



(51) International Patent Classification:

F03B 13/26 (2006.01) F03B 17/06 (2006.01)

(21) International Application Number:

PCT/GB2020/051562

(22) International Filing Date:

26 June 2020 (26.06.2020)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1909249.3 27 June 2019 (27.06.2019) GB

(72) Inventor; and

(71) Applicant: **OGDEN, James Samuel** [GB/GB]; 34 Shakespeare Road, Eastleigh Hampshire SO50 4GA (GB).

(74) Agent: **BOULT WADE TENNANT LLP**; Salisbury Square House, 8 Salisbury Square, London EC4Y 8AP (GB).

(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, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, 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: A HYDROPOWER ENERGY GENERATING DEVICE

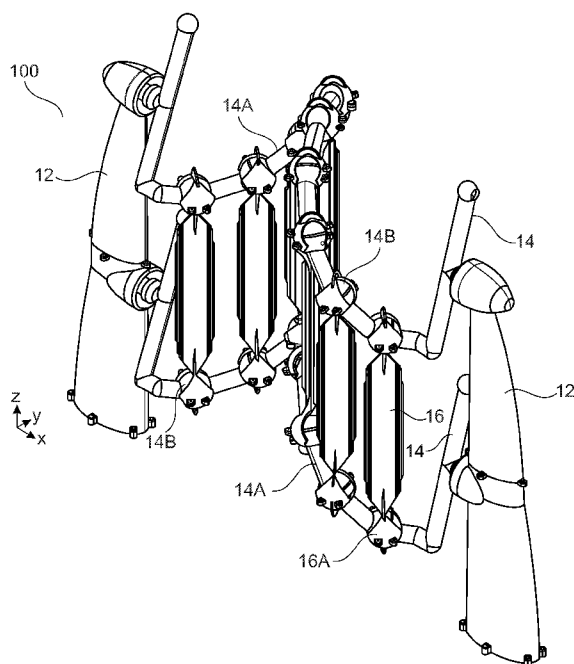


Fig. 1

(57) Abstract: An energy generating device is provided for converting a flow of fluid into energy. The device comprises: first and second supports (12) with first and second rotors (14) extending therebetween and rotatably mounted thereto. Each rotor (14) is substantially helical about its axis of rotation. A plurality of fins (16) extend between joints (14B) on the rotors. Each fin (16) comprises opposite first and second impingement surfaces, the fins (16) are rotatably attached at the joints (14B) to each rotate about their own fin axis of rotation transverse to the rotor axes between first and second positions in which the first and second impingement surfaces are respectively arranged to contact a flow of water to drive rotation of the first and second rotors. The joints (14B) are configured such that rotation of the rotors (14) causes oscillation of the fins between their positions. The rotor rotation drives an energy output from the device.

A HYDROPOWER ENERGY GENERATING DEVICE

Background

The present invention relates to a tidal or hydropower energy generating device. That is, a device which generates electricity based upon the flow of water in tidal regions. This can also be used to generate electricity from other sources of flowing water such as a river for run-of-the-river power generation. It should be noted that while, in practice, water is likely to be the motive fluid, the device is not limited to this and any other suitable motive fluid could be used.

Conventional tidal energy generation devices are in the form of propellers mounted underwater which are driven by the tidal flow of water to generate energy. These suffer from significant disadvantages, in particular in relation to scaling of the system to return sufficient energy to justify the necessary investment. The tip speed for a conventional propeller increases in a linear relationship with the radius of the turbine for a given angular velocity. However, the friction encountered is proportional to a square of the velocity in turbulent flow. As such, frictional and structural forces are significantly increased as the size of the propeller is increased. This results in significant engineering challenges to ensure the device can survive its environment. The fast-moving turbine blades may also suffer from cavitation phenomenon, which can gradually abrade the turbine blades. Additionally, the conventional propeller occupies a relatively small amount of the swept cross-section at any one time. Therefore, significant energy is allowed to pass by the turbine without being captured.

An example device for capturing energy from a fluid flow that is not a conventional propeller is disclosed in WO 2007/019607 A1. An oscillating member is mounted, with a hydrofoil rotatably attached thereto. The flow of water contacts the hydrofoil, to drive oscillation of the member. An electro-pneumatic actuator extends between the member and the hydrofoil in order to convert the oscillating motion of the member into grid-quality AC electricity. The angle of the fin is driven by a torque motor to move the hydrofoil relative to the member and relative to the direction of water flow to vary a direction of lift produced by the hydrofoil and thereby drive the member in its oscillatory path.

This device has significant limitations. In particular, a single hydrofoil can be mounted to the member and this hydrofoil must be driven by the actuator to generate the required

oscillatory motion. Accordingly, some of the energy generated is being used to drive the device. Furthermore, the hydrofoil suffers the same problems as a propeller in that it occupies a relatively small amount of the swept cross-section at any one time. The nature of the device is also such that it can only generate energy in a given position when water is
5 flowing in a single direction. When the tide changes, the member must be physically rotated around in order to generate energy from the reversed flow. Additionally, it is inconvenient to convert oscillating motion into electricity with a conventional electrical generator. Accordingly, a converter is required, such as the electro-pneumatic actuator. These conversion devices are bespoke and complex, compared to off-the-shelf generators.

10 Accordingly, the power output from a single device will be relatively low and each device must be quite complex.

There is therefore a need for an improved tidal energy generating device.

15 US 2013/343891 A1 discloses a spiral turbine including an axle configured to rotate and one or more spiral blades coupled to the axle by one or more support connections. Each spiral blade is formed around and outside of a conical inner space which is coaxial with the axle.

20 WO 01/48374 A1 discloses a reaction turbine capable of rotation in one direction under reversible fluid flow using aerofoil shaped radial blades in conjunction with aerofoil shaped helical blades to convert a portion of the energy from fluid flowing in an axial direction into rotational energy.

25 Summary

An energy generating device is provided according to claim 1. The device allows significant energy to be generated from a flow of tidal water. At any given point, a large proportion of the swept area is covered such that greater energy can be recovered than previous
30 devices. The connection between the joints and the fins ensures that constant rotation of the rotors can be generated as the fins self-align to the correct position. The rotors conserve their momentum by rotating smoothly under a constant flow rate. As such, this produces a form of motion which is particularly useful for generating electrical energy with a conventional generator.

Additionally, the device is fully submersible within the flow of water. As none of the motion components significantly operate in the reverse direction of flow. This contrasts to a water wheel where half is operating in the direction of the flow, and the other half travelling against the flow. Accordingly, the device shares both the advantages of the conventional turbine in being fully submersible, and shares the high occupied swept cross section of the water wheel. The device also does not require any barrage. This allows ships to pass over the device or around it. Additionally, barrages result in static water building up behind the device, where pollutants may accumulate. Furthermore, as the components rotate at a lower velocity than conventional propellers and hence may have less impact upon the local wildlife, such as passing fish.

