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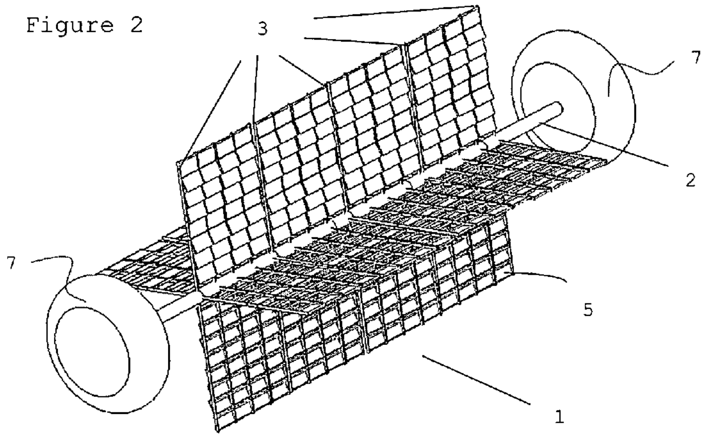
(54) **Title**: A PROPELLER CAPABLE OF PERFORMING FLUID MOTION ENERGY CONVERSION

Figure 2



(57) **Abstract**: The present invention relates to wave -energy propellers with moving blades designed for the purpose of obtaining renewable energy by utilization of the energy of waves in the oceans, seas or lakes.

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DESCRIPTION

A PROPELLER CAPABLE OF PERFORMING FLUID MOTION ENERGY CONVERSION

Field of the Invention

The present invention relates to wave energy propellers with moving blades designed for the purpose of obtaining renewable energy by utilization of the energy of waves in the oceans, seas or lakes.

Background of the Invention

The wave energy is a major source of energy generated as a result of the movement of the waves on the sea surface or the pressure changes beneath the surface, wherein it is one of the most proposed renewable energy technologies. Because it is a clean, cheap as well as a renewable energy, numerous wave energy applications have been realized from the past to the present day.

These various designs are developed for converting the potential and kinetic energy of the waves to different types of energy, such as mechanical or electrical. There are many concepts for wave energy conversion. Despite this wide variation in the design, wave energy converters are usually categorized by location and type thereof. Some of the wave energy designs are set up along the shoreline, some of them, close to the shore, and some of them, in the offshore areas.

In the shoreline applications, the energy generation structures are found as being fixed to the shore or buried therein.
Maintenance and construction thereof is easier than the other

applications.
Deep water connections or long underwater electrical cables are not needed. However, the generated wave energy can be much lower due to the wave regime of the shore and therefore these devices having less power generation ability. Examples of these applications can be given as oscillating water column, narrowing channel system and pendular.

The devices used in the applications close to the shore are referred to as being shallow water based devices. The devices in said locations are generally positioned to a specific sea level by being fixed to the sea bottom. These devices, as in the case of shoreline applications, also face the drawbacks of the shallow waters being prone to the formation of low power waves. In addition, the noise pollution caused by Wells turbines in shoreline or near-shore applications is also one of the disadvantages. In the applications close to the shore, Osprey and WOSP type devices are used.

In offshore applications, the devices are positioned in deep waters. By the concept of deep water, waters having depth of tens of meters or more than 40 meters is understood. In the deep water wave energy converter (WEC) applications, more energy will be generated as the waves of the deep waters will be larger. However, the construction and installation of the devices used in the offshore applications is more difficult due to the larger wave height and the energy of large waves in said locations, therefore additional costs are involved. Following can be given as examples to this application: the terminator type WEC Salter Duck, Floating Wave Power Vessel, Mighty Whale, Point observer WEC.

Although there are a wide variety of wave energy converters (WEC) in terms of design and concept, these devices can be classified in 3 dominant types: Attenuator, point observer and terminator. The majority of these systems used for wave energy are based on the principle of absorption of the wave energy by the up and down movement of the objects floating on the water with the wave motion.

The attenuator type wave energy converters mentioned above are floating structures positioned parallel to the direction of wave motion. The Pelamis and McCabe wave pumps are the most highly recommended types.

