

(19) **DANMARK**



Patent- og
Varemærkestyrelsen

(12)

Oversættelse af europæisk patentskrift

(10) **DK/EP 2401496 T3**

-
- (51) Int.Cl.: ***F 03 B 13/08 (2006.01)*** ***F 03 B 13/18 (2006.01)*** ***F 03 B 13/20 (2006.01)***
F 03 B 13/26 (2006.01) ***F 03 G 7/08 (2006.01)***
- (45) Oversættelsen bekendtgjort den: **2015-01-19**
- (80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2014-10-08**
- (86) Europæisk ansøgning nr.: **10711250.0**
- (86) Europæisk indleveringsdag: **2010-02-25**
- (87) Den europæiske ansøgnings publiceringsdag: **2012-01-04**
- (86) International ansøgning nr.: **GB2010050319**
- (87) Internationalt publikationsnr.: **WO2010097622**
- (30) Prioritet: **2009-02-26 GB 0903272**
- (84) Designerede stater: **AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR**
- (73) Patenthaver: **Lissajous Energy LLP, 29 Wood Street, Stratford upon Avon, Warwickshire CV37 6JG, Storbritannien**
- (72) Opfinder: **WILLIAMS, Ivan, Patrick, Stone Barns, The Bog, Shrewsbury, Shropshire SY5 0NJ, Storbritannien**
HEPWORTH, John, Malcolm, 4 Romney Place, Rugby, Warwickshire CV22 6HN, Storbritannien
SLATER, David, Homfray, Ruxton House, Kings Caple, Hereford, Hereford and Worcester HR1 4TX, Storbritannien
- (74) Fuldmægtig i Danmark: **Awapatent A/S, Rigersgade 11, 1316 København K, Danmark**
- (54) Benævnelse: **Energiindfangningsindretning**
- (56) Fremdragne publikationer:
DE-U1- 20 201 389
GB-A- 2 428 747
US-A- 4 196 591

EP 2 401 496 B1

Description

[0001] The present invention relates to a power capture device and, in a preferred embodiment, to an ocean based power generating device. A vast array of technologies have been proposed in the generation of power from the oceans in a number of wave and tidal generation technologies which are at various stages of development. A selection of the main system types are described below.

Wave Energy Devices

[0002] Wave energy devices operate using one of a number of principles. Devices can be located on the shoreline, near shore or off shore. Early devices were shoreline based but more recent concepts have focused on off shore sites where wave energies are higher but conditions can be more challenging.

Oscillating Water Column Systems

[0003] In these systems, waves are trapped in a chamber and the rise and fall of the water moves a column of air which drives a turbine. These devices can be located either on the shoreline (e.g. built into cliffs or break waters) or in floating offshore devices.

TAPCHAN Systems

[0004] These shoreline based systems use a gradually tapering channel (hence TAP - CHAN) to amplify wave heights to a level that allows a raised reservoir or lagoon a few metres above normal sea level to be filled. Electricity is generated as the water passes from the reservoir back to the sea via a low head turbine.

Point Absorbers

[0005] In these devices, the motion of a buoyant object is used to drive a generator. The complete system comprises a float (which may rest at or under the surface of the sea), generating equipment and, in most cases, a platform/foundations fixed to the seabed. The movement of the float (usually relative to the fixed platform) drives the generating equipment to produce electricity.

Hinged Contour Devices

[0006] These devices use the relative motion of a series of floating structures to generate electricity. The vertical and/or horizontal movement between the floats can be captured using either hydraulic or mechanical couplings.

Overtopping Devices

[0007] In these devices, waves flow over a structure and electricity is generated by using the falling water to directly, or indirectly, power a turbine. These types of devices can be located either onshore or offshore.

Tidal Energy Devices

[0008] Tidal devices fall into two main categories: Tidal barrages, and Tidal current turbines. Barrages have already been tried and installed in a number of places, and whilst they have proved successful, their cost and environmental impact mean that current turbines are the leading technology concepts being proposed at present.

Barrages

[0009] Tidal barrages are installed in tidal estuaries or inlets and work by holding back the flow of water at high/low tides. Once a sufficient head of water has been formed, the water can be released through turbines to generate electricity.

Tidal Stream Devices

[0010] Operating using the same principle as wind turbines, tidal stream turbines generate power directly from the flow of the tides. They are installed in the sea at places with fast tidal currents or where continuous currents are fast and strong enough to produce energy from the water flow. The turbines can be orientated either horizontally or vertically and

EP 2 401 496 B1

systems can be either floating or secured directly to the seabed.

[0011] The document DE 20201389 U discloses an example of a power capture device.

[0012] The present invention does not utilise any of the principles adopted in the known devices referred to above but instead harnesses the inertial force, e.g. tide, swell, waves, current, from an ocean immersed mass relative to a fixed point. The preferred embodiment of the device of the present invention takes the form of an elongate buoyant column journalled in a support structure and which can move in three dimensions which, seen from above, appears as a classic lissajou motion and a superimposed movement caused by vortex shedding.

[0013] The buoyant pivotal column moves like an inverted pendulum in the wind. However, unlike a pendulum, whose bob describes in two dimensions an arc of fixed radius (the length of the string), a pivotal column moves (in two dimensions), along the appropriate horizontal chord of a circle. In three dimensions, seen from above, this appears as a classic Lissajou figure of eight but the column is subject to vortex induced motion which keeps it virtually in constant motion.

[0014] Vortex induced motion is an unsteady flow that takes place in special flow velocities (according to the size and shape of the cylindrical body). In this flow, vortices are created at the back of the body and detach periodically from either side of the body and this is known as vortex shedding. Vortex shedding is caused when a fluid flows past a blunt object. The fluid flow past the object creates alternating low-pressure vortices on the downstream side of the object. The object will tend to move towards the low-pressure zone. Eventually, if the frequency of vortex shedding matches the resonance frequency of the structure, the structure will begin to resonate and the structure's movement can become self-sustaining.

[0015] It is this movement which can be harnessed to produce electrical energy.

[0016] The present invention provides a power capture device utilising movement of a fluid body according to claim 1, which device comprises an elongate buoyant column journalled in a support structure for universal movement relative thereto, the support structure being adapted to be secured to the ground with the column disposed in the path of fluid flow so that the column experiences vortex induced motion which creates universal motion relative to the support structure automatically in response to force transmitted by fluid flow past the column, wherein the support structure includes actuating means to convert movement of the column into an operative force to drive electrical power generating means.

[0017] In some preferred constructions according to the invention, the buoyant column may be adapted to stand upright relative to the support structure.

[0018] In other constructions, the buoyant column may be adapted to be suspended from the support structure.

[0019] According to a feature of this aspect of the invention, the support structure may be adapted to be secured to the bed or banks of a body of water, such as the sea bed or a river bed or bank and wherein the column is disposed for at least partially submerged universal motion relative to the support structure automatically in response to force transmitted by the flow of water past the column.

