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(54) **Title:** TIDAL POWER STATION

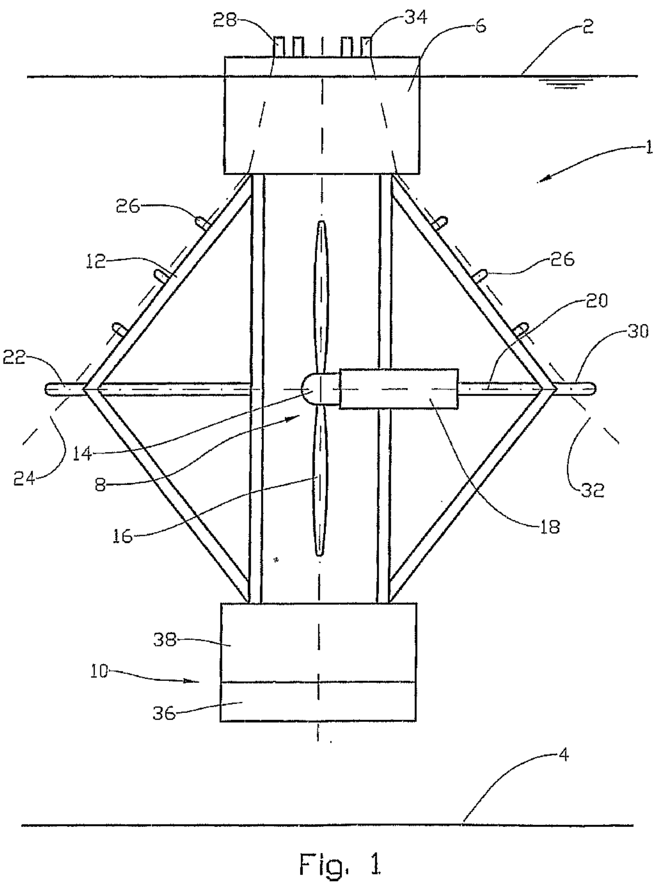

Fig. 1

(57) Abstract: A floating tidal power station (1) including a submerged turbine (8) and a buoyancy body (6) and also moorings (24, 32), the tidal power station (1) being provided with, spaced from the buoyancy body (6), at least one submerged counterweight (10) which is arranged, in cooperation with the buoyancy body (6), to balance torque forces to which the tidal power station (1) is subjected because of the power extraction of the turbine (8) from the water.

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TIDAL POWER STATION

This invention relates to a tidal power station. More particularly, it relates to a floating tidal power station including a submerged turbine and a buoyancy body and also moorings, the tidal power station being provided with, spaced from the buoyancy body, a submerged counterweight which, in cooperation with the buoyancy body, is arranged to balance torque forces, to which the tidal power station is subjected because of the power extraction of the turbine from the water.

It is known for turbines to be arranged on fixed structures in areas where there is considerable tidal current. It is also known to connect a turbine to an anchored floating object.

Prior art tidal power stations are relatively complex structures, however, which are relatively expensive. Because of the submerged position of the turbines it may also be difficult to maintain them.

When the turbine is connected to a floating structure, the floating structure must be relatively big and stable to absorb the axial forces and torque forces arising from the turbine. The structure is thereby subjected, to a considerable degree, to strains from the prevailing weather and wave forces.

The invention has for its object to remedy or reduce at least one of the drawbacks of the prior art.

The object is achieved in accordance with the invention through the features which are specified in the description below and in the claims that follow

A floating tidal power station in accordance with the invention includes a submerged turbine and a buoyancy body and also moorings, and is characterized by the tidal power station being provided with, spaced from the buoyancy body, at least one submerged counterweight which, in cooperation with the buoyancy body, is arranged to balance torque forces to which the tidal power station is subjected because of the power extraction of the turbine from the water.