4 floating cylindrical buoys designed by Pelamis, having a length of 30 m and a diameter of 3.5 m are linked by 3 hinged joints and the bends in the joints operate the hydraulic pumps positioned in said points by the wave motion.

The McCabe type wave pump comprises 3 rectangular steel (4 m wide) pontoons hinged to each other, arranged uniformly and moving by being connected to each other. Increasing the inertia of the central pontoon is achieved by adding an additional mass. Energy is generated from the motion in the hinge points by means of the hydraulic pump mounted between the central pontoon and the other pontoons.

OPT wave energy converter (WEC) is an example of the most preferred floating technologies in the WEC applications. The wave energy converter (WEC) developed by the Ocean Power Technologies (OPT) in the USA comprises a cylindrical structure having a diameter of 2-5 m, a closed upper part and a base opening to the sea. Hydraulic pump is disposed between the top part of the structure and the steel floater floating inside the structure. Electricity is generated by the relative movement of the floater with respect to the structure.

Another example of floating technologies for the wave energy converters is the Archimedes Wave Swing, wherein said system comprises a cylindrical, air filled floater having a diameter of 10-20 m. The wave passing over the system raises or lowers the pressure inside the floater. Thus, the ascending and descending movement of the floater with respect to the ground results in the energy generation.

Among the shoreline applications, oscillating water column (OWC) is another structure implemented mostly below the water line. In these systems, there is a water column and another air column thereon. The bottom gate allows water to enter into the system. The air compressed by the water drives the turbine provided at the outlet by passing through the narrow part. When the wave retreats, it evacuates the air provided inside the system and said motion enables the turbine to move again.

As mentioned above, a wide variety of designs is developed for the utilization of wave energy.

A significant part thereof has remained in the project phase due to the costs thereof as well as the forces and operating conditions to be subjected; in another part thereof, it has been concluded after the experiments that they are not feasible.

In the prior art, a moving blade system is proposed in the patent document US7686583. In said patent, blade structure of a cylindrical propeller for obtaining efficient energy from the wave motion of the water is discussed. Said system does not use the buoyant force of the water, but it uses the circular/agitation motion of the water. In addition, with said system, the direction of water flow is determined by means of sensors and the blades are positioned by a motor.

The patent document US2002/0078687 discloses an apparatus converting the ocean wave energy into electrical energy. In said patent, the apparatus comprising a horizontal shaft with a helical structure provided there around it and it is floated on a catamaran type pontoon/buoy. In the structure mentioned in said patent, the helical structure rotates the shaft by means of the agitation motion of the wave. The blade like helical structure in said construction is fixedly positioned and thus it is not always capable of catching the wave motion at every angle.

The patent document WO2008124028 (A1) discloses the conversion of energy into the circular motion or from the circular motion. In said structure, mechanical parts make adjustments and change and optimize the angle of the blades in relation to the fluid flow direction. However, this structure will not work efficiently in the presence of the wave.

As mentioned above, many systems used for wave energy are not sufficiently capable of converting the wave energy and therefore, the wave energy systems could not find adequate area of utilization.

The majority of existing systems are established to take advantage of the up and down motion of the wave. However, water waves actually advance with the circular motion of the water. Since said situation is not taken into account in the current systems or a method capable of generating energy from said motion is not known in the prior art, the performance of the wave energy systems remains low.

In a real sea, the waves cannot always be expected to be regular and irregular motions are also present.

The energy generation will be provided by absorbing the circular motion of the wave as well as the random motion of the water thanks to the structure according to the present invention. Rotation of the propeller in only one direction is provided by opening and closing of the propeller blades with the motion of the sea water and power is obtained. Many of the problems experienced in the aforementioned wave energy converters will be eliminated thanks to the propeller structure according to the present invention. With this structure, which is a practical application in terms of both the installation and use, advantageous utilization opportunity thereof can be provided in the locations that are usually far away from the shores as well as utilization thereof can be provided by being fixed to the shoreline or near-shore locations.

Objects of the Invention

The object of the present invention is to form a wave energy converter that can operate in the seas/oceans with low as well as high wave height. Generation of the energy in an easier manner becomes possible since said wave energy converter rotates a shaft by directly providing circular motion.