[0020] According to another feature of this aspect of the invention, the actuating means may comprise a plurality of piston and cylinder assemblies. Preferably, an array of piston and cylinder assemblies is provided by the support structure, and wherein the column is adapted to actuate the piston and cylinder assemblies in random sequence as a result of movement of the column relative to the support structure. It is also preferable that the array of piston and cylinder assemblies are disposed to present means to actuate the heads of the pistons to the supported end of the column which causes reciprocal movement of the pistons in random sequence as a result of said movement of the column. It is further preferred that the array of piston and cylinder assemblies are disposed in a part spherical arrangement and the supported end of the column includes a spherical actuator which rides around the part spherical arrangement of the piston and cylinder assemblies to cause said reciprocal movement of the pistons in random sequence. Even more preferably, the piston and cylinder assemblies are arranged in a plurality of concentric annular banks within a part spherical recess within the support structure.

[0021] According to another feature of the invention, in some constructions the array of piston and cylinder assemblies may be hydraulically or pneumatically connected to drive electrical power generating means contained within the support structure. In other constructions, the array of piston and cylinder assemblies may be mechanically actuated to drive electrical power generating means contained within the support structure.

[0022] According to a further feature of this aspect of the invention, the column may be journalled in the support structure by means of a ball and socket joint arrangement.

[0023] According to yet another feature of this aspect of the invention, the supported end of the column includes the ball of the ball and socket joint arrangement and the socket of the ball and socket joint arrangement is provided by a concave annulus within the support structure. Preferably, the column includes an extension within the support structure beyond the ball of the ball and socket joint arrangement which actuates said means in random sequence to drive electrical power generating means as a result of movement of the column relative to the support structure.

[0024] According to a still further feature of this aspect of the invention, the support structure and the column may have complementary formed faces to limit the universal movement of the column relative to the support structure.

[0025] Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

EP 2 401 496 B1

Figure 1 is a simplistic perspective view of the device in which the elongate column is shown moveably connected relative to a fixed support structure;

Figure 2 is an enlarged perspective view of the support structure and the lower end of the column shown partially in vertical cross-section;

5 Figure 3 is a further enlargement of the view shown in Figure 2 showing the base of the column and an array of hydraulic piston and cylinder assemblies;

Figure 4 is a still further enlarged view of the view of the base of the column showing annular banks of the piston and cylinder assemblies;

10 Figure 5 is a perspective view of one mechanical arrangement for the actuation of the hydraulic piston and cylinder assemblies;

Figure 5a is a sketch of the lower end of the device;

Figure 6 is mechanical arrangement for transferring movement of the column into rotational movement to drive generators;

Figure 7 is top view of the column showing movement as a result of vortex shedding; and

15 Figure 8 is view similar to figure 7 emphasising vortex induced eddies.

[0026] Referring first to Figures 1 to 6 of the drawings, the device 10 comprises an elongate buoyant column 12, which is received and journaled in a support structure 14 adapted to be secured to the sea bed. It is envisaged that the column may have a length of the order of 200m and be of up to 40m in diameter. It is therefore a massive structure but may be
20 formed from a suitable plastics material.

[0027] It is further envisaged that the column 12 can be formed from a stack of modular sections of annular form. If the column is formed as a modular structure its height can be varied for different water depths. Moreover, although this structure is non-intrusive when installed, it readily can be repaired if damaged by impact.

[0028] The column is journaled in the support structure by means of a ball and socket joint adjacent the upper end of the support structure. The ball and socket joint comprises a spherical portion 16 (Figures 2 and 4) of the column adjacent its lower extremity and a concave annulus 18 formed in the support structure. Thus, the column can move universally relative to the support structure automatically in response to force transmitted by the various complex movements of the ocean. However, the overall movement of the column is limited by shaped complementary mating bearing surfaces 20, 22 provided by the column and the head 24 of the support structure, respectively.

[0029] The extremity of the supported end of the column is formed with a spherical actuator 26 which is spaced from the spherical portion 16 by an integral arm 28. The spherical actuator 26 operates within a semi-spherical bowl 30 formed within the support structure. The spherical actuator 30 rides around protruding spheres which actuate the pistons in an array 32 of piston and cylinder assemblies. The pistons are actuated in random sequence consequent upon the movement of the column. As shown, and best seen in Figures 3 and 4 the array of piston and cylinder assemblies are arranged in
35 the bowl 30 in a number of concentric annular banks, e.g. 34, 36, 38. The piston and cylinder assemblies are connected by suitable hydraulic and/or pneumatic circuits to a number of electrical power generators 40 which are housed in a chamber 42 of the support structure disposed below the bowl 30. The actuation of the pistons and the connecting fluidic circuitry is such that continuous generation of electrical power is obtained through the constant motion of the column. However, it is envisaged that the electrical power generating means may be housed separately from the support structure and may be located on-shore so that the device pumps hydraulic fluid, which could be sea water, to energy accumulators for the remote generation of electricity.

[0030] Referring now to Figure 5 of the drawings details one embodiment of a single piston and cylinder assembly 44 of the array 32 is shown. The piston and cylinder assembly 44 comprises a housing in the form of a cylindrical sleeve 46, each of which is contained in bores formed in the semi-spherical bowl 30. One end of the sleeve 46 provides a seat
45 for a spherical force transmission element, which preferably is a ball 48. Ball 48 can rotate relative to the sleeve 46 and move axially within it, but is constrained from being dislodged from the open top of the sleeve by an inwardly directed lip 47. The spherical actuator 26 at the supported end of the column 12 periodically bears down on each of the transmission balls 48 as the spherical actuator passes over them and depresses the transmission ball against a compression spring into the sleeve. The transmission ball abuts a spherical end 50 of a piston rod 52 of a hydraulic ram 54. Thus, axial
50 movement of the transmission ball 48 down the sleeve 46 depresses the piston rod against the force of a return spring 56 to operate the piston of the hydraulic ram. The hydraulic ram causes hydraulic fluid to be transferred to an accumulator means which, in turn, drives one or more electrical generators. When the spherical actuator 26 is out of contact with that particular piston and cylinder assembly, the transmission ball returns to its upper inactive position at the top end of the sleeve by the restorative force of the return spring 56.

55 [0031] Referring now to Figure 6 of the drawings, another embodiment of piston and cylinder assembly is shown, and like parts to those of Figure 5 are designated like reference numerals, with the addition of suffix 'a' and function in a similar manner.

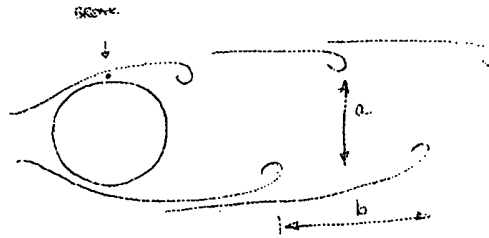
[0032] In this alternative embodiment, the piston and cylinder assembly 44a does not involve the inclusion of hydraulic

EP 2 401 496 B1

or pneumatic components but rather is a mechanical assembly. Thus, the piston rod 52a reciprocates within sleeve 46a, against the force of return spring 56a, and protrudes through an opening 58 formed in an end wall 60 of the sleeve. The exposed lower end of the piston rod is formed with an axial gear 62 which meshes with and drives planet gear wheel 64 in consequence of reciprocal movement of the piston rod 52a. Gear 64 meshes with and drives a sun drive gear 66 of an electrical generator to produce electrical power.

[0033] Figures 7 and 8 of the drawings illustrate the phenomena of vortex shedding to which the buoyant column is subject when disposed in a fluid flow.

[0034] The buoyant column is designed to extract energy from tidal flows of 2 -6 m/s, and is caused to oscillate from side to side by the process of vortex shedding.