Preferably, the counterweight is at a lower height level than the buoyancy body, the turbine being at a height level between the buoyancy body and the counterweight. As the turbine is rotated about its centre axis during the extraction of power from the flowing tide, the tidal power station will be turned in the direction of rotation of the turbine. By the fact that the centre of gravity of the counterweight is then no longer vertically below the centre of gravity of the buoyancy body, a first torque lever is created, which, multiplied by the weight of the counterweight, adjusted for buoyancy forces, seeks to resist and, in the operating position, to balance the torque from the turbine. The tidal power station will thereby take a balanced, somewhat tilted position in the water.

The mooring of the tidal power station is typically bipartite, a first mooring being connected to the tidal power station at a distance from the turbine in the direction countercurrent to the direction of the tidal flow, and a second mooring being connected to the tidal power station at a distance from the turbine in the direction co-current to the direction of the tidal flow.

The attachment of the moorings to the tidal power station has the effect that the first mooring essentially absorbs the mooring forces when the tide flows in a first direction, whereas the second mooring essentially absorbs the mooring forces when the tide flows in a second direction. The centre axis of the turbine thereby stays essentially parallel to the direction of flow both when the tide is flowing in the first and in the second direction.

The water flowing towards the turbine exerts a force also in the longitudinal direction of the turbine axis. The force in the mooring taking up these axial forces has a downward vertical component. This component seeks to turn the tidal power station about a horizontal axis which is approximately perpendicular to the centre axis of the turbine. The rotation is resisted by the centre of gravity of the counterweight no longer being vertically below the centre of gravity of the buoyancy body, whereby a second torque arm is created. The second torque arm seeks, together with the weight of the counterweight, adjusted for buoyancy, to balance the torque from the anchoring.

By providing the buoyancy body with greater flow resistance than that of the counterweight, the current-affected turning of the tidal power station can be reduced to a considerable degree because of the vertical power component of the anchoring.

It is advantageous that each of the moorings is V-shaped, the free end portions of each of the moorings being connected to respective anchors, whereas the opposite end portions are connected to the tidal power station. Thereby, the tidal power station maintains a laterally more stable position compared to each mooring including only one anchor.

The moorings are, with advantage, designed to be disposed at the installation site before the tidal power station arrives. The moorings are then connected to the tidal power station in a manner known *per se* and tightened to a desired tension.

The buoyancy body and/or counterweight are/is typically boat-shaped with a bow and a bow-shaped stern to reduce the force from the flowing tide.

The counterweight is provided with a chamber which can optionally be filled with a liquid, typically water, or a gas, for example air. When the tidal power station is in its operating position, the chamber is typically filled with water. When the turbine is to be raised to the water surface, in the event of maintenance for example, the water is expelled from the chamber typically by means of pressure air. The counterweight thereby rises in the water, the tidal power station taking a horizontal position at the water surface, which improves, to a substantial degree, the access to the components submerged in the operating position.

In an alternative embodiment the turbine is disposed in a suspension means which is rotatable about a vertical axis. The suspension means may, with advantage, be constituted by a frame which is supported in the buoyancy body and in the counterweight.

The turbine is turned about the vertical axis every time the tide turns, so that the same side of the turbine faces the tidal flow as the tide flows in the first direction and in the second direction. As it will be known to a person skilled in the art, a considerable improvement in the efficiency of the turbine can be achieved when it may be designed to receive the water flow from one direction, compared to if it must be designed to provide acceptable efficiency by water flow from both its axial directions.

The invention provides a tidal power station of a relatively simple construction which can easily be placed at most sites of interest as the tidal power station is substantially independent of the water depth and floor conditions. The construction makes it possible for the cross-section in the horizontal plane of the buoyancy body, and also the freeboard, to be relatively small. Thereby, the buoyancy body is relatively little affected by wind and weather.