More efficient and more effective energy conversion is aimed thanks to the manufacturing of the 'propeller capable of performing energy conversion' according to the present invention with less material as compared to the existing ones.

Description of the Figures

Figure 1. The schematic showing the wave motion, particle motions of the water and the wavelength on the surface of the ocean.

Figure 2. Horizontal perspective view of the propeller.

Figure 3. Front view of the propeller.

Figure 4. Transverse view showing the semi-open blades disposed between the two arms of the propeller.

Figure 5. Top transverse view of a blade.

Figure 6. Front view of the movement of a single blade structure provided on the shaft according to the counter-clockwise motion of the water.

Figure 7. Front view of the movement of a single blade structure provided on the shaft according to the clockwise motion of the water.

Figure 8. View of the direction change, for the fluid motion, of the two blades provided on the arm in the counter-clockwise motion of the fluid.

Figure 9. View of the direction change, for the fluid motion, of the two blades provided on the arm in the clockwise motion of the fluid.

Figure 10. View of the direction, for the fluid motion, of the four blades provided on the 2 arms in the case of a very large counter-clockwise circular motion of the fluid.

Figure 11. View of the direction change, for the fluid motion, of the four blades provided on the 2 arms in the case of a very large clockwise circular motion of the fluid.

The parts shown in the figures mentioned above are individually numbered, wherein part names corresponding to these numbers are given below:

A. Water particle motion
B. Negligible water motion
 1. Propeller
 2. Shaft
 3. Arm
 4. Support piece
 5. Blade
 6. Blade shaft
 7. Flotation aids (Pontoon)

Description of the Invention

The present invention relates to a device in propeller structure disposed to be positioned horizontally on the sea by being fixed, although not required, to the near-shore locations, designed to carry out circular motion by rotating around its own axis according to the circular or elliptical motion of the water and intended to provide energy conversion by said motion thereof.

The propeller (1) according to the present invention, capable of performing fluid motion energy conversion, as shown in Figure 3, in terms of the structure thereof, comprises the following: a horizontal shaft (2) positioned so as to be parallel to the sea surface in the center thereof; a plurality of arms (3) provided on the shaft (2), fixed so as to be parallel to each other at certain points spaced equally along the shaft (2) and extending outwards; as shown in detail in Figure 4, the blades (5) in the form of sheets positioned preferably with equal spacing, through the thick edges of the blades (5), between the arms (3) such that they are not in contact with each other and the other 3 sides thereof are disposed so as to move freely; blade shafts (6) extending by being passed through the inner part of thick edges of each blade structure and by being fixed from both sides to the arms (3); and support pieces (4) disposed in fixed positions so as to be parallel to the blade shafts (6).

Flotation aids (7) disposed on both ends of the shaft (2) for being implemented during the utilization of the propeller according to the present invention in the offshore deep seas/oceans and serving as a pontoon for the purpose of enabling the positioning of the propeller (1) continuously above the sea at the desired level can be used.

Said flotation aids (7) are preferably spherical, cylindrical, or in a different geometric structure suitable for flotation and provided with a hollow inner part or an inner part filled with materials such as foam (styrofoam), etc., that can be floated in water. A single flotation aid (7) or a plurality of them extended by being added to each other can be provided. The flotation aids (7) mounted at the ends of the shaft on both sides of the propeller can be in a catamaran like elongated structure.

The flotation aids (7) that can be applied to the propeller structure according to the present invention can rotate together with the shaft having cylindrical symmetry as well as they can be fixed while the shaft (2) rotates. The generators to be connected to the propeller can be disposed inside or on the flotation aids (7).

Alternatively, in another application of the propeller according to the present invention, which is the case for near-shore locations, said propeller is positioned at the desired point with respect to the sea level by means of the sea bottom fixing pieces (rode, post, line, etc.).

When the view resulting from the rotation motion of the shaft (2) of the propeller according to the present invention around its own axis is considered three dimensionally it will be in a cylindrical structure.