[0035] The following equation applies to the frequency of oscillations due to vortex shedding, but this may be perturbed if the oscillations are damped.

$$\frac{fd}{u_{\infty}} = 0.198 \left(1 - \frac{19.7}{Re} \right)$$

[0036] Where Re is the Reynold's number and $Re = \frac{u_{\infty} d}{\nu}$

ν = water.viscosity = 0.001Pa.s

ρ = water.density = 1025kg / m³

d = device.diameter

u_{∞} = water.velocity

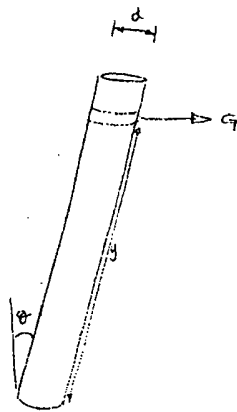
h = deviceheight

f = frequency

T = period

C_L = liftcoefficient = 1to3.5

EP 2 401 496 B1



$$f = 0.198 \left(1 - \frac{19.7v}{u_{\infty}d} \right) \frac{u_{\infty}}{d}$$

Then

The lift force due to the vortex is given by $L = C_L (0.5\rho u^2)$ per unit area. C_L is uncertain in the vortex situation, but is probably between 1 and 3.5. A value of 1.0 is used here.

Consider a band 1 metre thick, a distance "y" metres above the fulcrum, then the total force from this band is taken to be the lift force * 0.5 * diameter $G = C_L 0.5d$. Assuming half of the diameter is the area over which the lift occurs.

The torque due to the force G arising from this band is then $\tau = Gy$

$$\Gamma = \int_0^h Gy dy$$

The total torque on the device is obtained by integrating the effect of all bands from $y=0$ to $y=h$, this gives

$$\Gamma = 0.5Gh^2$$

[0037] If the buoyant column swings by θ radians then the work done or energy is $E = \Gamma\theta$ J (Joules)

[0038] The power is then $P = E/T$ or $P = E f$ J/s or W

[0039] Substituting from all of the above

$$P = \frac{0.198}{8} \rho u^2 d \theta h^2 \left(1 - \frac{19.7v}{u_{\infty}d} \right) \frac{u_{\infty}}{d} \text{ Watts}$$

$$P = 0.02475 \rho u^3 \theta h^2 \left(1 - \frac{19.7v}{u_{\infty}d} \right) \text{ Watts}$$

[0040] To estimate the available power in the water flow, the power is based on standard energy flux and area, with the area being the frontage area of the device (hd). This is very much an estimate, and it may be that in reality it is smaller, or on the other hand, it may be larger as the area swept out by the device may be the real area ie $2h\theta$.

$$P_w = 0.5A\rho u^3 \text{ Watts}$$

[0041] But we can take $A=hd$ and so

$$P_w = 0.5dh\rho u^3 \text{ Watts}$$

[0042] The conversion efficiency will therefore be

EP 2 401 496 B1

$$\eta = \frac{P}{P_w}$$

$$\eta = \frac{P}{P_w} = \frac{0.198}{8} \rho u^3 \theta h^2 \left(1 - \frac{19.7v}{u_\infty d}\right) / 0.5 d h \rho u^3$$

$$\eta = \frac{P}{P_w} = \frac{0.198 * 2}{8} \left(1 - \frac{19.7v}{u_\infty d}\right) \frac{\theta h}{d}$$

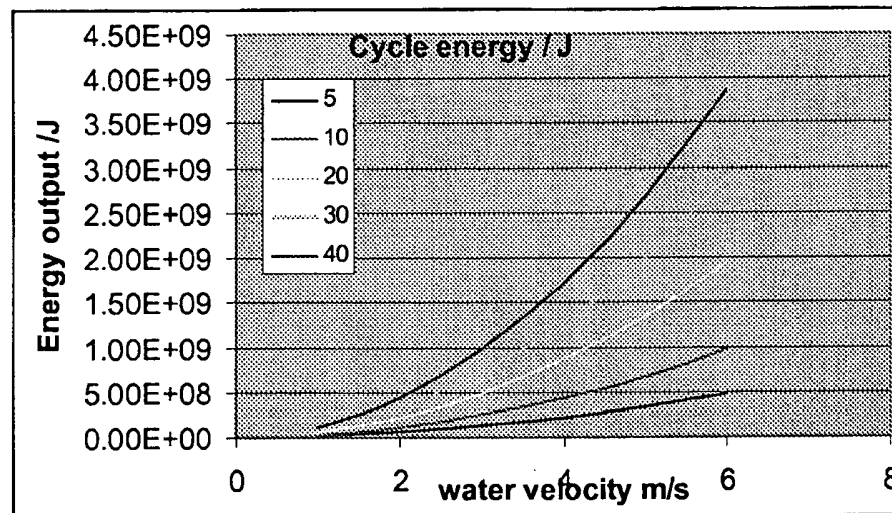
$$\eta = 0.0495 \left(1 - \frac{19.7v}{u_\infty d}\right) \frac{\theta h}{d}$$

[0043] The above calculations are used to obtain some numerical values, to some extent subject to a number of uncertainties.

[0044] The following calculations are for a column length of 200m from pivot to water surface. The column diameter varies from 5 to 40m, and the water velocity runs up to 6m/s.

ENERGY

[0045]



[0046] The energy captured in each cycle is strongly dependent on device diameter and water velocity.

PERIOD

[0047] The period of vortex induced oscillations is shown below, and is also strongly dependent on device diameter and water velocity.