An angle of incidence may be defined between the first and second impingement surfaces and the plane, the fins arranged such that the angle of incidence is maximised when the fins pass through the plane and minimised when the fins are furthest from the plane. This optimises the energy transferred from the flow of fluid to the rotation of the rotors.

The angle of incidence may oscillate between less than $\pm 90^\circ$, preferably the angle of incidence may oscillate between less than $\pm 80^\circ$, most preferably the angle of incidence may oscillate between less than $\pm 60^\circ$. The angle of incidence may oscillate between more than $\pm 10^\circ$, preferably the angle of incidence may oscillate between more than $\pm 30^\circ$. These angle limits are particularly appropriate for the tidal or river energy generation of the present invention.

The first and/or second central portion may have a helix diameter larger than a width of the supports transverse to the plane, preferably the first and/or second central portion may have a helix diameter at least 4 times larger than the width of the supports transverse to the plane. This ensures that the fins extend well beyond any footprint of the supports, and hence are generally contacting water which has not been impeded by the supports.

The first and/or second central portion may have a helix angle of between 0° and 90° , preferably the first and/or second central portion may have a helix angle between 10° and 80° , most preferably the first and/or second central portion may have a helix angle between 30° and 60° . These angle limits are particularly appropriate for the tidal or river energy generation of the present invention.

The first and/or second central portion may each comprise one turn. This is particularly appropriate for the tidal or river energy generation of the present invention. A single turn is inherently counterbalanced by its weight about the centre line of each central portion, which may ensure smooth rotation by aligning the centre of mass with the centre line of rotation,
5 thus gravitational force shall not apply a significant acceleration to the motion of the device.

Each joint may comprise a ball and socket joint, wherein: either an inner surface of the socket or an outer surface of the ball comprises one or more projections; the other of the inner surface of the socket or the outer surface of the ball comprises a track for receiving
10 the follower projection such that movement of the follower in the track transfers the rotation of the first and/or second rotor about the first and/or second axes into oscillation of each fin about each fin axis. A ball and socket joint is a reliable connection method, and the projection and track arrangement is a reliable method to convert rotation of the rotor into oscillation of the fin.

15

The one or more projections may be a plurality of projections. A plurality of projections reduce the possibility of the joint becoming jammed or damaged.

The energy transfer device may comprise a first generator attached to the first rotor. This is
20 a convenient location to arrange a generator in order to produce electrical energy.

The energy transfer device may further comprise a second generator attached to the second rotor. This further distributes the generation of the electrical energy and distributes the torsional forces impeded upon the rotors from the resisting generators. The use of
25 multiple generators may be utilised to add redundancy to the electrical generating capability of the invention.

Each generator may be provided within the first and/or second support. This allows the supports with generators to be installed as a single unit. Installing generators in the first
30 and second support distributes the torsional forces impeded upon the rotors from the resisting generators. The use of multiple generators may be utilised to add redundancy to the electrical generating capability of the invention.

An energy generating apparatus is provided according to claim 13. This apparatus may
35 effectively form a tidal fence, which extends across a wider area of water to increase

energy generation. Aligning the devices into a tidal fence increases efficiency by disallowing the pass of energy contained within a flow of a fluid around the sides of a single device, since these sides are also obscured by an adjacent device. As the tidal fence does not require a barrage but has the same high occupied cross-sectional efficiency as one, it
5 represents an improvement thereover.

A method of generating energy from a flow of fluid is provided according to claim 14. This method takes advantage of the device or apparatus set out above.

10 A method of driving a flow of fluid is provided according to claim 15. This method effectively operates the device or apparatus in reverse, akin to a pump.

Brief Description of the Figures

The present invention will now be described, by way of example only, with reference to the
15 accompanying Figures in which:

Figure 1 shows a perspective view of an energy generating device according to the present invention;

Figure 2 shows a side view of the energy generating device of Figure 1;

Figure 3 shows an end view of the energy generating device of Figure 1;

20 Figure 4 shows a top view of the energy generating device of Figure 1;

Figure 5 shows a schematic of the attachment mechanism between the fins and rotors of the energy generating device of Figure 1;

Figure 6 shows a further schematic of the attachment between the fins and rotors of the energy generating device of Figure 1;

25 Figure 7 shows a schematic force diagram from a top view cross section of the fins of the energy generating device of Figure 1;

Figure 8 shows a schematic force diagram from a top view of the energy generating device of Figure 1; and

30 Figure 9 shows a schematic force diagram of an end view of the energy generating device of Figure 1.

Detailed Description of the Figures

Figures 1 to 4 show an embodiment of an energy generating device 100 according to the present invention. The energy generating device 100 comprises first and second supports
35 12. The supports 12 may be mounted to the floor of the water pathway (such as a sea or

river bed). A plane is defined which passes through both of the supports. In particular, the plane may pass through a centre line of each of the supports. The energy generating device 100 is used to convert a flow of fluid, typically water, into energy. In order to achieve this, the energy generating device 100 is typically deployed in the flow of fluid with the energy generating device 100 aligned such that the flow of fluid is generally in the direction of the plane. That is, the flow of fluid is generally parallel to the plane. Of course, any flow of fluid will inherently be turbulent and will include many different components. The flow direction referenced above refers to the general direction which the entire fluid flow can be characterised by. In tidal situations this may be represented by the tide coming in or going out. In a river application, this may be defined by the direction of flow of the river (i.e. from upstream to downstream).

Extending between the first and second supports 12 are a plurality of rotors 14. In the depicted embodiment there are two rotors 14. However, it is anticipated that any suitable number of rotors 14 can be employed. In particular, in certain embodiments there may be three rotors 14 or four rotors 14. The rotors 14 comprise a first rotor and a second rotor. The first rotor 14 extends between the first and second supports 12. In particular, the first rotor 14 is rotatably mounted to the first and second supports 12. The rotational mounting is about a first axis of rotation. The first axis of rotation is in the plane of the supports 12. The first rotor 14 comprises a first central portion 14A which is substantially helical (as best shown in the combination of Figures 3 and 4) with the helix defined around the first axis of rotation.

The helix may preferably have a diameter larger than a width of the supports 12. The width being defined in a direction transverse, preferably perpendicular, to the plane. This ensures that the device 100 extends beyond the portion of the flow of fluid obscured by the supports. Accordingly, better energy generation can be achieved. For example, the helix may have a diameter at least four times larger than this width.

The central portion 14A may have a helix angle of between 0° and 90° , preferably the helix angle is between 10° and 80° , most preferably the helix angle is between 30° and 60° . The angle should be selected to ensure that there are no clashes between components of the device 100. The angle can also be selected to optimise the device for a given application. For example, the helix angle could vary along the length of the device 100 in order to optimise the device for flow in a single direction.