The blades (5) positioned between the arms (2) provided on the shaft (2) of the propeller according to the present invention can open and close by rotating back and forth with an angle of ±90° around the axis thereof with the motion of water. Support pieces (4) shown in Figure 4 are positioned so as to restrict said circular motion of the blades (5) in one direction.

As can be clearly seen in Figure 5, the blade structures are provided with a thin plate form (sheet form) and flow line geometry.

The force F generated on the blades (5) provided in the propeller (1) structure according to the present invention resulting from the fluid motion is shown in detail as the minimum force (Fmin) in Figure 5 and the maximum force (Fmax) in Figure 7.

In Figures 8-11, the operation of the system based on 4 different flow motions with different angles of water, the opening and closing motions of the blades (5) provided on the arms (3) and the forces exerted on the blades (5) by the water are shown. In this 4 different flow motions, the formulations regarding the torque values generated on the blades (5) are given below.

1. First Possibility: As shown in Figure 6, in the case of small circular motion with the counter-clockwise direction of water flow, when the blade (5) with the force F1 applied thereon is in open position and the blade (5) with the force F2 applied thereon is in closed position:
   (Torque: T, Force: F, Moment arm length: r, The angle between the applied force and the moment point: Q)

$$T = F \times r = r.F.Sin(Q)$$

$$\text{if, } T > 0$$

$$(F_2.r_2 - F_1.r_1) > 0, \text{ energy generation is possible.}$$

2. Second Possibility: As can be seen in Figure 6, in the case of small circular motion with the clockwise direction of water flow, when the blade (5) with the force F1 applied thereon is in closed position and the blade (5) with the force F2 applied thereon is in open position:

$$\text{if, } T > 0$$

$$(F_1.r_1 - F_2.r_2) > 0, \text{ energy generation is possible.}$$

3. Third Possibility: If the flow motion of the water is a large circular motion in the clockwise direction, (Figure 7):

$$\text{Torque } (T) = F \times r = r.F.Sin(Q)$$

$$Q = 90°$$

Torque is at maximum at the point where angle Q is 90°. (Sin= 1)

In this case, when the angle of incidence of the force exerted on each of the blades (5) resulting from the water and the impact based on this angle is calculated the torque will be maximum. Since the total value will be the highest for this possibility, the case in which the efficiency of the device according to the present invention is expected to be the highest is calculated in the following formula.

$$\text{Torque}, \ (F_1.r_1 + F_2.r_2 + F_3.r_3 + F_4.r_4) > 0$$

In this case, energy generation will also be maximum.

4. Fourth Possibility: If the flow motion of the water is a large circular motion in the counter-clockwise direction, (Figure 8):

In this case, which is very difficult to encounter;

the torque value can be considered as being $T \leq 0$.

In such a case energy generation is not possible.

In practice, it should be considered that the shaft (2) axis of the propeller (1) according to the present invention is positioned on the sea so as to be just at the sea surface level. However, depending on the characteristics of the waves and the characteristics of the system such as friction, etc., said position can be changed in the upward and downward direction with respect to the water line so as to obtain the ideal power point.

When the operating mechanism of the propeller (1) according to the present invention, capable of performing fluid motion energy conversion is examined, the blade (5) turns to an orientation that is parallel to the direction of flow when the water strikes to the blade (5) in the opposite direction. When the water moves in the right direction, the blade (5) moves, abuts the support piece (4) provided in the front part thereof and closes the flowing direction of the water so as to generate the maximum rotation force. Thus, the force generated on the blade (5) enables the whole propeller (1) to rotate around the shaft (2) axis.

The arms (3) connected to the shaft (2) in the center of the propeller (1) according to the present invention, capable of performing fluid motion energy conversion and extending outwards from the center can be in a linear structure as well as in a curved structure.

While only the lifting characteristic of the wave is used in the techniques according to the prior art, circular motion/agitation feature of the water in wavy seas is utilized in the technique according to the present invention. For example, if the motion of the water rotates the propeller (1) in the clockwise direction, the blades (5) provided on the propeller (1) prevent the water flow by closing and enable the propeller (1) to rotate around the shaft (2) axis by creating resistance. If the water flow is in a form that rotates the propeller (1) in the other direction, the blades (5), by opening, position themselves parallel to the water flow direction and prevent reverse power transfer to the propeller (1). In this way, different types of energy conversions (electrical energy, etc.) can be provided by applying force/torque to the propeller constantly in the same direction and transmitting the energy of the wave to the shaft (2).