EP 2 401 496 B1

5

10

15

20

POWER

25

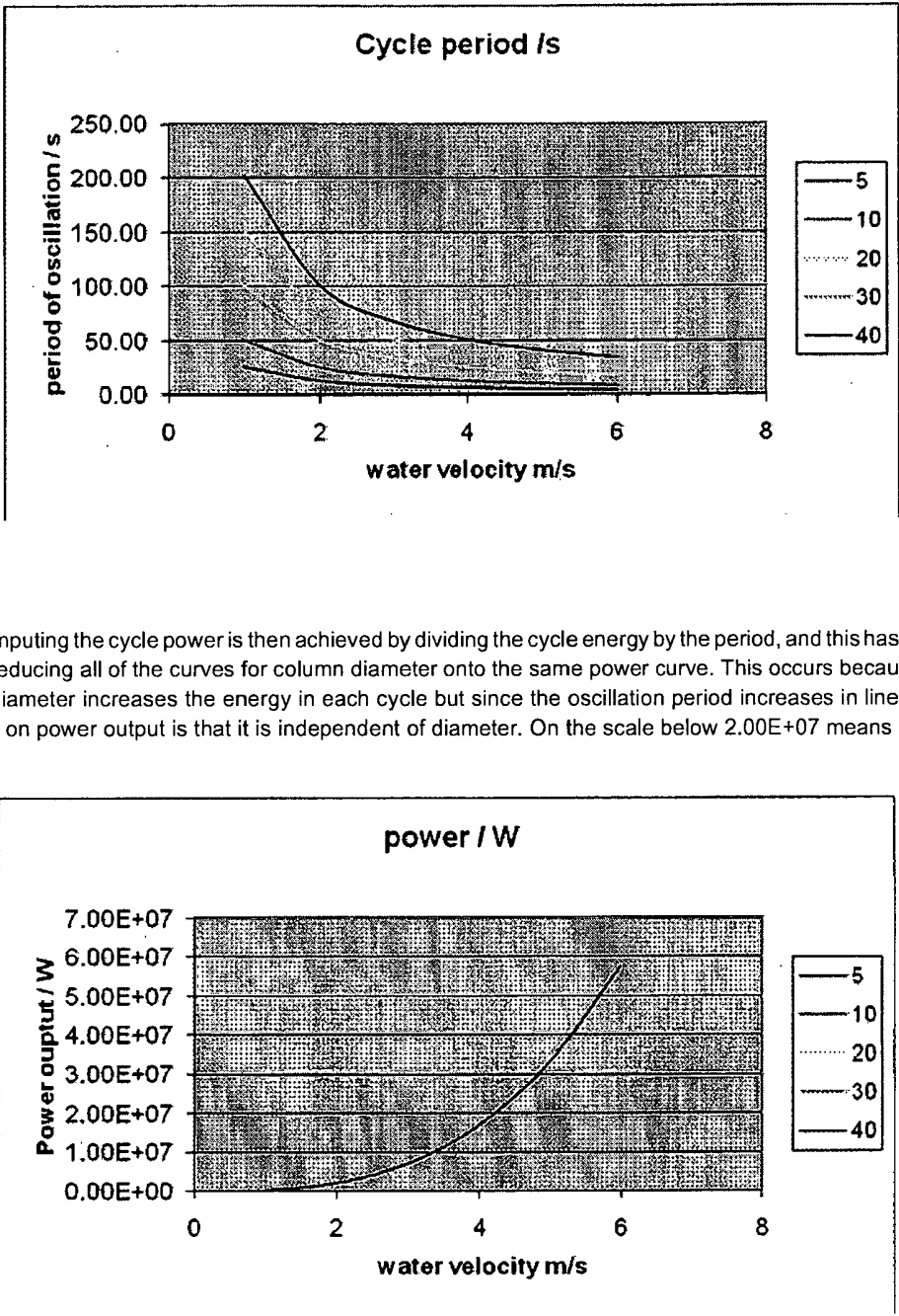
[0048] Computing the cycle power is then achieved by dividing the cycle energy by the period, and this has the important outcome of reducing all of the curves for column diameter onto the same power curve. This occurs because increasing the column diameter increases the energy in each cycle but since the oscillation period increases in line with this, the overall effect on power output is that it is independent of diameter. On the scale below 2.00E+07 means 20MW.

30

35

40

45



EFFICIENCY

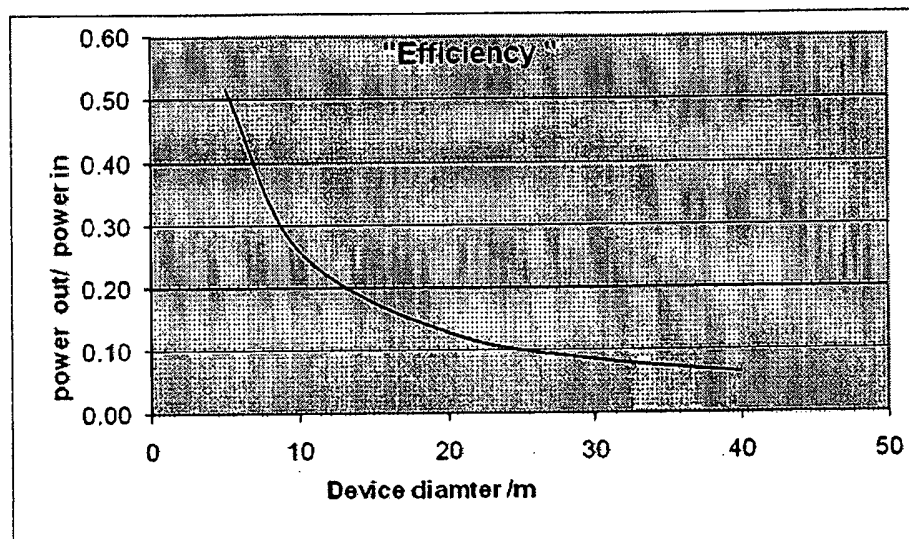
50

[0049] It is possible to estimate the efficiency by considering the output power relative to the power in the water flow. This has a number of uncertainties and may be of little value, but the trend shown suggests that the efficiency is better at lower device diameters.

55

[0050] The single curve applies to all water velocities.

EP 2 401 496 B1



Tank and model tests.

[0051] Small scale model tests have been conducted in a flume tank and load/displacement measurements were made subsequently.

[0052] Assuming the model to be at a scale of 1:600, (0.33m :200m), then using Froude scaling, the flow in the tank, which was variously 10,20,30,40 litres per second, corresponded to a velocity of 2.7, 5.4, 8.2 and 10.8 m/s respectively.

[0053] The load/displacement measurement result of 15N for the force corresponds to $15 \times 600^3 = 3.24 \text{ GN}$

[0054] If the column swings through 15 degrees then the Energy = 848 MJ

[0055] From the tank test results the period of motion was of the order of 1s, which corresponds to a full scale period of $1 \times 600^{0.5} = 24.49 \text{ s}$

[0056] The full scale power will therefore be $848 \text{ MJ}/24.49\text{s} = 34 \text{ MW}$

[0057] The maths and small scale tests show the potential for the concept. The body moves in the manner predicted and on the basis of many assumptions output power levels of 10's of MW are estimated. A full scale device of 200m, and any diameter from 5 to 40 m might produce 50MW in water velocities of 6m/s.

[0058] The assumptions of effective surface area, lift coefficient, vortex mechanism, influence of damping, swept area etc could be refined, and yield superior performance. A lift coefficient of 1 was used in the present calculations, whereas it might be as high as 3.5 , which would give a direct improvement of a factor of 3.5. On the other hand efficiencies are unlikely to exceed 0.59 (59%) as this is a theoretical limit in open flow according to Lanchester-Betz criterion.

[0059] It is also envisaged within the scope of the present invention that the device could be installed in an inverted attitude so that the column is suspended from the support structure in a body of water. In such an arrangement the lower free end of the column would be weighted and would act like a pendulum with universal motion. The support structure itself would be supported by a gantry spanning a natural or man-made channel through which water flows or the gantry could span the banks of a river.

[0060] In a still further embodiment of the invention, it is envisaged that the device could be modified for use as a wind powered device. In this arrangement the column could be formed from a light weight fabric, plastics or other suitable material providing a sealed buoyant cylinder filled with air or helium.

P A T E N T K R A V

1. Energiindfangningsindretning (10) til at udnytte bevægelse af et fluidt legeme i brug, hvilken indretning indbefatter en aflang søjle (12), som flyder i et fluid til en forrykket orientering, og som tilgrænsende til en yderste ende er i en lejret tilknytning til en støttestruktur (14) til universel bevægelse deromkring defineret af den lejrede tilknytning, hvilken støttestruktur (14) er indrettet til at være fastgjort til søjlen (12) arrangeret i en fluid strømning i brug sådan, at søjlen (12) ved sin facon, position og længde oplever variabel bevægelse grundet en induceret hvirveeffekt ved nedstrømssiden af søjlen (12) i strømmingen balanceret af opdriften af søjlen (12) til den forrykkede orientering, som skaber universel bevægelse i forhold til støttestrukturen (14) grundet fluidstrømning forbi søjlen (12) i brug, hvor indretningen omfatter et aktuatormiddel (30) til at omdanne bevægelse af søjlens (12) yderste ende til en virksom kraft, hvilket aktuatormiddel omfatter et middel til at samvirke med dele af den yderste ende (26) på den anden side af den lejrede tilknytning for at bevæge og/eller forskyde en aktuator (30), som den yderste ende (26) af søjlen (12) bevæger sig, for at tilvejebringe en virksom kraft.

