein said anchor cables is disposed between said buoyant collector and end of a strong chain.

[Claim 8] The power plant of claim 1, wherein a flexible collector is disposed between a buoyant intake and a buoyant energy extraction unit.

[Claim 9] The power plant of claim 1, wherein said anchor cables is tethered to a pile, an onshore pillar, or any other fixed point as anchors.

[Claim 10] The power plant of claim 1, wherein a combination of said collectors and said energy extraction units may be used in said submersible power plant.

[Claim 11] The power plant of claim 1, wherein a plurality of said energy extraction units may be used in a single said submersible power plant.

[Claim 12] The power plant of claim 1, wherein shaft-less turbine, conventional turbine, or any other kind of turbines is used as said energy extraction unit.

[Claim 13] The power plant of claim 1, wherein size of said anchor cables are determined before fix in water.

[Claim 14] A submersible power plant for extracting energy stored in reciprocating current, comprising:

at least one tethered reciprocating collector seamlessly coupled to at least one energy extraction units, said energy extraction units configured to extract energy from the flow of water provided by said fixed (tethered) reciprocating collector;

wherein said tethered reciprocating collector is configured so as to permit intensify the potential and kinetic energy of water current before reaching said energy extraction units.

[Claim 15] The power plant of claim 14, wherein said reciprocating collector of said power plant rest on base, estuary bed, river bed, or any other places for fixing said power plant.

[Claim 16] The power plant of claim 14, further comprising at least one buoyant tank is disposed on said tethered reciprocating collector and a plurality of anchor cables and anchors, piles, onshore pillars, or any other fixed points;

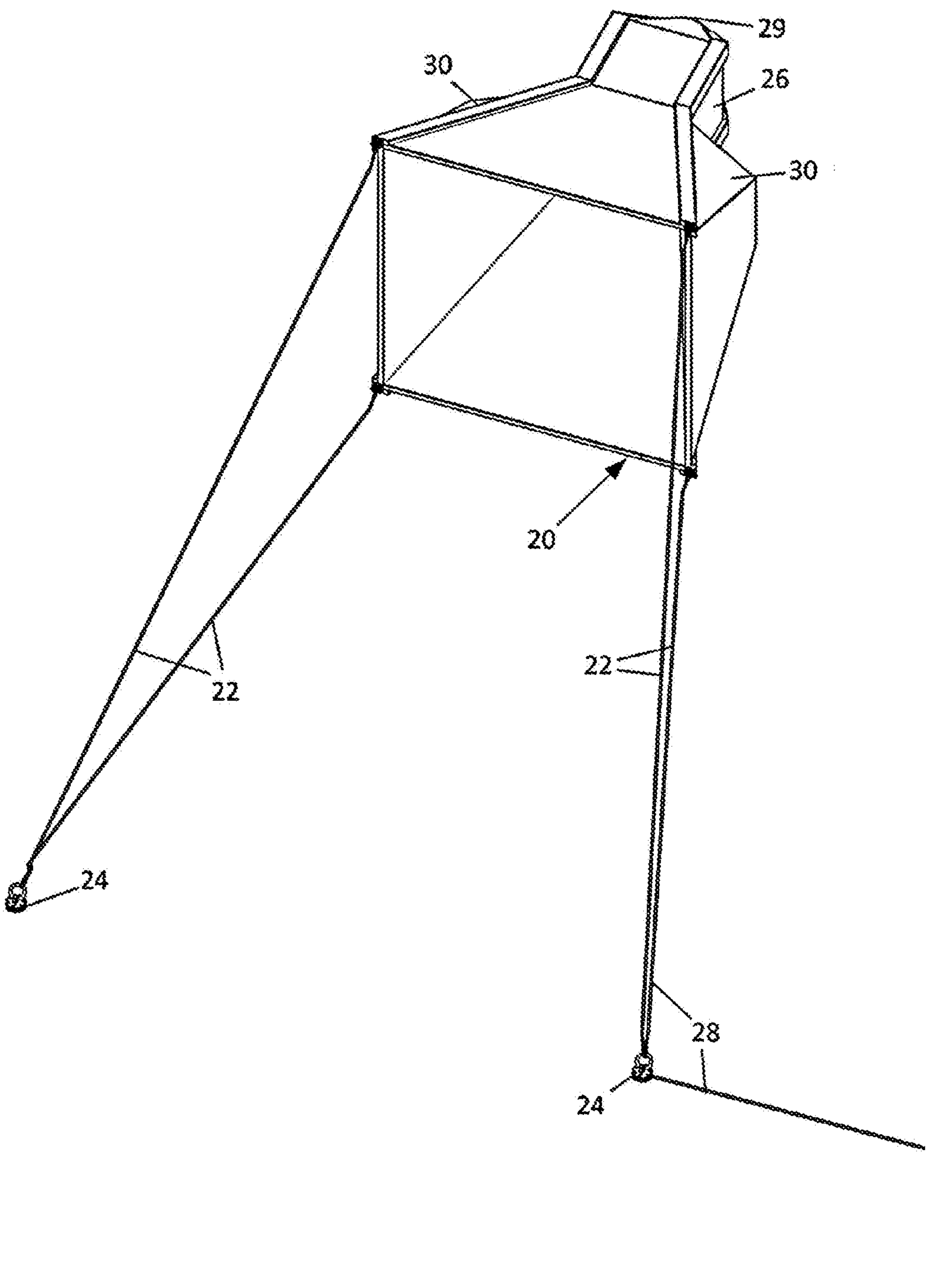
wherein said anchor cables is disposed between said tethered reciprocating collector and said fixed points.