The self-positioning of the blades (5) according to the present invention by the motion of water and generation of the torque thereby constantly in the same direction is a totally new application for the wave energy systems.

CLAIMS

1. A propeller (1) capable of performing fluid motion energy conversion, wherein it comprises the following: a horizontal shaft (2) positioned so as to be parallel to the sea surface in the center thereof; a plurality of arms (3) provided on the shaft (2), fixed so as to be parallel to each other at certain points spaced equally along the shaft (2) and extending outwards; the blades (5) in the form of sheets positioned preferably with equal spacing, through the thick edges of the blades (5), between the arms (3) such that they are not in contact with each other and the other 3 sides thereof are disposed so as to move freely; blade shafts (6) extending by being passed through the inner part of thick edges of each blade structure and by being fixed from both sides to the arms (3); and support pieces (4) disposed in fixed positions so as to be parallel to the blade shafts (6).

2. A propeller (1) capable of performing fluid motion energy conversion, wherein it comprises at least 2 or more flotation aids (7) disposed on both ends of the shaft (2) and serving as a pontoon for the purpose of enabling the positioning of the propeller (1) continuously above the sea at the desired level.

3. Flotation aids (7) according to claims 1 and 2, wherein they are spherical, cylindrical or in a different geometric structure suitable for flotation of desired size and provided with hollow inner parts.

4. Flotation aids (7) according to claims 1, 2 or, wherein the filled inner part of the structure thereof can be made of a material that is lighter than the water.

5. A propeller according to claim 1, wherein the blades (5) positioned between the arms (2) provided on the shaft (2) disposed in the structure thereof can open and close by rotating back and forth with an angle of ±90° around the axis thereof with the motion of water.

6. A propeller (1) according to claim 1, wherein the structure of the blades (5) provided thereon is in the form of a thin plate in the flow line geometry.

7. A propeller according to claim 1, wherein the arms (3) connected to the shaft (2) provided in the center of the propeller (1) and extending outwards from the center can be in a linear structure as well as in a curved structure.

Figure 1.

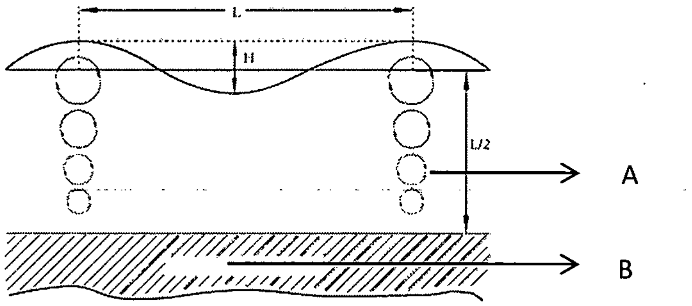

Figure 2.