2. Energiindfangningsindretning ifølge krav 1, hvor den flydende søjle (12) er indrettet til at stå opret i forhold til støttestrukturen (14).

3. Energiindfangningsindretning ifølge krav 1, hvor den flydende søjle (12) er indrettet til at være ophængt i støttestrukturen (14).

4. Energiindfangningsindretning ifølge et hvilket som helst af de foregående krav, hvor støttestrukturen (14) er indrettet til at sikres til bunden eller bredden af et legeme af vand, såsom havbunden eller flodbunden eller flodbredden, og hvor søjlen (12) er indrettet til i det mindste delvis nedsænket universel bevægelse i forhold til støttestrukturen (14) automatisk som reaktion på kraft overført af vandstrømmen forbi søjlen.

5. Energiindfangningsindretning ifølge et hvilket som helst af de foregående krav, hvor aktuatormidlet indbefatter flere stempel-og-cylinder-aggregater (32).

6. Energiindfangningsindretning ifølge krav 5, hvor et arrangement af stempel-og-cylinder-aggregater (32) er tilvejebragt ved støttestrukturen (14), og hvor søjlen (12) er indrettet til at aktivere stempel-og-cylinder-aggregaterne (32) i tilfældig rækkefølge som følge af bevægelse af søjlen (12) i forhold til støttestrukturen (14).

7. Energiindfangningsindretning ifølge krav 6, hvor arrangementet af stempel-cylinder-aggregater (32) er indrettet til at præsentere et middel til at aktivere stempelhovederne for den støttede ende (28) af søjlen (12), hvilket forårsager reciprok bevægelse af stemplerne i tilfældig rækkefølge som følge af søjlens bevægelse.

8. Energiindfangningsindretning ifølge krav 7, hvor arrangementet af stempel-og-cylinder-aggregater (32) er arrangeret i et delvist sfærisk arrangement, og den støttede ende af søjlen (28) omfatter en sfærisk aktuator, som bevæger sig omkring i det delvist sfæriske arrangement af stempel-og-cylinder-aggregaterne (32) for at bevirke den reciproke bevægelse af stemplerne i tilfældig rækkefølge.

9. Energiindfangningsindretning ifølge krav 8, hvor stempel-og-cylinder-aggregaterne er arrangeret i flere koncentriske, ringformede rækker (34, 36, 38) i en delvist sfærisk ud-

sparing i støttestrukturen.

10. Energiindfangningsindretning ifølge et hvilket som helst af kravene 6 til 9, hvor arrangementet af stempel-og-cylinder-aggregater (32) er hydraulisk eller pneumatisk forbundet for at drive et elgenererende middel (40) indeholdt i støttestrukturen (14).

- 5 11. Energiindfangningsindretning ifølge et hvilket som helst af kravene 6 til 9, hvor arrangementet af stempel-og-cylinder-aggregater (32) er mekanisk aktiveret til at drive det elgenererende middel (40) indeholdt i støttestrukturen (14).

12. Energiindfangningsindretning ifølge et hvilket som helst af de foregående krav, hvor søjlen (12) er lejret i støttestrukturen ved hjælp af et kugleledsarrangement (16, 18).

- 10 13. Energiindfangningsindretning ifølge krav 12, hvor den støttede ende af søjlen omfatter kuglen af kugleledsarrangementet (16, 18), og skålen i kugleledsarrangementet er tilvejebragt ved en konkav ring (18) i støttestrukturen (14).

14. Energiindfangningsindretning ifølge krav 13, hvor søjlen (12) omfatter en forlængelse (28) i støttestrukturen på den anden side af kuglen i kugleledsarrangementet (16, 15 18), hvilken aktiverer midlet i tilfældig rækkefølge for at drive det elgenererende middel (40) som følge af bevægelse af søjlen (12) i forhold til støttestrukturen (14).

15. Energiindfangningsindretning ifølge et hvilket som helst af de foregående krav, hvor støttestrukturen (14) og søjlen (12) har komplementært formede flader (20, 22) til at begrænse den universelle bevægelse af søjlen (12) i forhold til støttestrukturen (14).

- 20 16. Energiindfangningsindretning ifølge et hvilket som helst af de foregående krav, hvor søjlen indbefatter en stak af flydende modulære sektioner.