[Claim 17] The power plant of claim 14, further comprising a plurality of anchor cables that is disposed between anchors, pile, onshore pillar, or any other fixed points and said tethered reciprocating collector made from light and buoyant material.

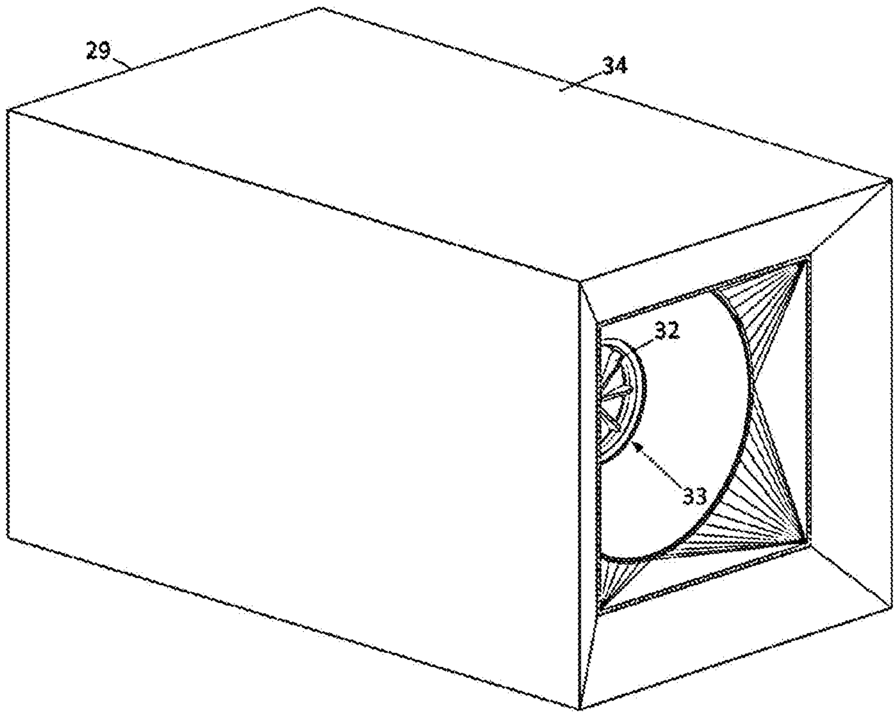
[Claim 18] The power plant of claim 14, wherein said tethered reciprocating power plant is used in coastal waves, or any other reciprocating currents.

[Claim 19] The power plant of claim 14, wherein said tethered reciprocating power plant is used in coastal waves as breakwater.

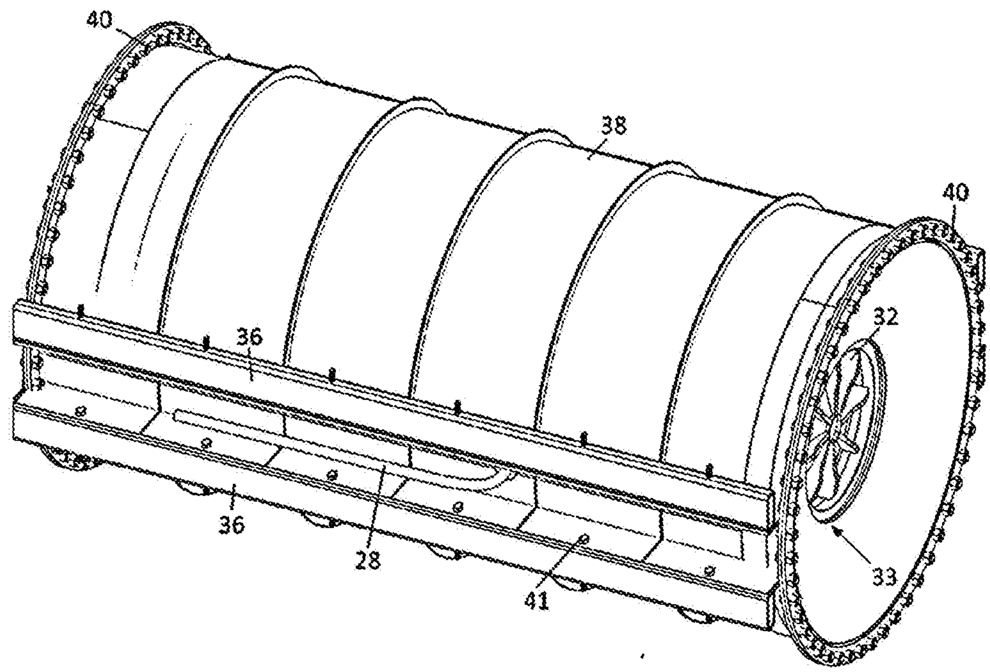
[Fig. 1]