In what follows is described a non-limiting example of a preferred embodiment which is visualized in the accompanying drawings, in which:

Figure 1 shows schematically a side view of a tidal power station according to the invention;

Figure 2 shows schematically a plan view of the tidal power station;

Figure 3 shows schematically an end view of the tidal power station; and

Figure 4 shows schematically a side view of the tidal power station in an alternative embodiment.

In the drawings the reference numeral 1 indicates a tidal power station which is floating in the water 2, and which is anchored to the seabed 4 by mans of anchorings, not shown. The tidal power station 1 shows a boat-shaped buoyancy body 6 which lies relatively deep in the water 2, a submerged turbine 8 and a counterweight 10 positioned at a lower level of height than the buoyancy body 6.

The buoyancy body 6, turbine 8 and counterweight 10 are interconnected by means of a supporting frame 12. The supporting frame 12 is connected at its, in the position of use, upper portion to the buoyancy body 6 and at its lower portion to the counterweight 10. The turbine 8 is connected to the supporting frame 12 between the buoyancy body 6 and the counterweight 10.

The turbine 8 includes a rotor 14 with turbine blades 16 connected to a power machine 18 in the form of an electric generator or a fluid pump. The rotor 14 is rotatable about the centre axis 20 of the turbine 8. Electrical energy generated or pressure fluid is carried away from the power machine 18 in a manner known *per se*.

At a horizontal distance from the turbine 8, at a height near the centre axis 20, the supporting frame 12 is provided with a first mooring attachment 22 which is connected to a first mooring 24. The first mooring 24 continues from the first mooring attachment 22 via guides 26 up to a first tensioning device 28 which is positioned on the buoyancy body 6.

Correspondingly, the supporting frame 12 is provided with a second mooring attachment 30 which is spaced horizontally from the turbine 8 in the opposite direction relative to the first mooring attachment 22. The second mooring attachment 30 is connected to a second mooring 32 extending via guides 26 to a second tensioning device 34.

By means of their respective tensioning devices 28, 34 the moorings 24, 32 can be tightened to a desired tension in order to achieve an appropriate distribution of forces within the moorings 24, 32. When the tidal power station 1 is to be turned into its maintenance position, see below, the moorings

24, 32 are slackened.

The counterweight 10 includes a counterweight weight 36 and a chamber 38. The chamber 38 is filled at least partially with water when the tidal power station 1 is in its operating position. By evacuating the water from the chamber 38 by means of pressure air, for example, the counterweight 10 is brought to rise, thereby turning the tidal power station 1 into a position in which it floats approximately horizontally at the water surface. This position is favourable for the inspection and maintenance of the tidal power station 1.

When the tidal power station 1 is operative, see figure 3, the rotor 14 is rotated about its centre axis 20. Because of rotational resistance from the power machine 18 the tidal power station 1 is also rotated in the same direction, here clockwise. Thereby the centre of gravity 40 of the counterweight 10 is no longer vertically below the centre of gravity 42 of the buoyancy body 6, but spaced horizontally therefrom at A. By centre of gravity 40, 42 is meant in this connection a resultant centre of gravity of mass and buoyancy of the respective body.

Thereby a torque is generated, seeking to turn the tidal power station 1 anticlockwise. In operation the tidal power station 1 places itself at an angle relative to the vertical position in which said torques balance each other.

A balancing of the torque from the downward component of the force in the respective upstream mooring 24, 32 will be performed correspondingly by a rotation of the tidal power station 1 about a horizontal axis, not shown, which is approximately perpendicular to the centre axis 20.

In an alternative exemplary embodiment, see figure 4, the turbine 14 is placed in a suspension means 44 in the form of a rotational frame positioned between the buoyancy body 6 and the counterweight 10.

Here, the rotor 14 is supported in an external, preferably water-lubricated turbine bearing 46 and in the power machine 18. By means of bearings 48, the suspension means 44 is rotatable about a vertical axis 50. By means of turning machinery, not shown, in the buoyancy body 6, the suspension means 44 is arranged to be turned so that the tide will flow towards the turbine blades 16 from the same side, regardless of whether the flow comes in a first or a second direction.