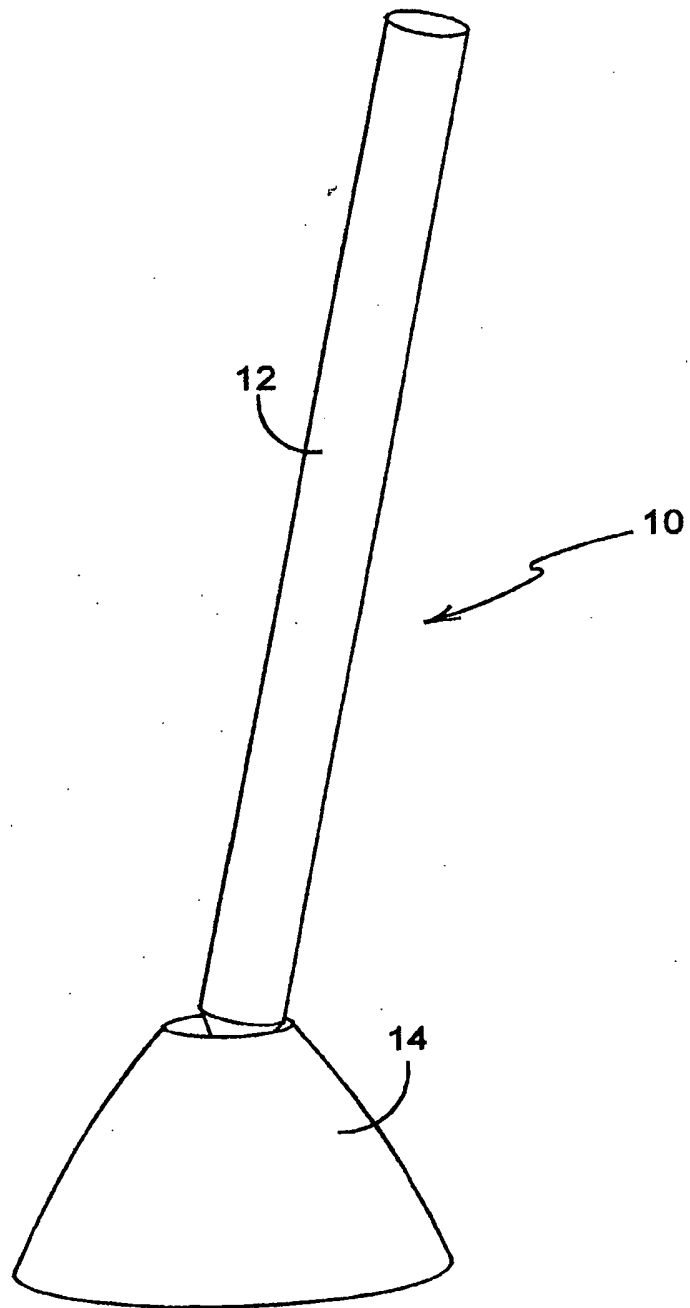


FIGURE 1

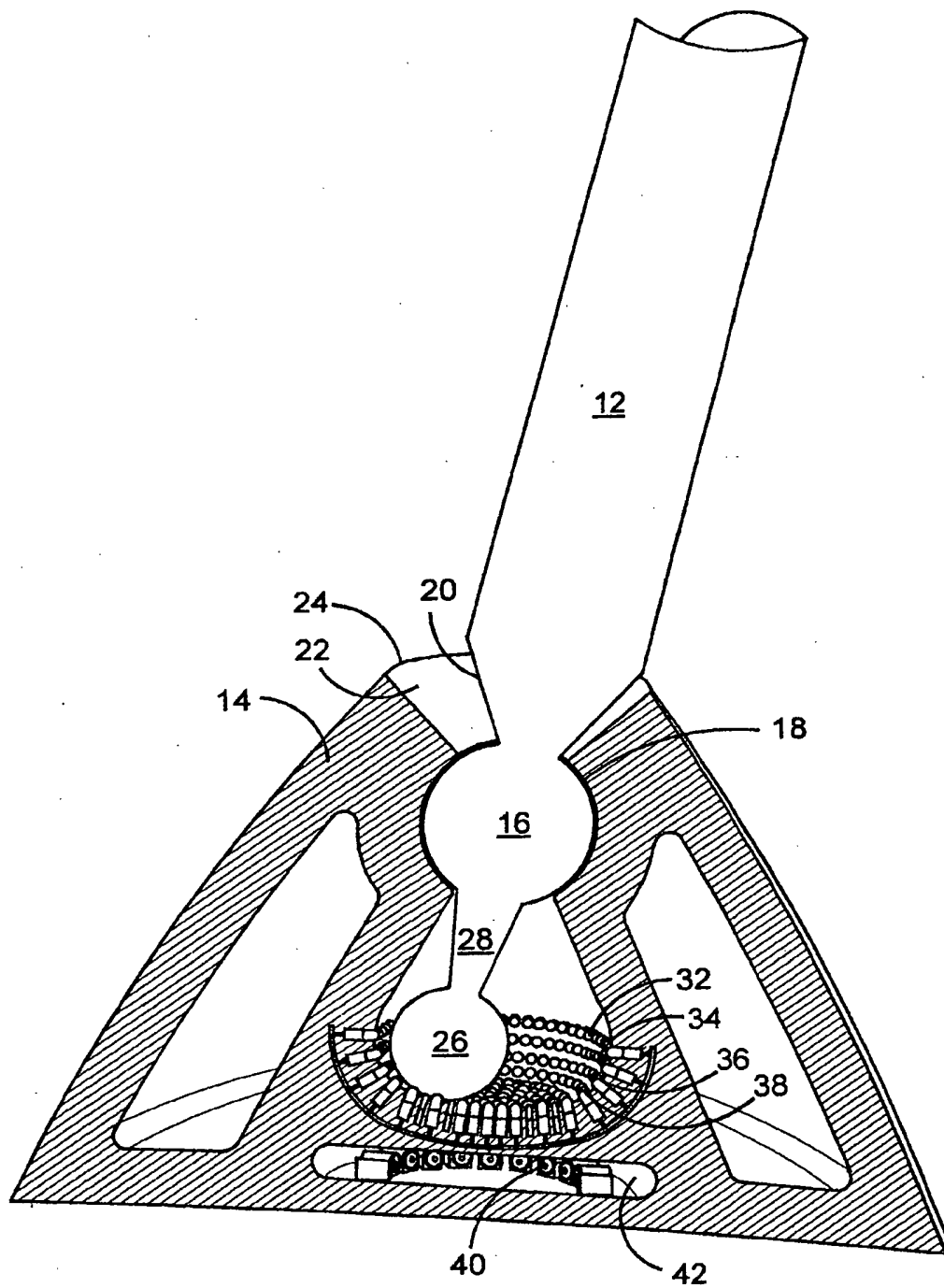
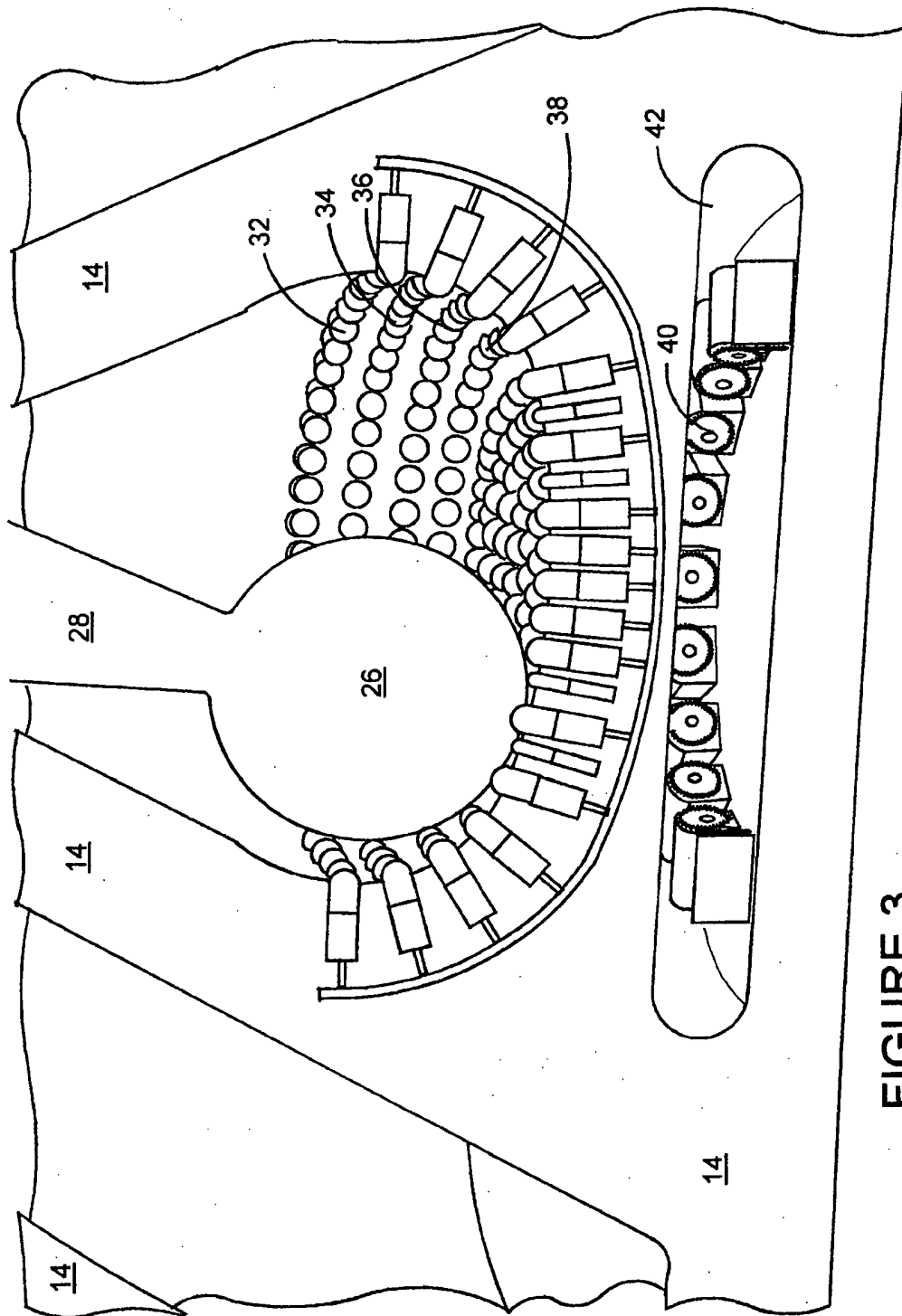