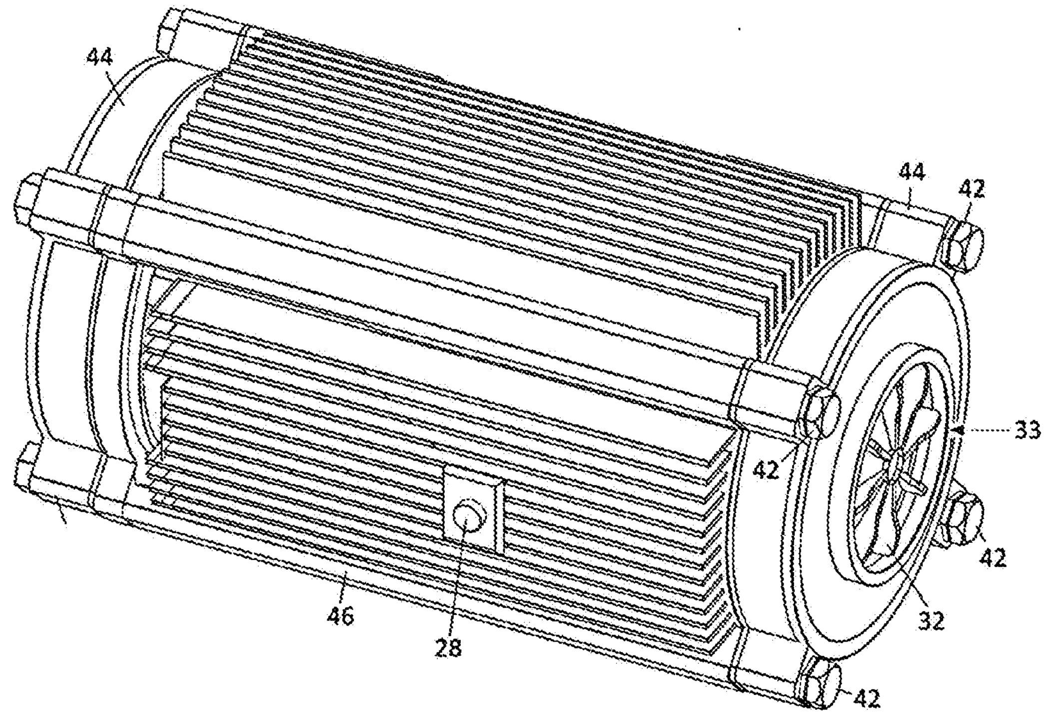
[Fig. 2A]



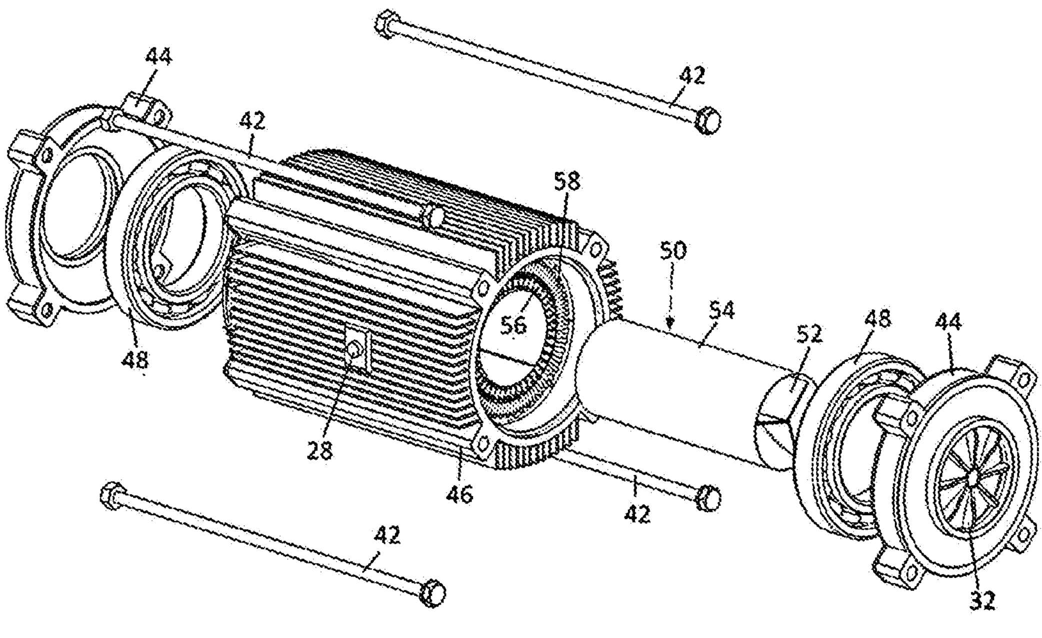
[Fig. 2B]