Each helix may consist of one and only one turn. Alternatively, each helix may have any other number of turns, including partial turns. The present invention includes counterbalancing arms on the rotors 14. In other embodiments, the number of turns on the helix could be selected in order to counterbalance the device 100. For example. The device 100 could consist of 0.95 turns.

The second rotor 14 is generally similar to the first rotor 14. The second rotor 14 likewise extends between the first and second supports 12 and is rotatably attached thereto to rotate around a second axis of rotation. The second axis of rotation is also in the plane and is offset from the first axis of rotation. The second axis of rotation is generally parallel to the first axis of rotation. As with the first rotor 12, the second rotor 12 also comprises a central portion 14A which is substantially helical. The second central portion 14A may generally have the same shape and dimensions discussed above with reference to the first central portion 14A.

Each rotor 14 comprises a plurality of joints 14B. The joints are correspondingly spaced along the central portion 14A of each rotor 14. A plurality of fins 16 extend between these joints 14B. In particular, each fin 16 extends between a respective joint 14B on the first rotor 14 and a respective joint 14B on the second rotor 14. In this sense, the plurality of fins 16 form a lattice along the length of the rotors 14. Each fin 16 may be generally parallel to each other fin 16. Each of the fins 16 is elongate and comprises first and second impingement surfaces. The first and second impingement surfaces are provided on opposite sides of the fins 16. Each fin 16 is rotatably attached at the joints 14B. This rotatable attachment is about a fin axis of rotation. Each fin axis of rotation will be separate to one another. Each fin axis of rotation is transverse, preferably perpendicular, to the first and second axis of rotation. Each fin axis of rotation may be generally parallel to the plane.

The fins 16 are rotatably attached such that they can rotate between a first position in which the first impingement surface is arranged to contact a flow of water in a first direction generally parallel to the plane and a second position in which the second impingement surface is arranged to contact the flow of water. That is, the fins oscillate between two positions where each impingement surface is presented to a flow of water in a given direction. As the fins oscillate they will present different ramped surfaces for impingement. As a result, the generated acceleration on the rotors will oscillate in direction. This will be

described in more detail later but is relevant to ensure that a constant rotating movement is imparted to the rotors 14. The joints 14A of the rotors connect to a connection portion 16A of the fin 16. This connection is such that as the rotors rotate about the first and second axes, the fins 16 oscillate between the first and second positions to ensure that the
5 generated acceleration is in the correct direction to ensure continued rotation of the rotors. In the particular embodiment shown in Figures 5 and 6 the joint 14B is a ball and socket joint. The ball portion comprises a track 14C into which a follower projection 16B extends. In the present embodiment the projection is on the socket portion and the track on the ball
10 portion of the ball and socket joint it is also anticipated that these could be reversed with the track on the socket and the projection on the ball. As a result of this track and projection as the rotor 14 rotates the follower pin 16B will move in the track 14C so as to generate the oscillatory motion described above.

The track may be generally straight (i.e. forming a circular path) as shown in Figure 5.

15 Alternatively, the track may include deviated portions for generating particular movement of the fins 16.

This connection at the joint 14B may be such that an angle of incidence θ can be defined between the impingement surface facing the flow of water and the plane. The angle of
20 incidence may be maximised as the fins pass through the plane and minimised when the fins are furthest from the plane. As a result, the generated forces are maximised as the fins 16 pass through the plane and minimized as the fins 16 are furthest from the plane. In particular embodiments, the angle of incidence may oscillate between less than $\pm 90^\circ$, preferably the angle of incidence may oscillate between less than $\pm 80^\circ$, most preferably the
25 angle of incidence may oscillate between less than $\pm 60^\circ$. The angle of incidence may oscillate between more than $\pm 10^\circ$, preferably the angle of incidence may oscillate between more than $\pm 30^\circ$.

In embodiments with three or more rotors 14, each additional rotor may also be rotatably
30 attached between the supports 12. Fins 16 may be attached between the second rotor 14 and a third rotor 14. Alternatively, or additionally, fins 16 may be attached between a third rotor 14 and a fourth rotor 14, and so on.

As a result, a method of generating energy is such that an energy generating device
35 can be supplied to a flow of water and as the water flows it impinges upon the first or

second impingement surfaces of fins 16 along the length of the rotors 14. This impingement generates a net rotational movement for the rotor 14. As the rotor 14 rotates the fins 16 oscillate so that the generated acceleration continues to drive rotation of the rotor 14. An energy output is then connected to the first and/or second rotor in order to extract energy from the energy generating device 100. In particular, the energy output may be in the form of one or more generators attached to the rotor 14. In a particular embodiment, each rotor may be connected at either end to a generator (for a total of four generators in a two rotor design). Alternatively, any suitable number of generators may be provided. The generators may be provided inside the supports 12. That is, the supports 12 may include a portion for retaining the generator, for example in an integral unit. The generators may be connected, for example by means of undersea cables, to an electricity system on the mainland, such as a national grid.

Figures 7 to 9 show how the forces imparted to each fin 16 result in rotation of the rotor 14. The fin 16 of Figure 7 is at an angle of incidence θ to the plane and consists of first impingement surface 16C and second impingement surface 16D on opposite sides of the fin 16. A flow of water 22 impinges upon the first impingement surface 16C. This flow of water is then deflected and accelerates in the direction 26. The fin 16 is restrained at either end by the joints 14B, which apply a reaction force 27. As a result of this, an acceleration 24 is applied to the fin 16 and transferred to the rotor 14. As the angle of incidence θ is varied, the resultant forces will likewise be varied. In a midway point neither the first nor the second impingement surfaces 16C, 16D are generally facing the flow of water 22. As a result, there is substantially no acceleration generated. As the fin 16 passes this point the direction of the generated accelerated 24 switches. This is illustrated in Figure 8 which shows the generated acceleration A_n for a number of fins 16 along a rotor 14. From above we can see that A_1 , A_2 , A_8 and A_9 have an acceleration towards the right of the figure A_4 , A_5 and A_6 have an acceleration towards the left of the figure and A_3 and A_7 generally have no generated acceleration. When looking along the rotor 14 according to Figure 9 it can be seen how these generated accelerations are relevant to the present invention. As depicted in this Figure, the summed accelerations at each point constantly ensure that the rotational movement 32 is generated. At each point the generated acceleration is such as to drive the rotor in the correct direction. As the fins 16 oscillate this relationship is maintained. As a result, the rotor 14 is constantly driven in a circular motion and rotational energy is thereby generated.

As each fin 16 is rotatable in this manner, the device 100 is reversible. This allows energy to be generated both when a tide is coming in and when a tide is going out. This is as a result of the generally symmetrical design of the device 100. The device 100 would operate in exactly the same manner as described above for the forward operation.