FIGURE 2



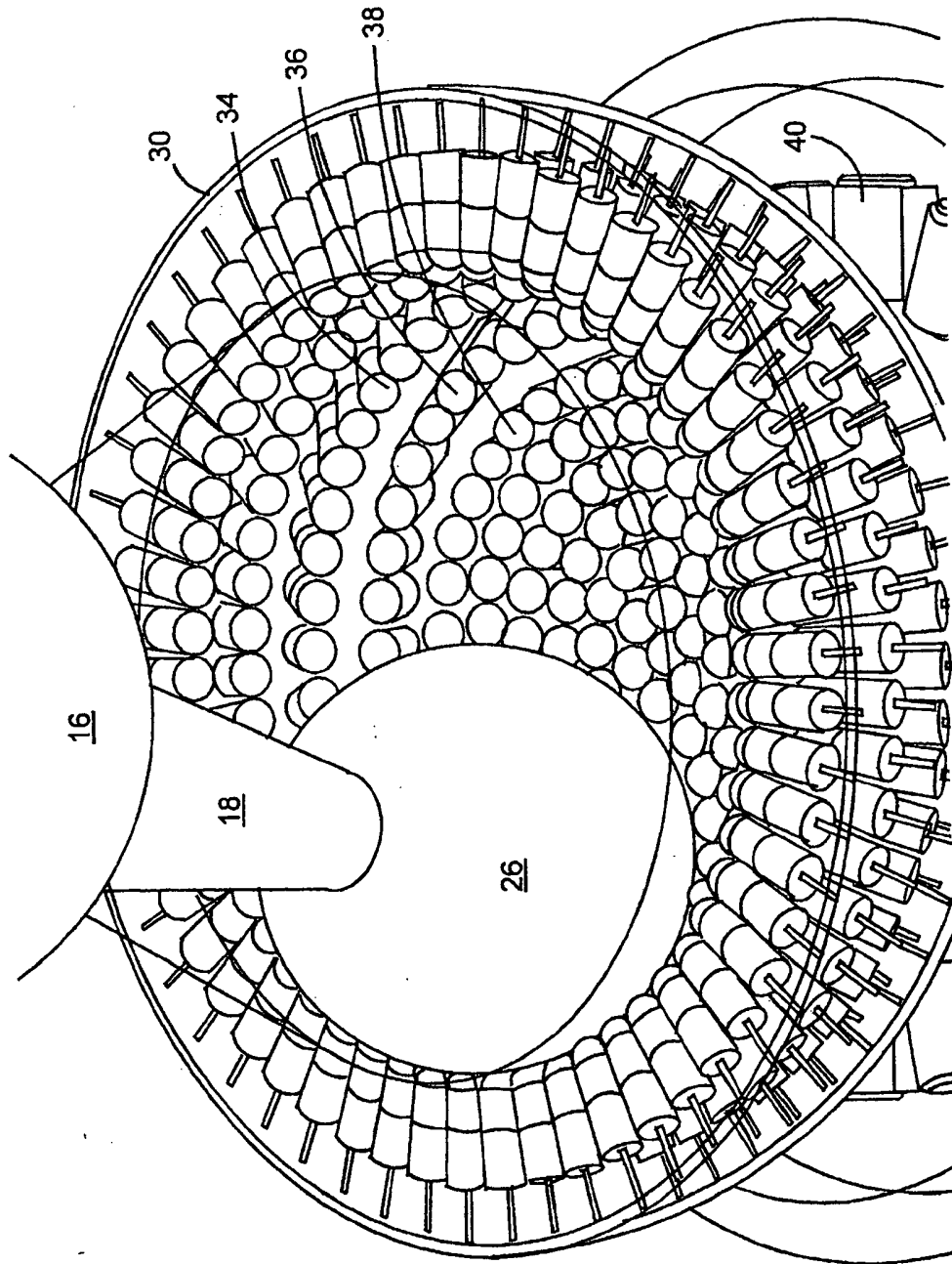


FIGURE 4

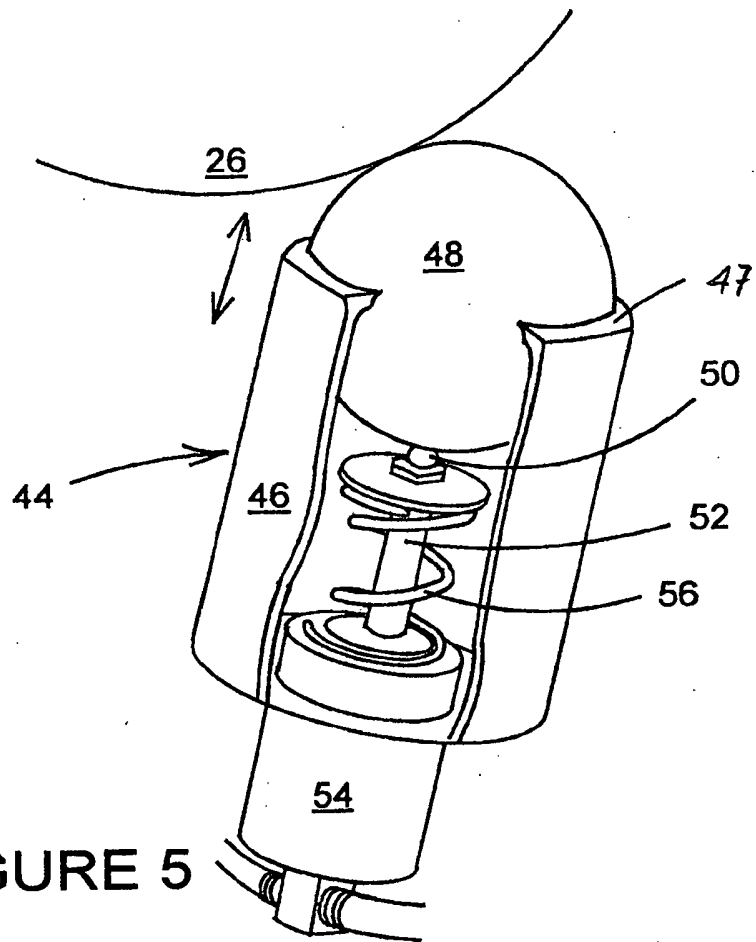


FIGURE 5

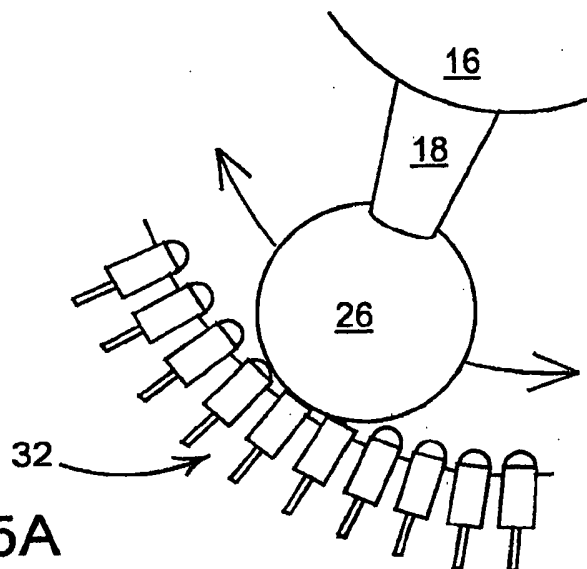