Said turning is preferably carried out when there is no tidal current and the rotor 14 is not rotating. In the embodiment shown also the turbine blades 16 must be in an approximately vertical position during the turning.

C l a i m s

1. A floating tidal power station (1) including a submerged turbine (8) and a buoyancy body (6) and also moorings (24, 32), the tidal power station (1) being provided with at least one submerged counterweight (10) spaced from the buoyancy body (6), c h a r a c - t e r i z e d i n that the counterweight (10), in cooperation with the buoyancy body (6), is arranged to balance torque forces to which the tidal power station (1) is subjected because of the power extraction of the turbine (8) from the water.

2. The floating tidal power station in accordance with claim 1, c h a r a c t e r i z e d i n that the counterweight (10) is at a lower level of height than the buoyancy body (6), the turbine (8) being at a height level between the buoyancy body (6) and the counterweight (10).

3. The floating tidal power station in accordance with claim 1, c h a r a c t e r i z e d i n that the mooring (24, 32) is bipartite, a first mooring (24) being connected to the tidal power station (1) at a distance from the turbine (8) in the direction counter-current to the tidal flow direction, and a second mooring (32) being connected to the tidal power station (1) at a distance from the turbine (8) in the direction co-current to the tidal flow direction.

4. The floating tidal power station in accordance with claim 1, c h a r a c t e r i z e d i n that at least one of the buoyancy body (6) and the counterweight (10) is boat-shaped.

5. The floating tidal power station in accordance with claim 1, c h a r a c t e r i z e d i n that the counterweight (10) is provided with a chamber (38) which can optionally be filled with liquid or gas.

6. The floating tidal power station in accordance with claim 1, c h a r a c t e r i z e d i n that the turbine (8) is placed in a suspension means (44) which is rotatable about a vertical axis (50).