5

In order to achieve this, each fin 16 may be substantially rotationally symmetrical about its centre for 180° of rotation. As a result, substantially the same shape is presented, regardless of the direction of the flow of water.

10 Alternatively, each fin 16 may be shaped so as to generate more energy from water flowing in a particular direction, such as in a river installation.

While we have referred to the device 100 as an energy generating device 100, it is also anticipated that the same device 100 could be driven by an external motor and act
15 substantially as a pump. Driving of the device 100 would impart a flow to a fluid. In this sense the device 100 could be used to generate a flow of water. The operating principle would be the same as above, but movement of the rotors would cause the fins to impinge upon the water and thereby generate a thrust.

20 In particular embodiments, a tidal fence can be formed. The tidal fence is an energy generating assembly which comprises a plurality of energy generating devices 100 according to the present invention. These plurality of energy generating devices 100 can be set up next to one another with generally parallel planes. This tidal fence thereby extends across a very wide waterway in order to extract the maximum possible energy. In such an
25 embodiment it is possible that each energy generating device 100 has an individual support 12. Alternatively, each support 12 may extend from a larger central support acting as the superstructure for the energy generating assembly. That is, each individual support 12 may be as branches from a larger support for the entire structure. Alternatively, or additionally, supports 12 could be shared between multiple energy generating devices 100 in the
30 assembly.

In this sense, the energy generating device 100 or energy generating assembly may be placed into a waterway such that a flow of fluid is substantially parallel to the plane(s). Thus, as the fluid flows past the energy generating device 100 or assembly the flow of

water is converted into rotational energy which is then captured or then transferred elsewhere as appropriate.

CLAIMS:

1. An energy generating device for converting a flow of fluid into energy, the energy generating device comprising:

first and second supports defining a plane passing through both supports, the device for deployment in water with a flow of water generally parallel to the plane;

a first rotor extending between the first and second supports and rotatably mounted thereto with a first axis of rotation in the plane, the first rotor comprising a first central portion which is substantially helical around the first axis of rotation;

a second rotor extending between the first and second supports and rotatably mounted thereto with a second axis of rotation in the plane, offset from the first axis of rotation and generally parallel to the first axis of rotation, the second rotor comprising a second central portion which is substantially helical around the second axis of rotation;

a plurality of fins, each extending between a respective joint on the first rotor and a respective joint on the second rotor, each of the plurality of fins comprising first and second impingement surfaces on opposite sides of the fin, the plurality of fins rotatably attached at the joints to each rotate about their own fin axis of rotation transverse to the first and second axes between a first position in which the first impingement surface is arranged to contact a flow of water in a first direction generally parallel to the plane and a second position in which the second impingement surface is arranged to contact the flow of water such that impingement of the flow of water upon the impingement surface drives rotation of the first and second rotors, the joints configured such that rotation of the first and second rotors causes oscillation of the fins between the first and second positions; and

an energy output for transferring energy of the rotation of the first and/or second rotor from the device.

2. The energy generating device of claim 1, wherein an angle of incidence is defined between the first and second impingement surfaces and the plane, the fins arranged such that the angle of incidence is maximised when the fins pass through the plane and minimised when the fins are furthest from the plane.

3. The energy generating device of claim 2, wherein the angle of incidence oscillates between less than $\pm 90^\circ$, preferably the angle of incidence oscillates between less than $\pm 80^\circ$, most preferably the angle of incidence oscillates between less than $\pm 60^\circ$.

4. The energy generating device of claim 2 or 3, wherein the angle of incidence oscillates between more than $\pm 10^\circ$, preferably the angle of incidence oscillates between more than $\pm 30^\circ$.

5 5. The energy generating device of any preceding claim, wherein the first and/or second central portion has a helix diameter larger than a width of the supports transverse to the plane, preferably the first and/or second central portion has a helix diameter at least 4 times larger than the width of the supports transverse to the plane.

10 6. The energy generating device of any preceding claim, wherein the first and/or second central portion has a helix angle of between 0° and 90° , preferably the first and/or second central portion has a helix angle of between 10° and 80° , most preferably the first and/or second central portion has a helix angle of between 30° and 60° .

15 7. The energy generating device of any preceding claim, wherein the first and/or second central portion each comprise one turn.

8. The energy generating device of any preceding claim, wherein each joint comprises a ball and socket joint, wherein:

20 either an inner surface of the socket or an outer surface of the ball comprises one or more projections;

the other of the inner surface of the socket or the outer surface of the ball comprises a track for receiving the follower projection such that movement of the follower in the track transfers the rotation of the first and/or second rotor about the first and/or second axes into
25 oscillation of each fin about each fin axis.

9. The energy generating device of claim 8, wherein the one or more projections is a plurality of projections.

30 10. The energy generating device of any preceding claim, wherein the energy transfer device comprises a first generator attached to the first rotor.

11. The energy generating device of claim 10, wherein the energy transfer device further comprises a second generator attached to the second rotor.

12. The energy generating device of claim 10 or 11, wherein each generator is provided within the first and/or second support.

13. An energy generating apparatus comprising a plurality of devices according to any
5 preceding claim arranged next to one another.

14. A method of generating energy from a flow of fluid comprising the steps of:
placing a device according to any of claims 1 to 12, or the energy generating
apparatus of claim 13, into a flow of fluid such that the flow of fluid is substantially parallel
10 to the plane.

15. A method of driving a flow of fluid, comprising the steps of:
placing a device according to any of claims 1 to 12, or the energy generating
apparatus of claim 13, into a fluid; and
15 driving rotation of the first and second rotors from an energy source.