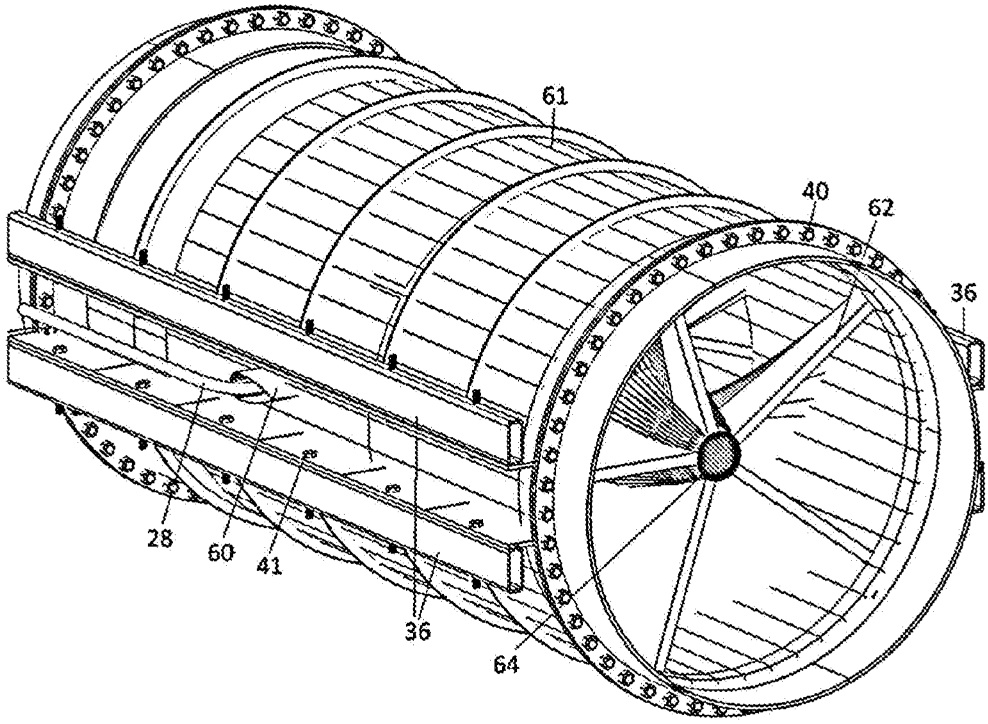
[Fig. 2C]


44
44
42
33
42
42
32
46
28
42

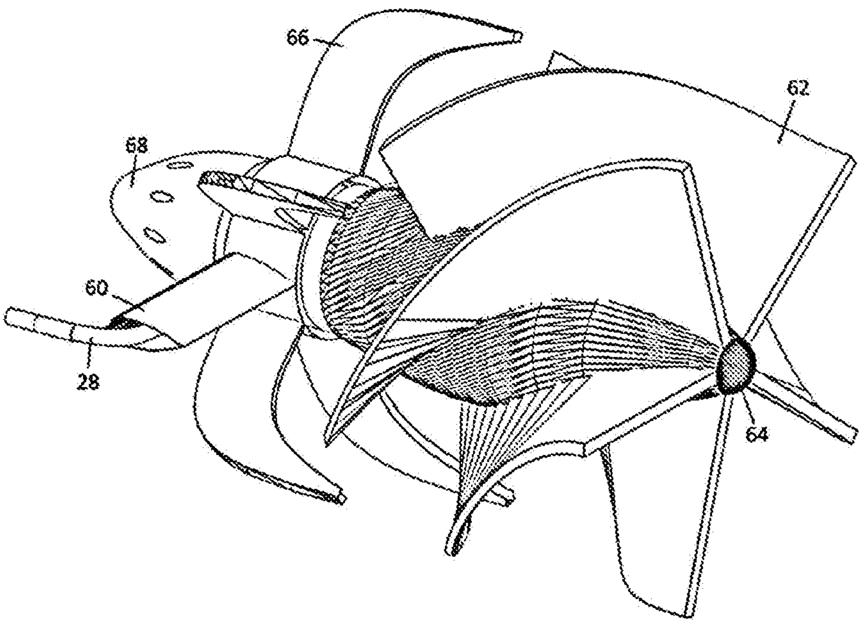
[Fig. 2D]


42
44
42
58
50
54
56
52
48
44
48
28
46
42
42
32

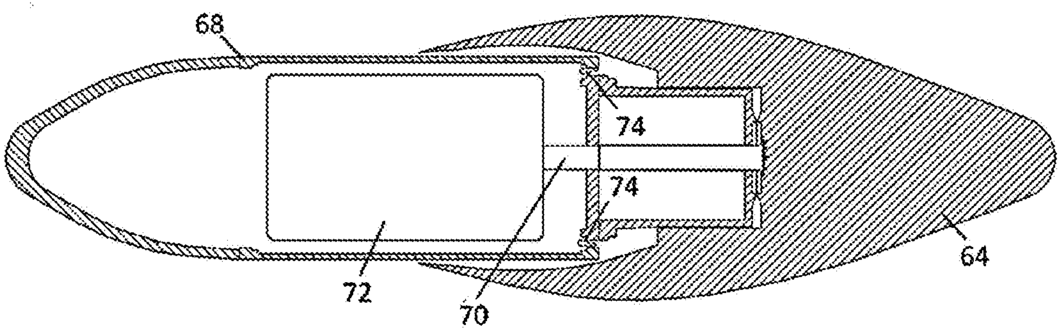
[Fig. 3A]