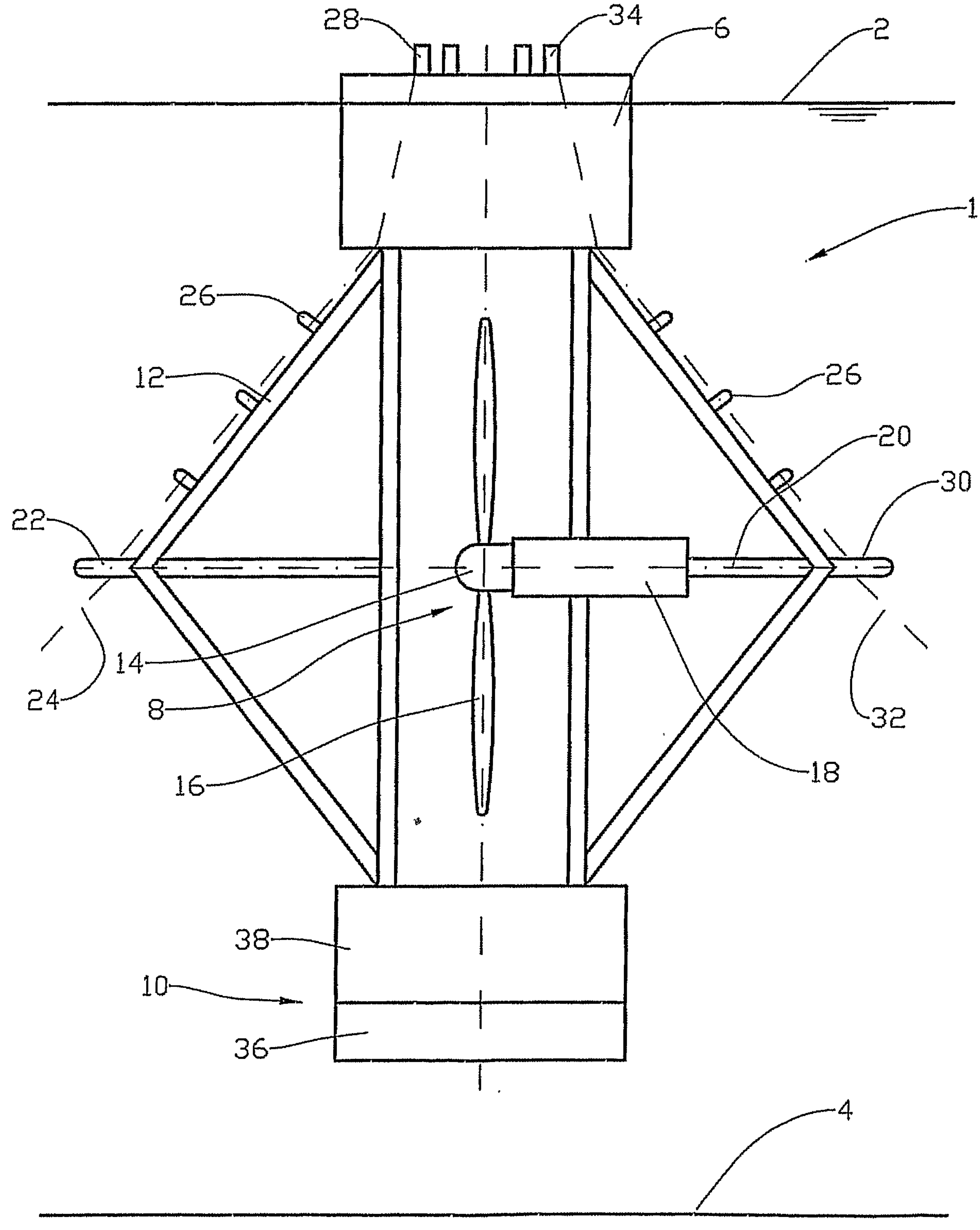

Fig. 1

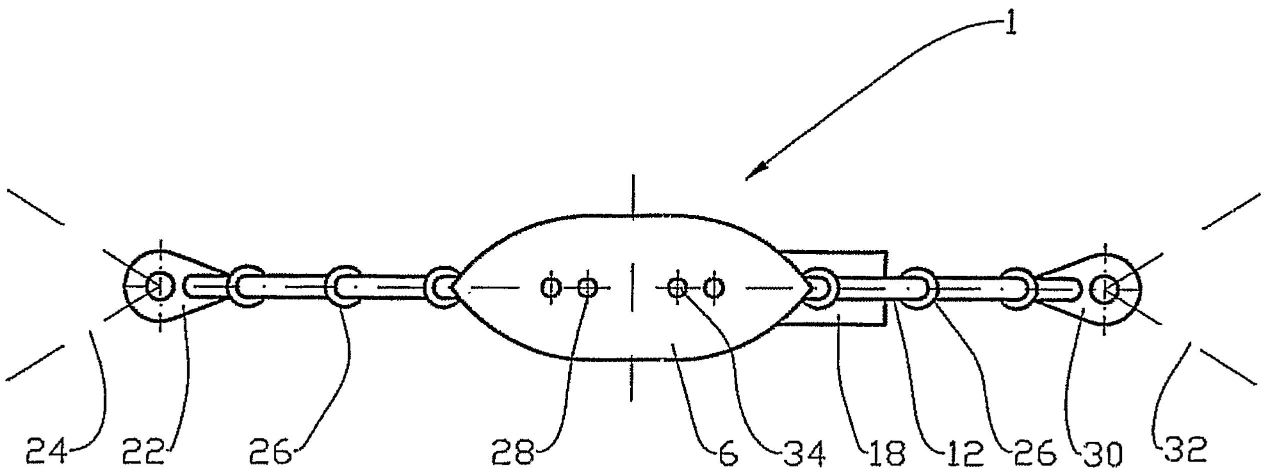