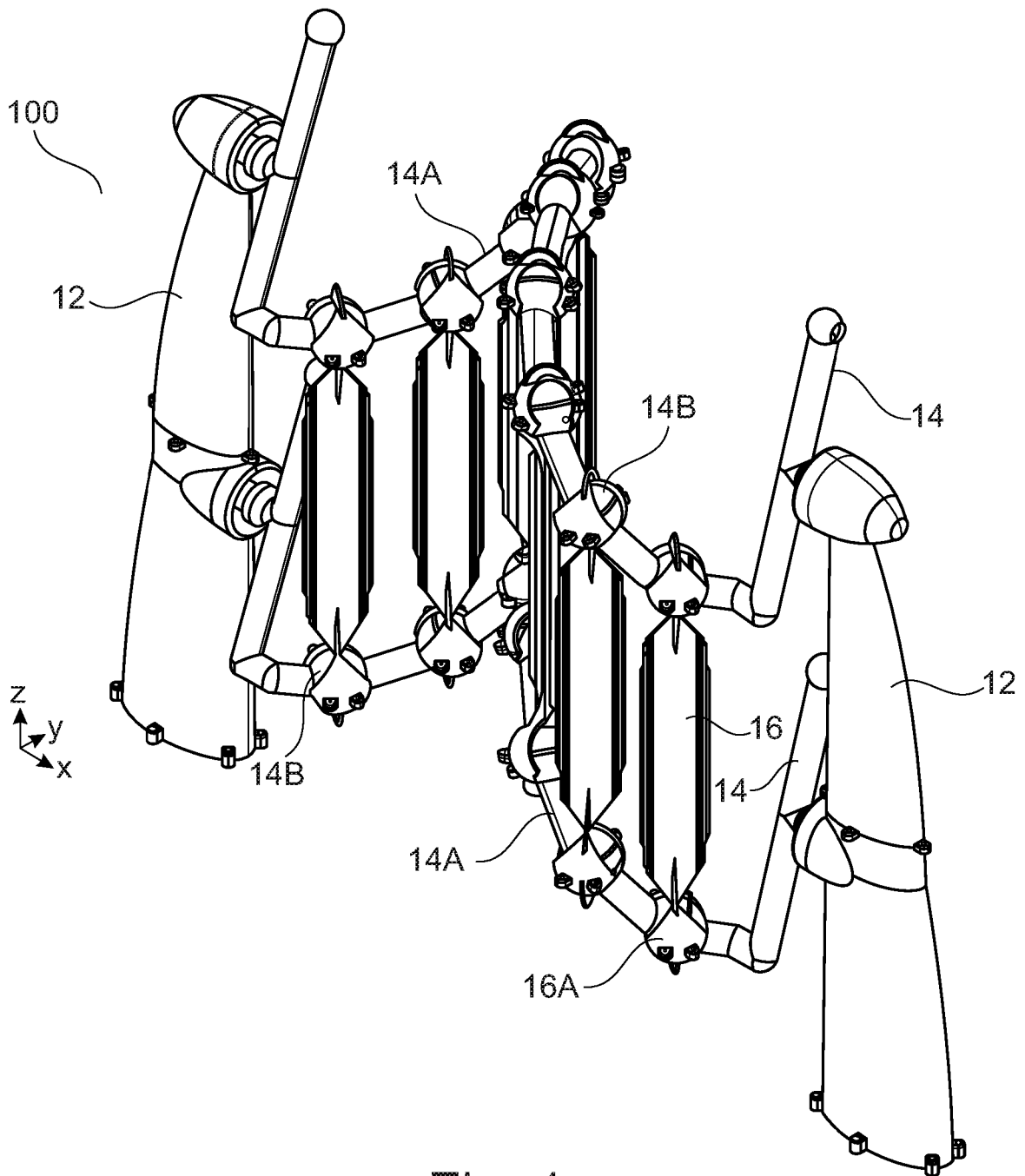


Fig. 1

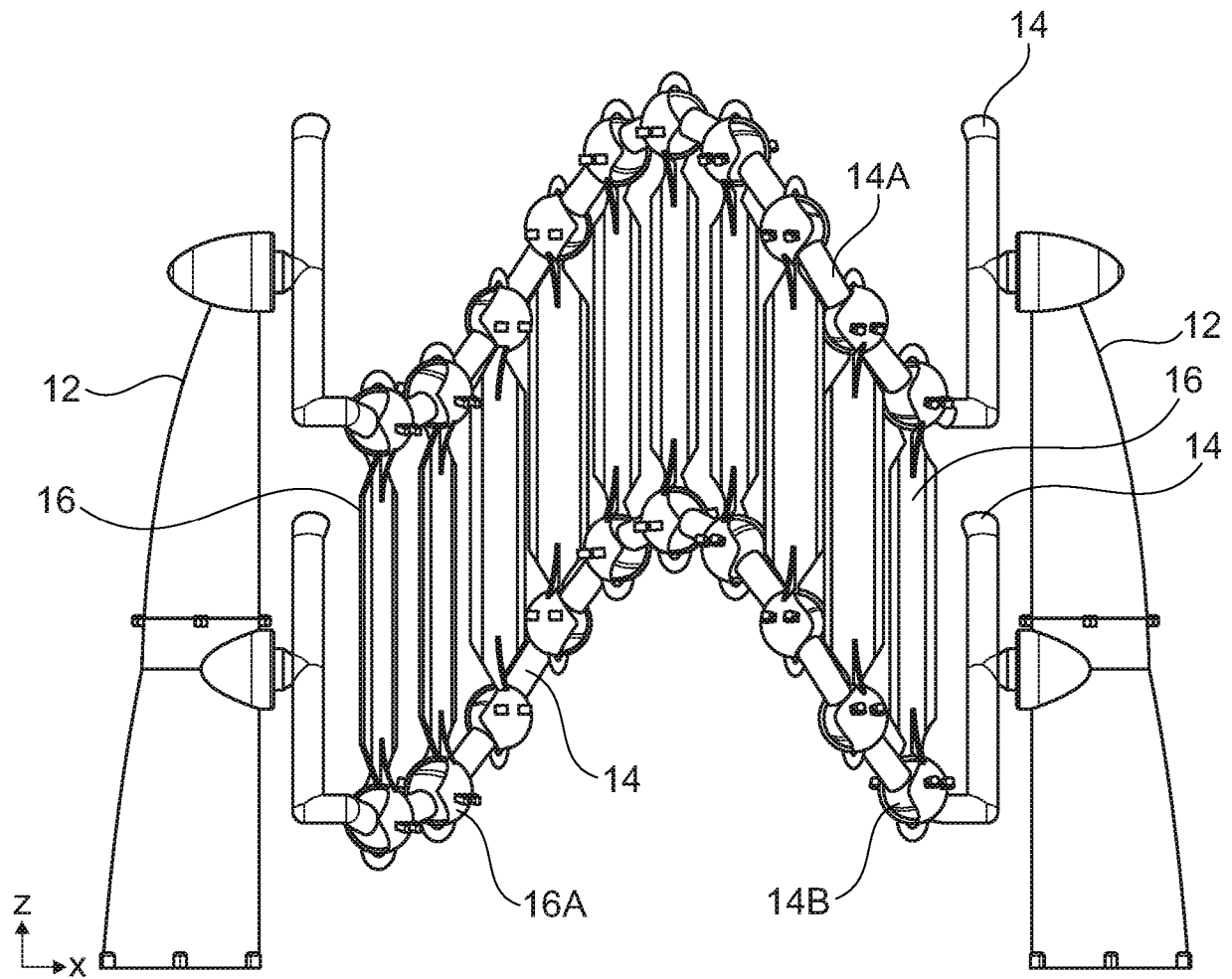


Fig. 2

3/7

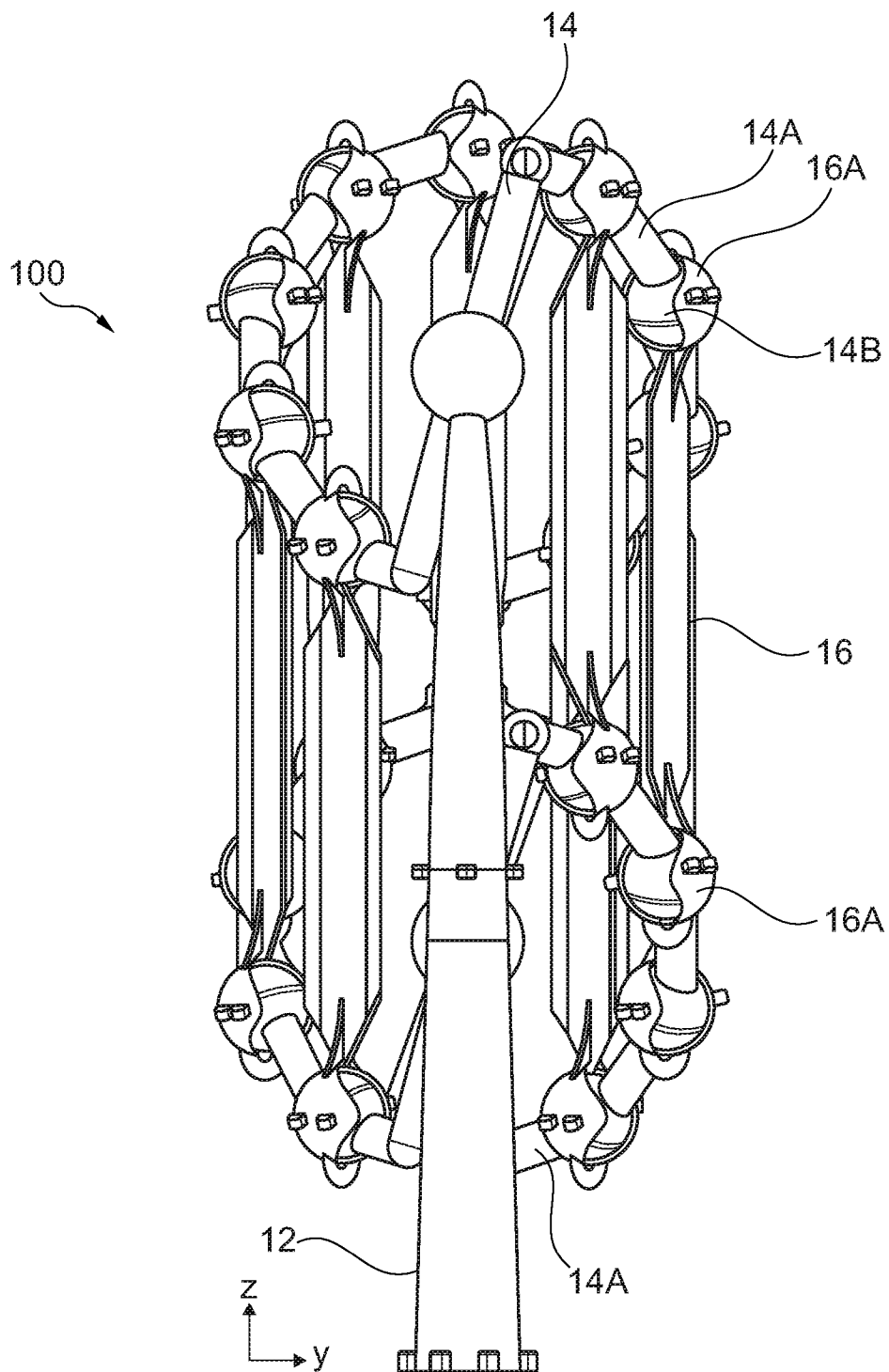


Fig. 3

4/7

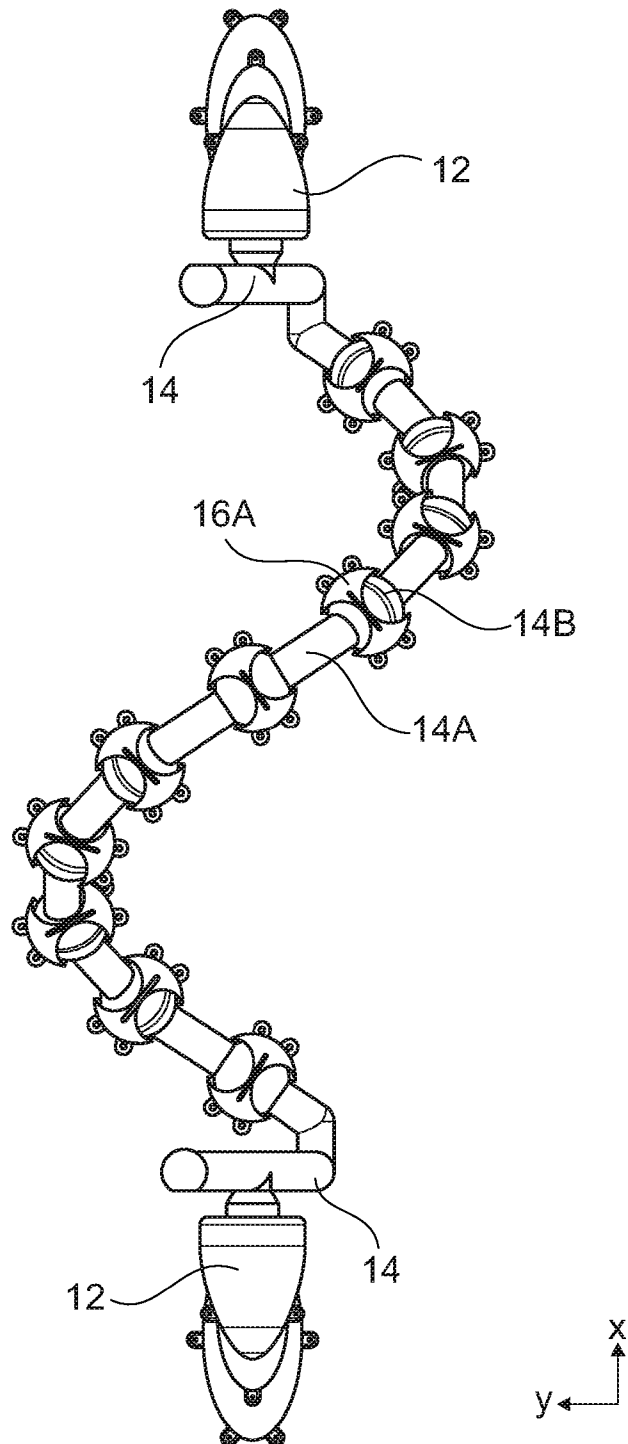


Fig. 4

5/7

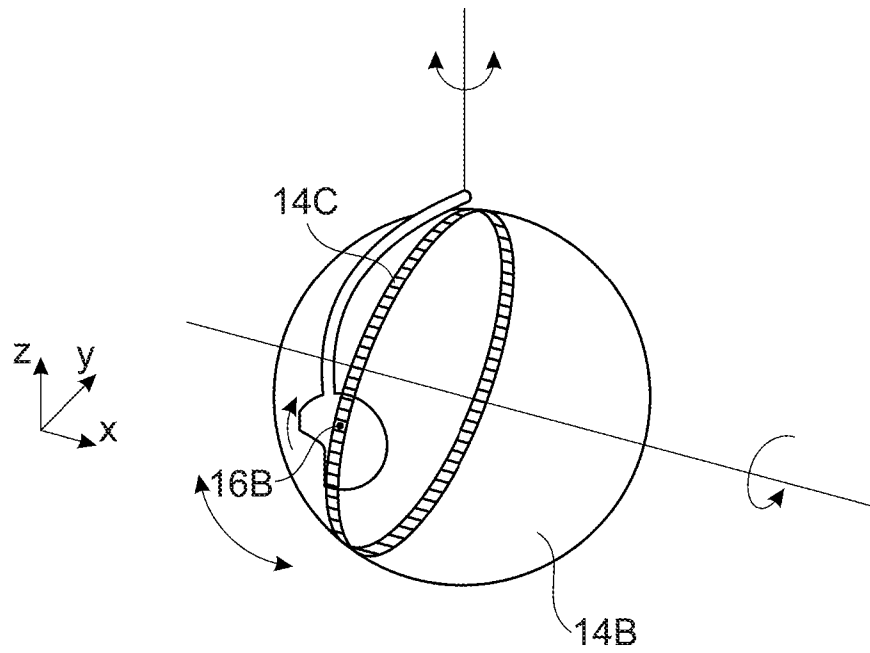


Fig. 5

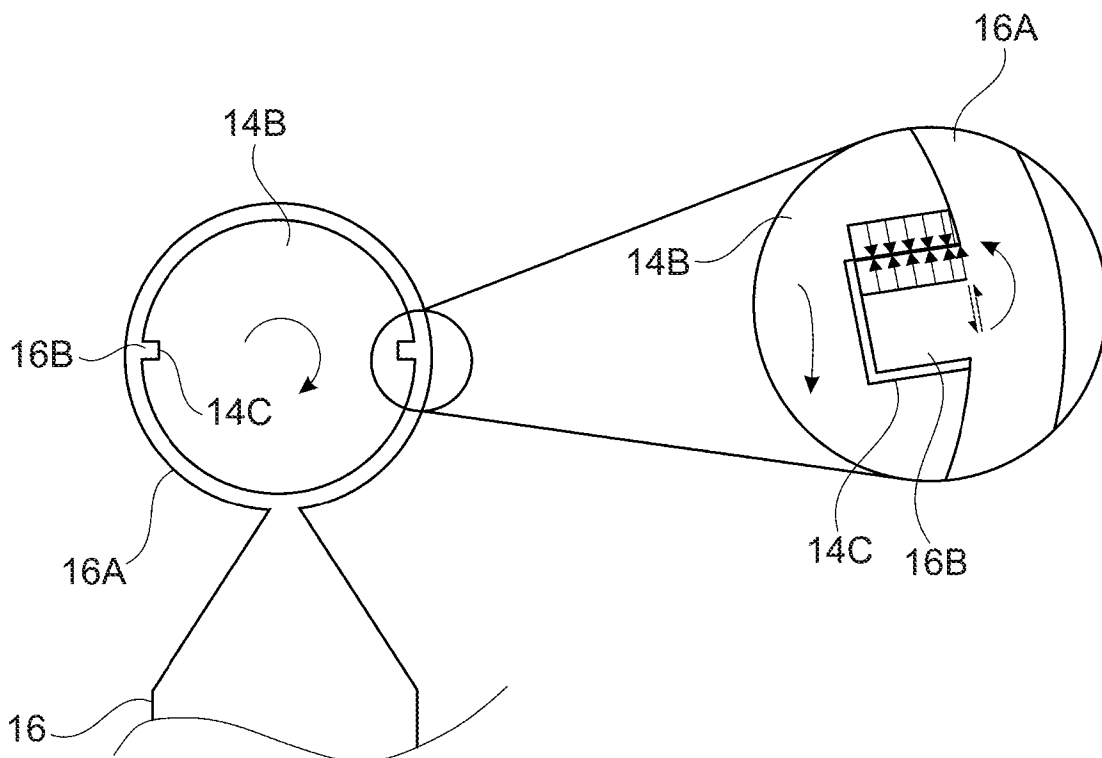


Fig. 6

6/7

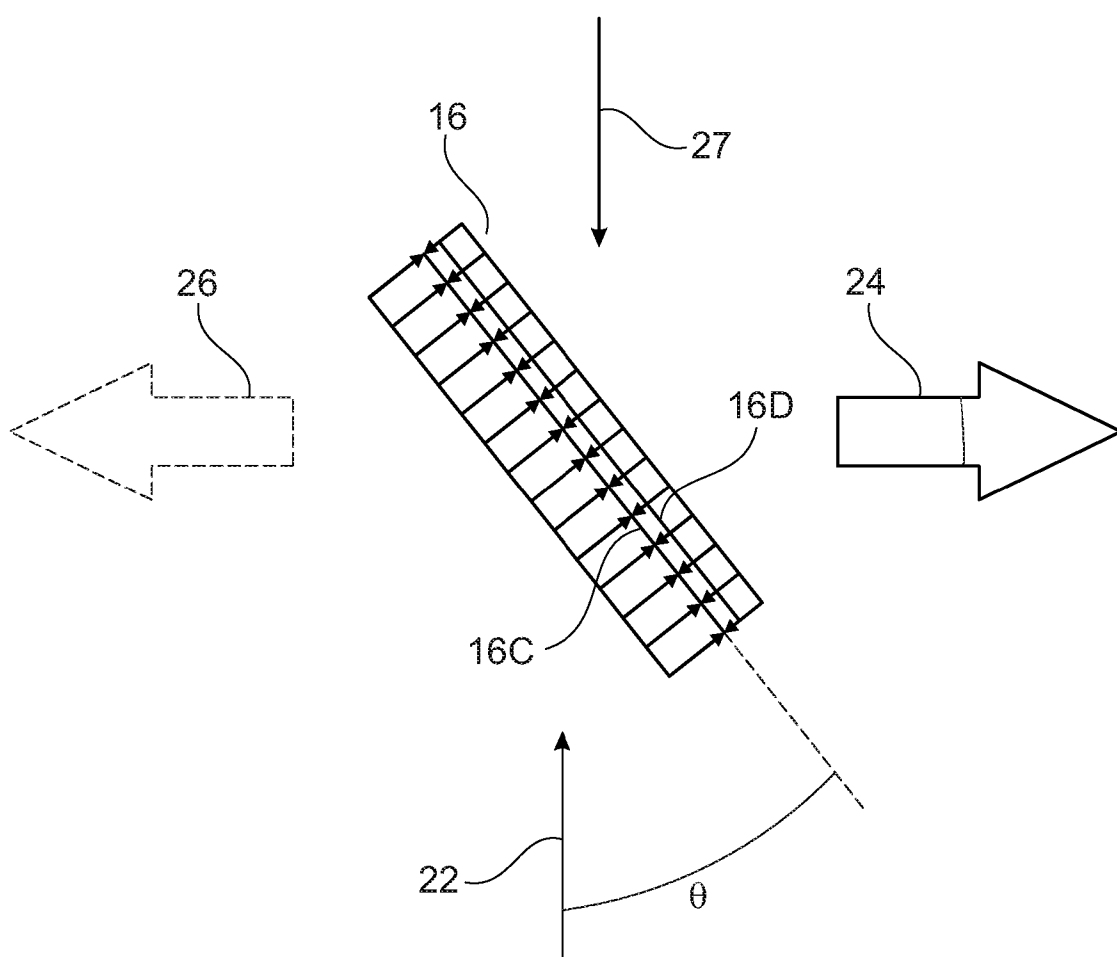


Fig. 7

7/7

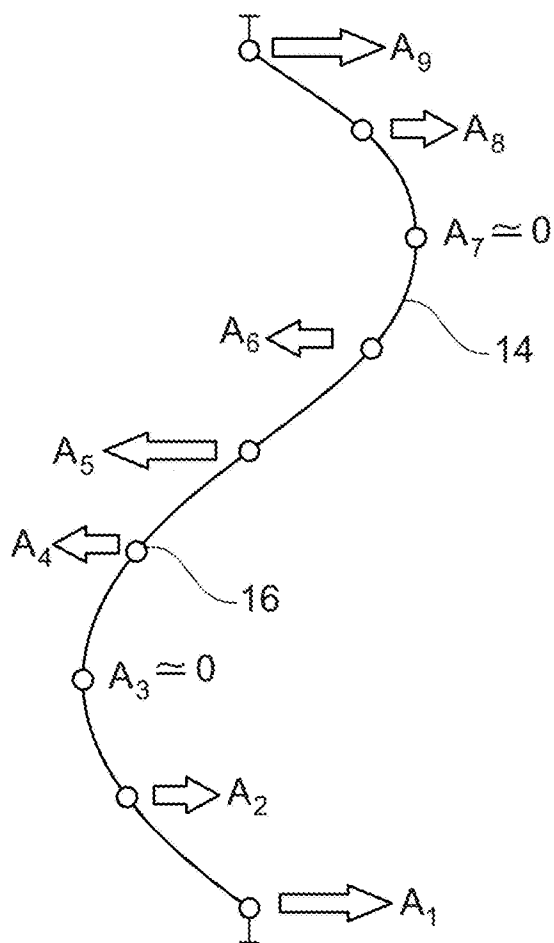


Fig. 8

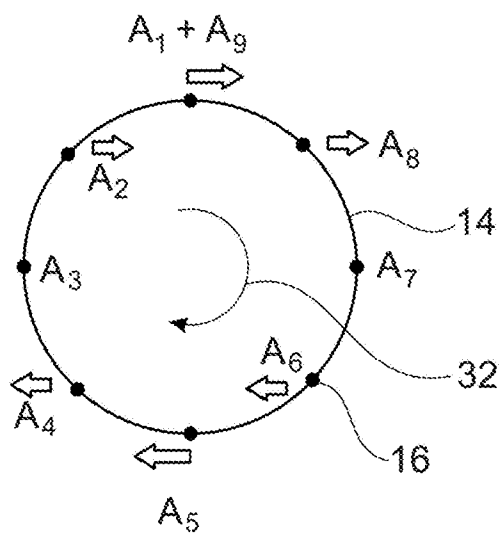


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2020/051562

A. CLASSIFICATION OF SUBJECT MATTER
INV. F03B13/26 F03B17/06
ADD.