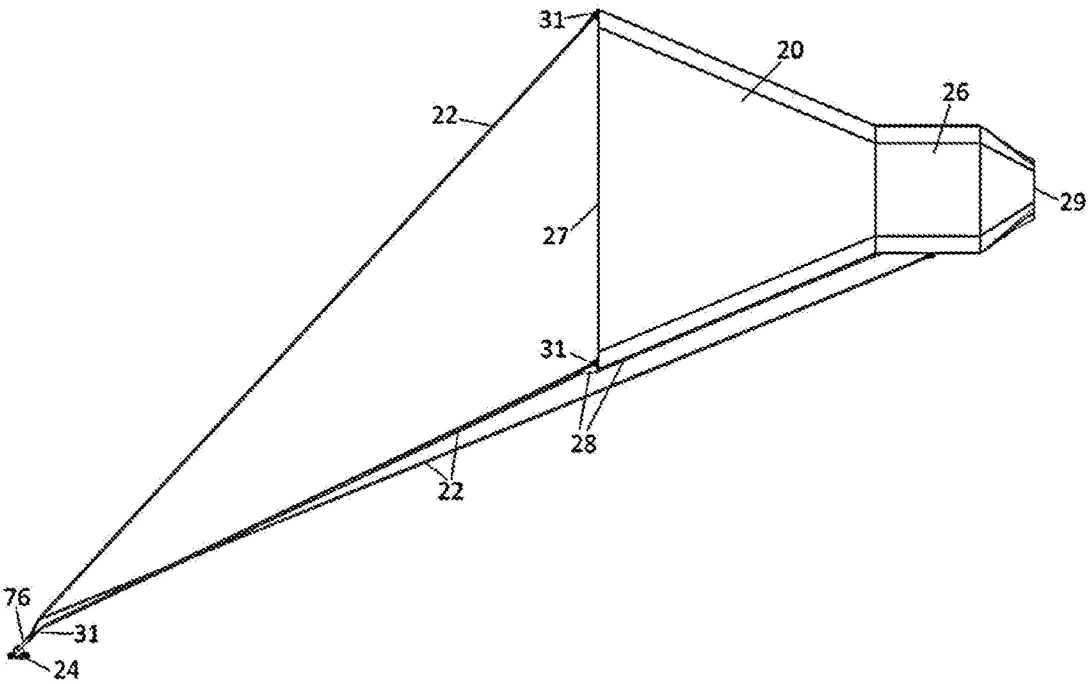
[Fig. 3B]



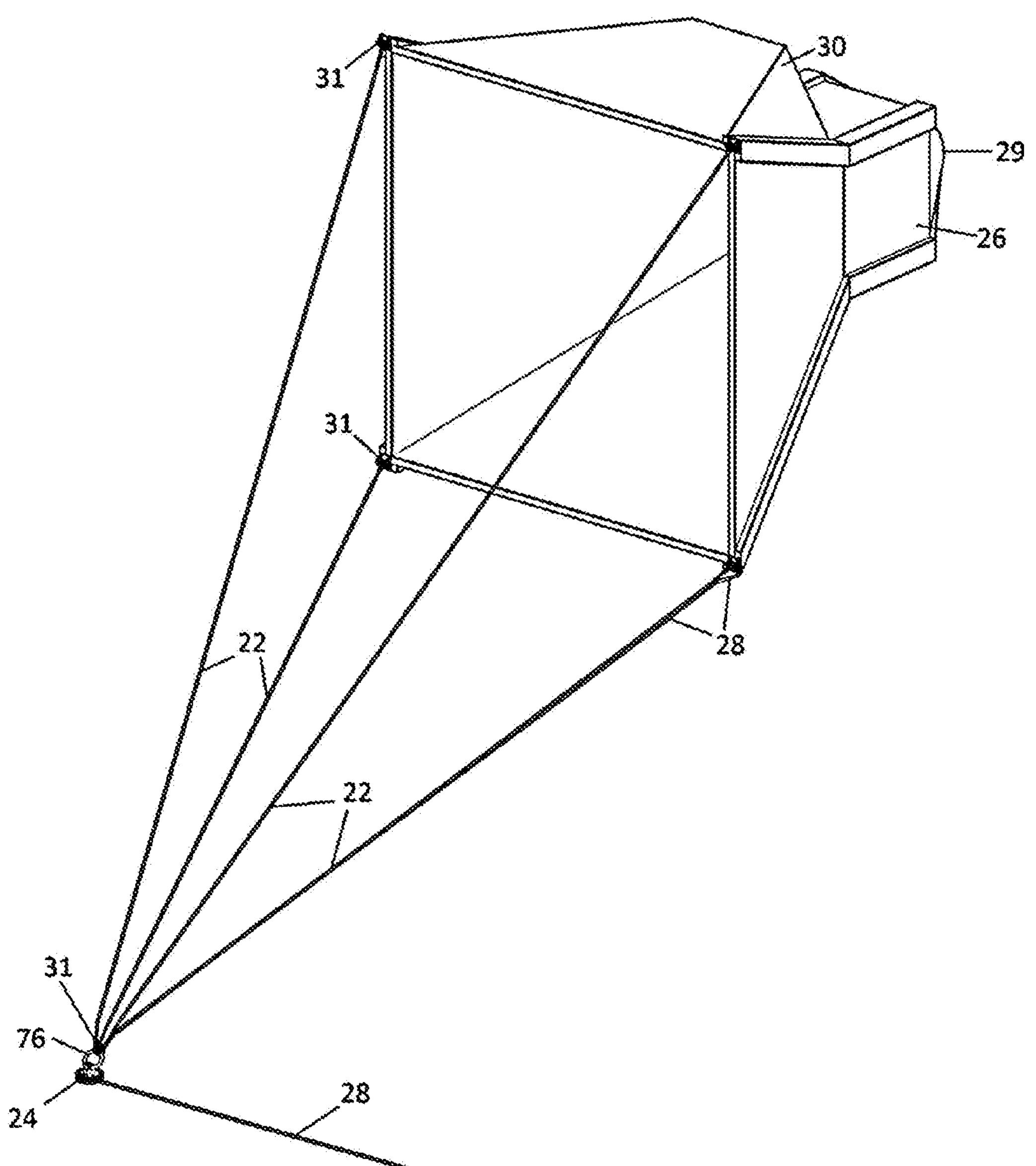
[Fig. 3C]