FIGURE 5A

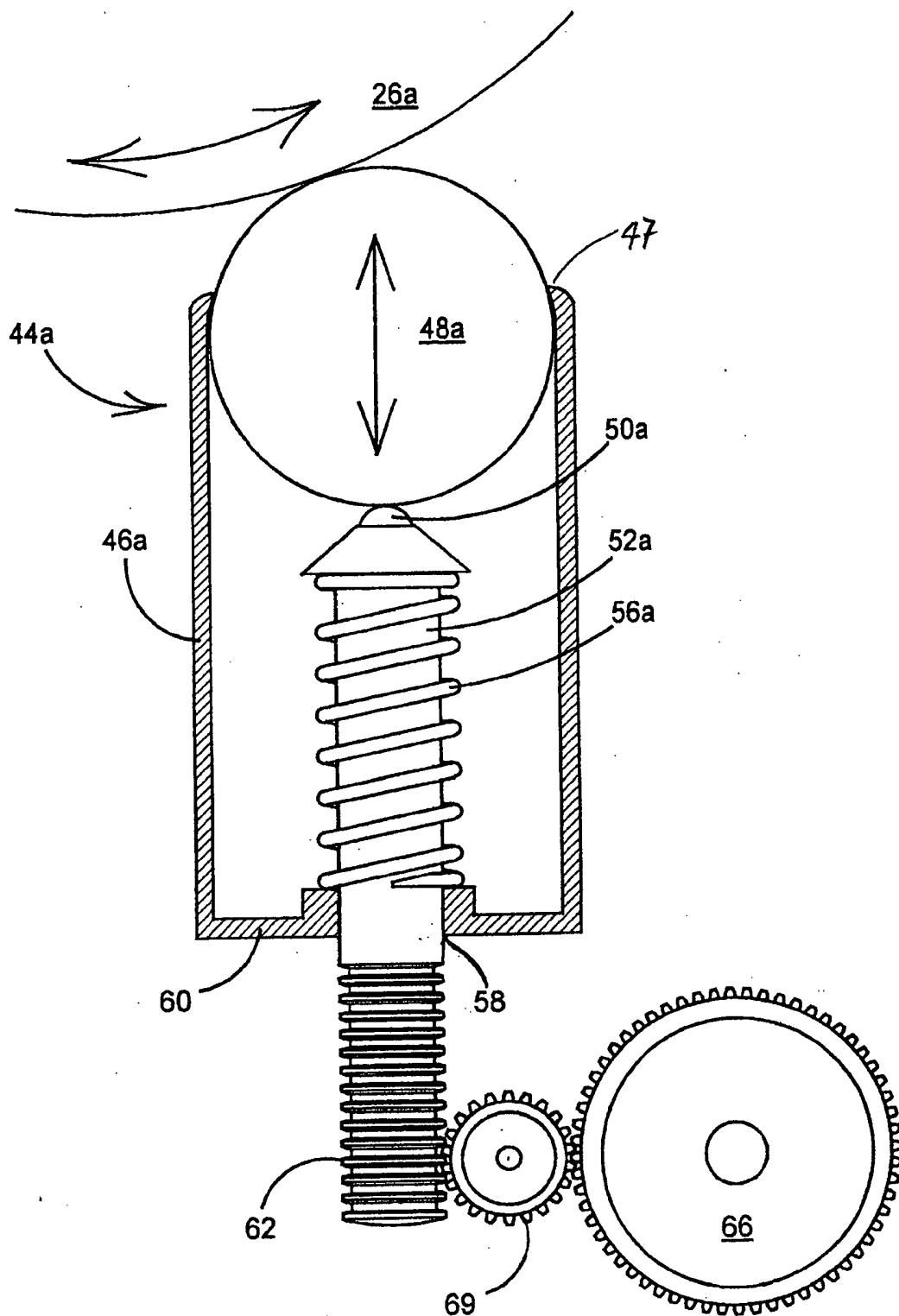


FIGURE 6

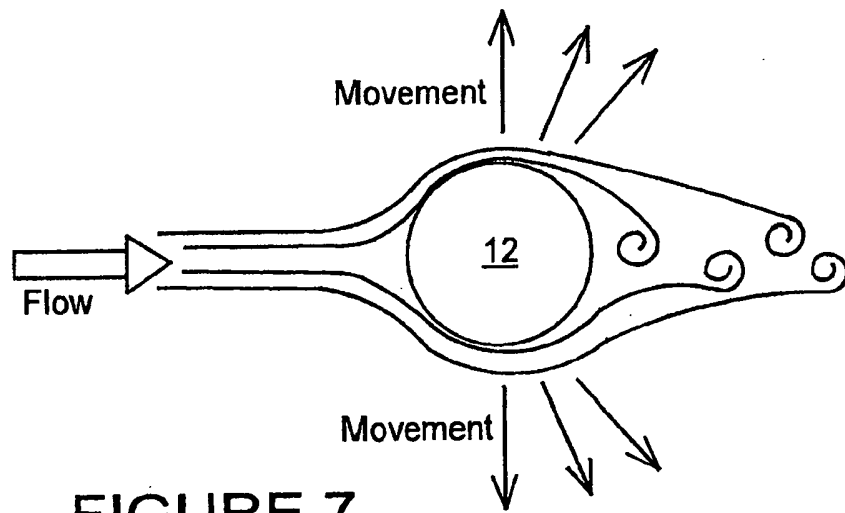


FIGURE 7

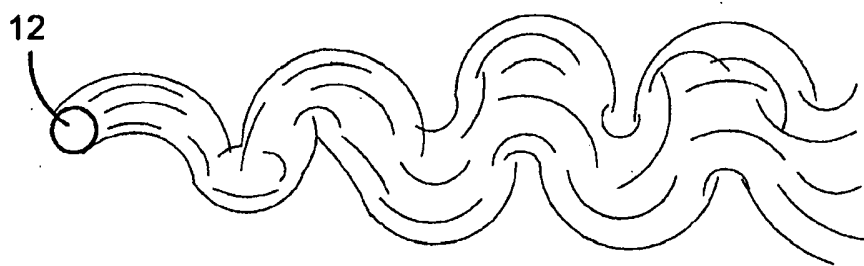


FIGURE 8