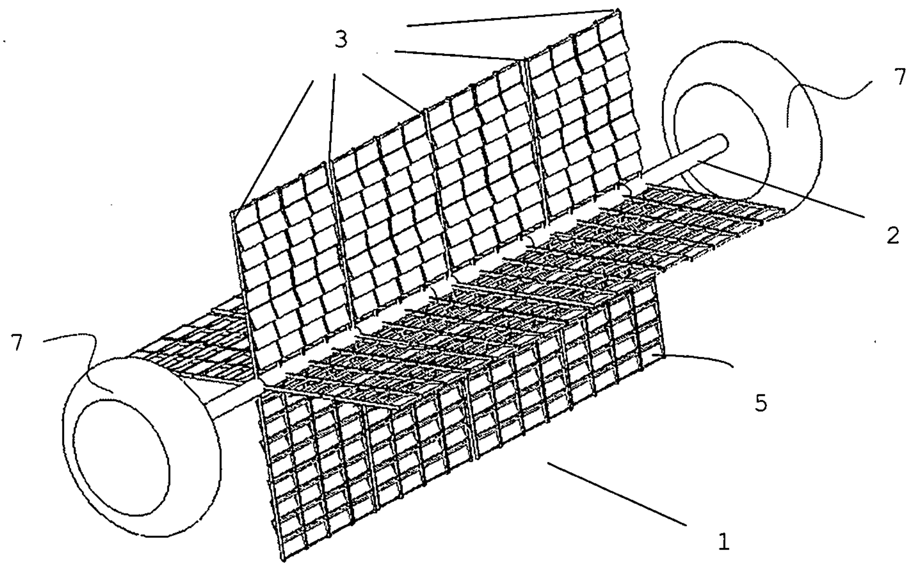

Figure 3.

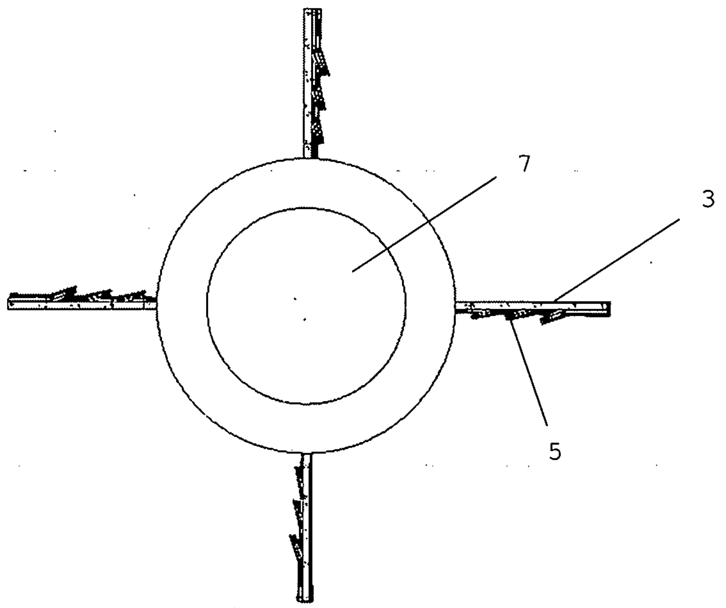

Figure 4.

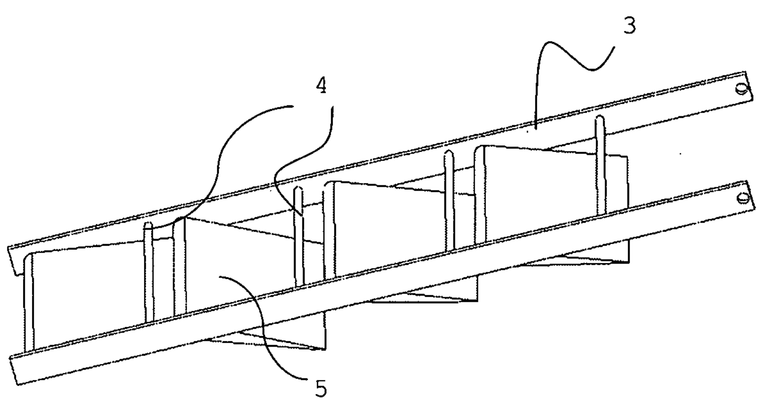

Figure 5.

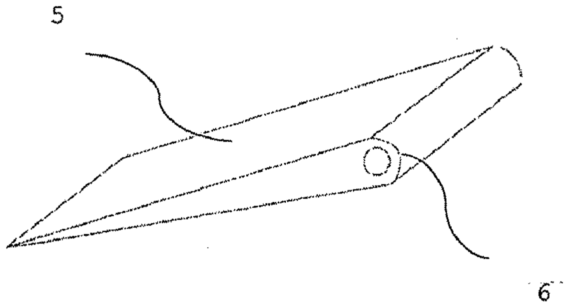

Figure 6.