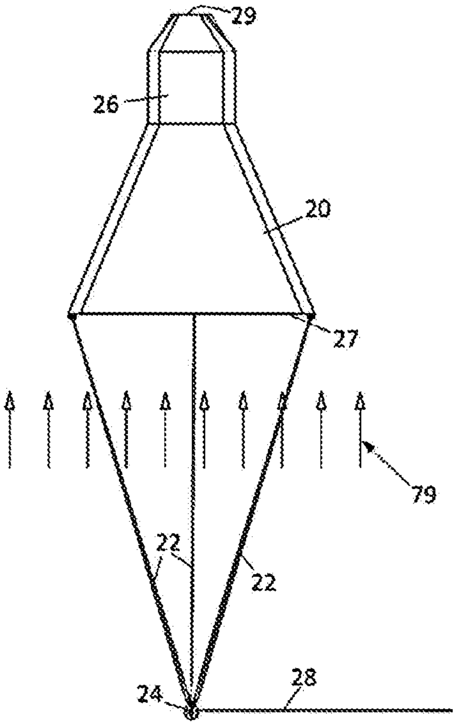
[Fig. 4]



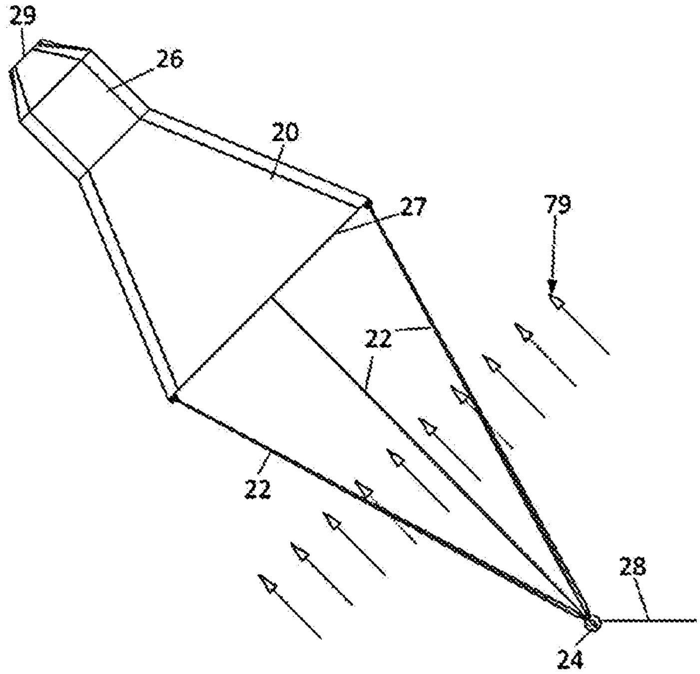
[Fig. 5]