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2013/343891 A1 (RAJAKARUNA UPPALA [US] ET AL) 26 December 2013 (2013-12-26) cited in the application paragraphs [0002], [0028], [0035] - [0040] figures 1,7,9 -----	1-15
A	US 6 273 680 B1 (ARNOLD LEE [US]) 14 August 2001 (2001-08-14) column 2, line 9 - column 3, line 34 figures 1,5,6 -----	1-15
A	US 2016/160650 A1 (KULLANDER STEN THOMAS [SE]) 9 June 2016 (2016-06-09) paragraph [0097] figure 3 ----- -/-	1-15



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

31 July 2020

Date of mailing of the international search report

25/08/2020

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Lux, Ralph

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2020/051562

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2001/000197 A1 (GORLOV ALEXANDER M [US]) 12 April 2001 (2001-04-12) paragraphs [0010] - [0016], [0045] - [0048], [0063] figure 16 -----	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2020/051562

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013343891	A1	26-12-2013	AU 2013271391 A1 29-01-2015
			CN 104520579 A 15-04-2015
			EP 2909475 A1 26-08-2015
			US 2013343891 A1 26-12-2013
			WO 2013185068 A1 12-12-2013

US 6273680	B1	14-08-2001	AT 266811 T 15-05-2004
			AU 727700 B2 21-12-2000
			BR 9714342 A 11-04-2000
			CA 2266632 A1 26-03-1998
			CN 1231021 A 06-10-1999
			DE 69729106 T2 12-05-2005
			EP 0927304 A1 07-07-1999
			IL 129049 A 23-05-2002
			JP 4187268 B2 26-11-2008
			JP 2001500941 A 23-01-2001
			KR 200000048506 A 25-07-2000
			NZ 335186 A 27-10-2000
			RU 2198318 C2 10-02-2003
			US 6273680 B1 14-08-2001
			WO 9812433 A1 26-03-1998

US 2016160650	A1	09-06-2016	EP 3025055 A1 01-06-2016
			SE 1330093 A1 24-01-2015
			US 2016160650 A1 09-06-2016
			WO 2015012752 A1 29-01-2015

US 2001000197	A1	12-04-2001	AU 693346 B2 25-06-1998
			BR 9608842 A 07-12-1999
			CA 2222115 A1 05-12-1996
			CN 1188526 A 22-07-1998
			DE 69630218 T2 12-08-2004
			EP 0830506 A1 25-03-1998
			HK 1015436 A1 30-06-2006
			JP H11506180 A 02-06-1999
			US 5642984 A 01-07-1997
			US 6036443 A 14-03-2000
			US 6155892 A 05-12-2000
			US 2001000197 A1 12-04-2001
			US 2001001299 A1 17-05-2001
			WO 9638667 A1 05-12-1996