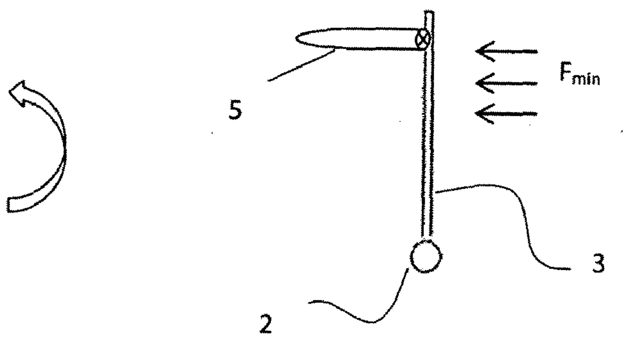

Figure 7.

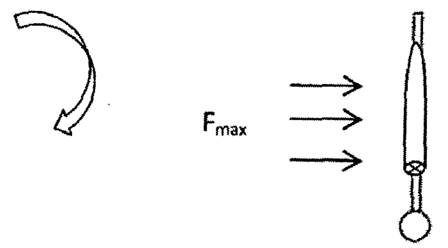

Figure 8.

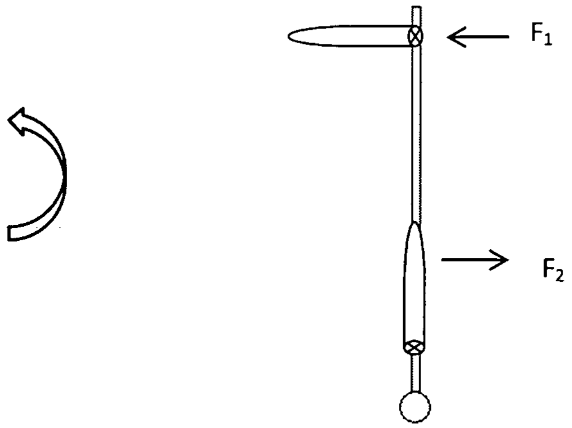

Figure 9.

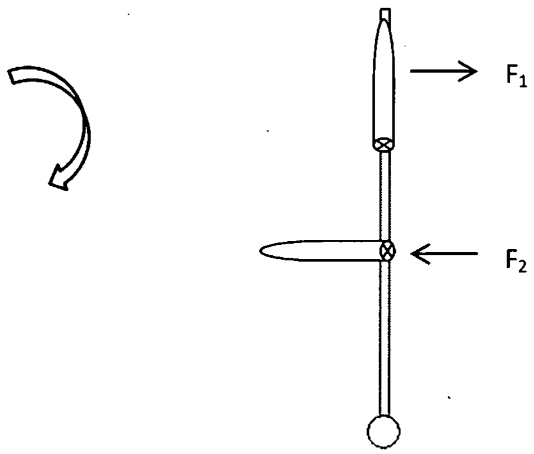

Figure 10.

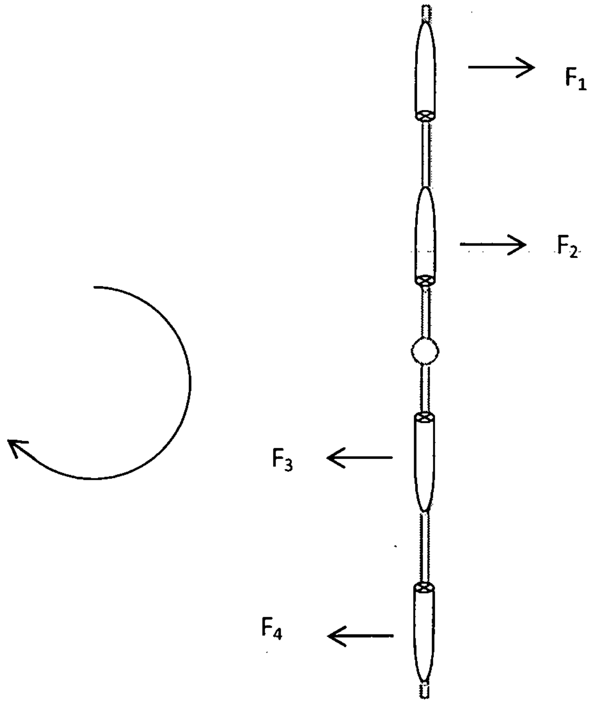

Figure 11.