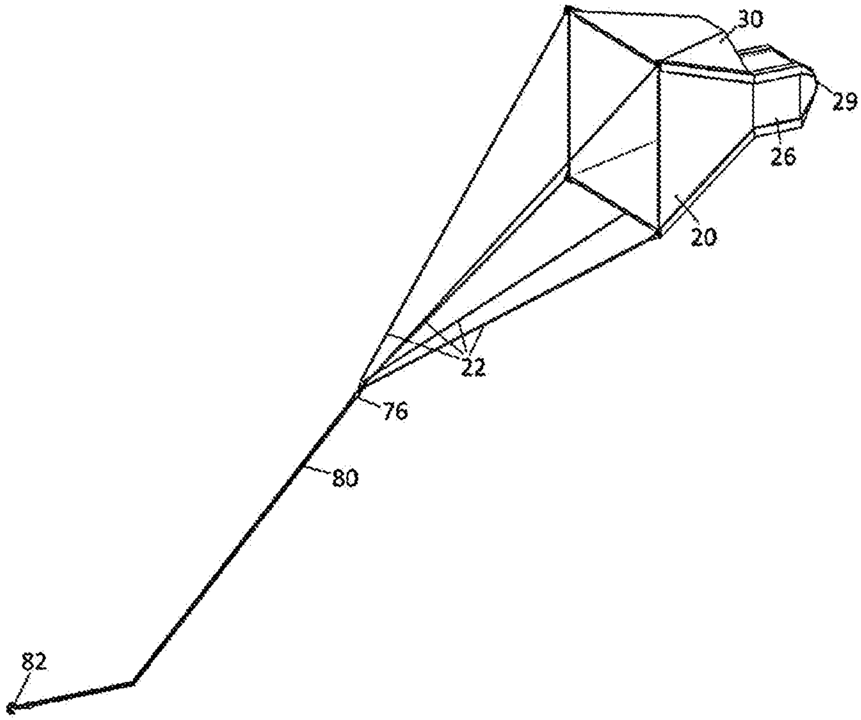
[Fig. 6A]



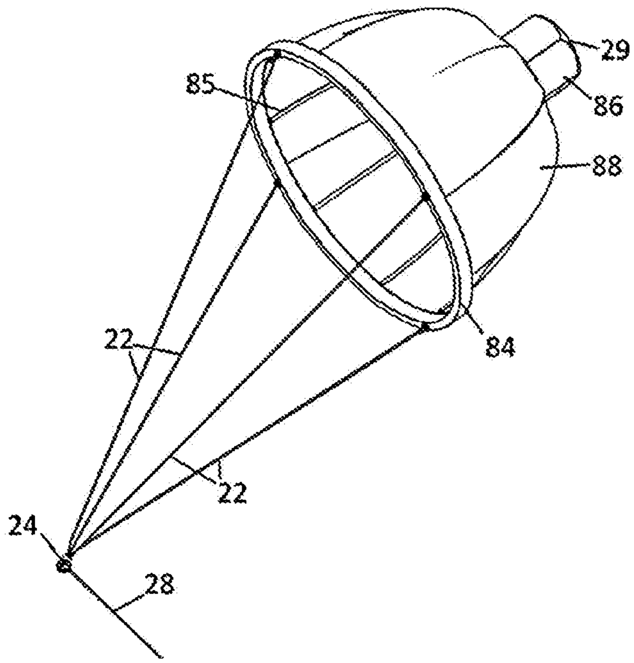
[Fig. 6B]



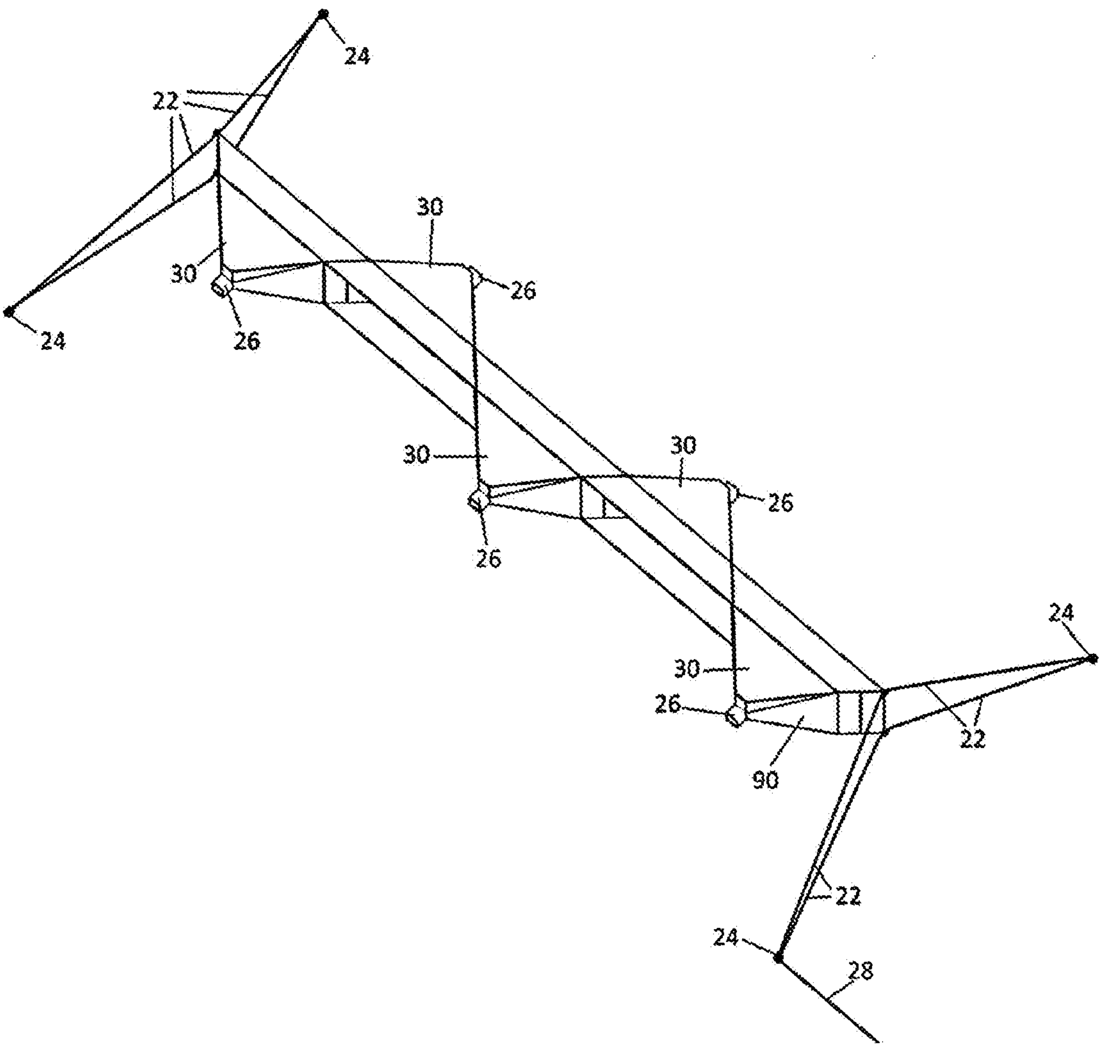
[Fig. 7]



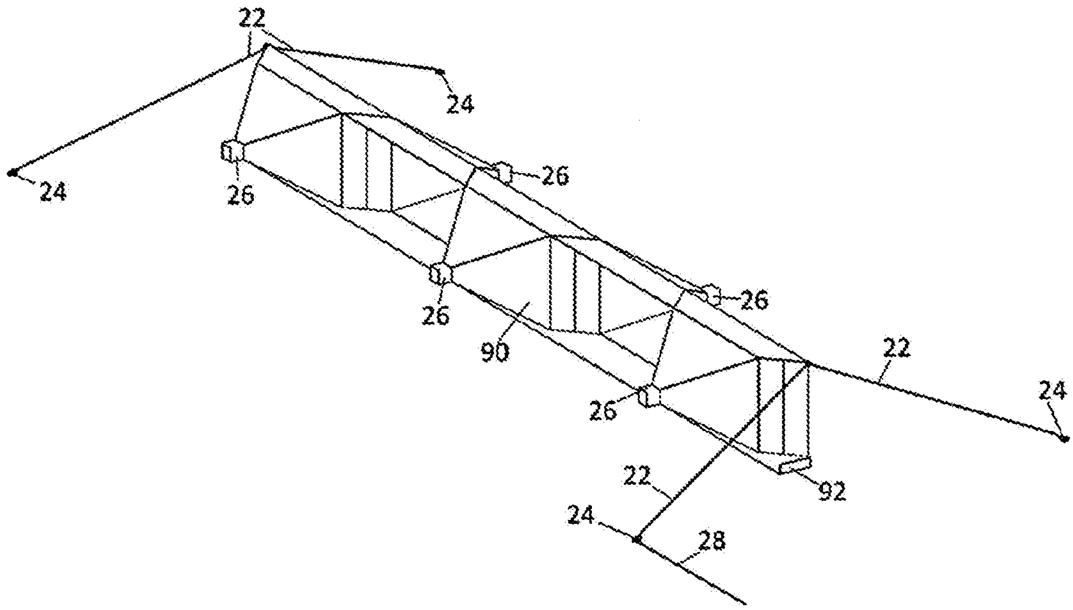
[Fig. 8]



[Fig. 9]



[Fig. 10]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2018/054988

A. CLASSIFICATION OF SUBJECT MATTER
F03B13/14 Version=2018.01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

TotalPatent One, IPO Internal Database Keywords: (buoyant collector, tank, anchor cables, tide, master link, turbine, reciprocating collector)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US20070231072 (A1) (JENNINGS, Clifford Allen et al.) 04 OCTOBER 2007 (04.10.2007) Abstract; Paragraph 0009, 0021, 0062-0063, 0066, 0082, 0126; Figure 1-12	1-7, 9-15, 17-19
A	Abstract; Paragraph 0009, 0021, 0062-0063, 0066, 0082, 0126; Figure 1-12	8, 16

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30-10-2018	30-10-2018
Name and mailing address of the ISA/ Indian Patent Office Plot No.32, Sector 14,Dwarka,New Delhi-110075 Facsimile No.	Authorized officer Anurag Singh Telephone No. +91-1125300200