Fig. 2

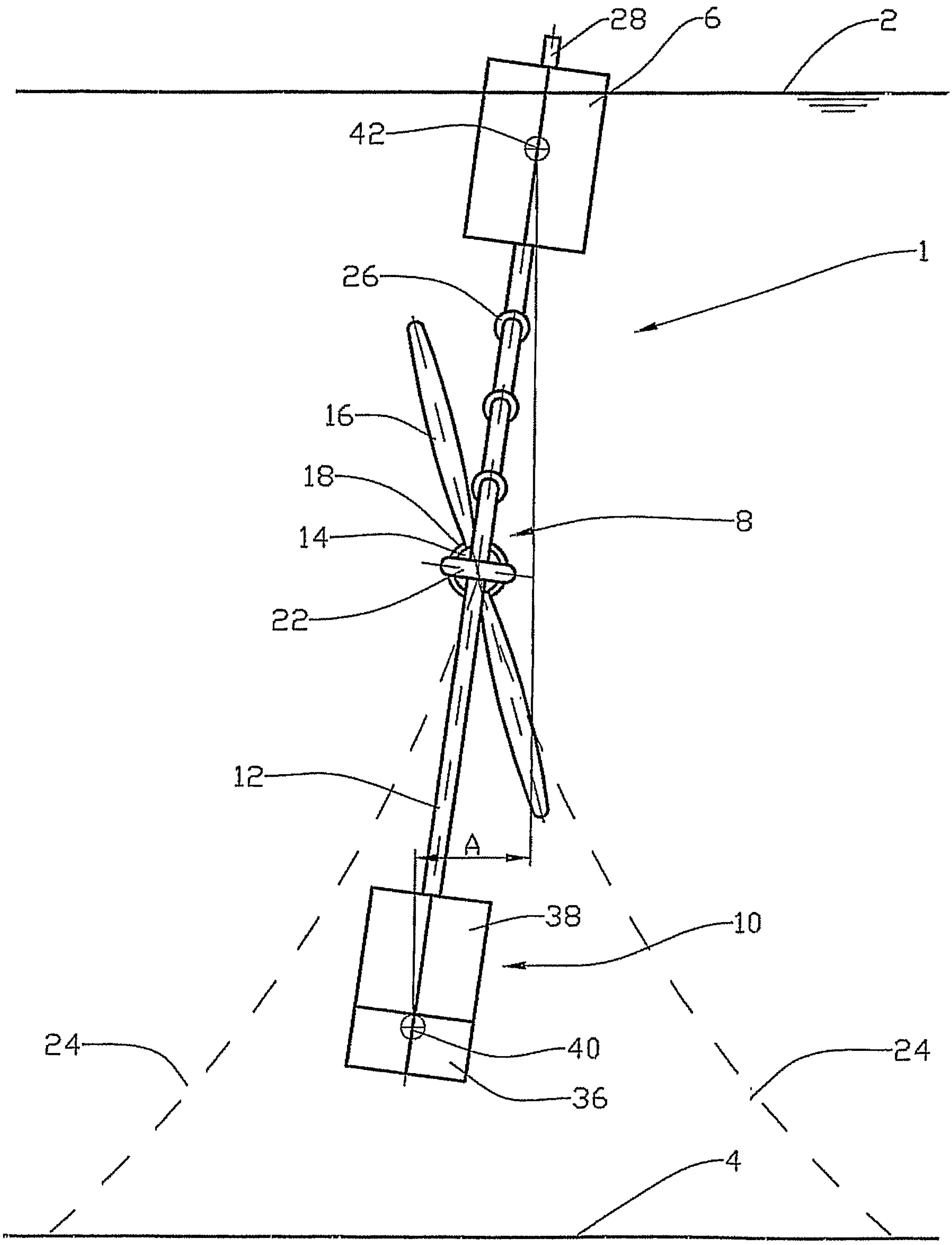

Fig. 3

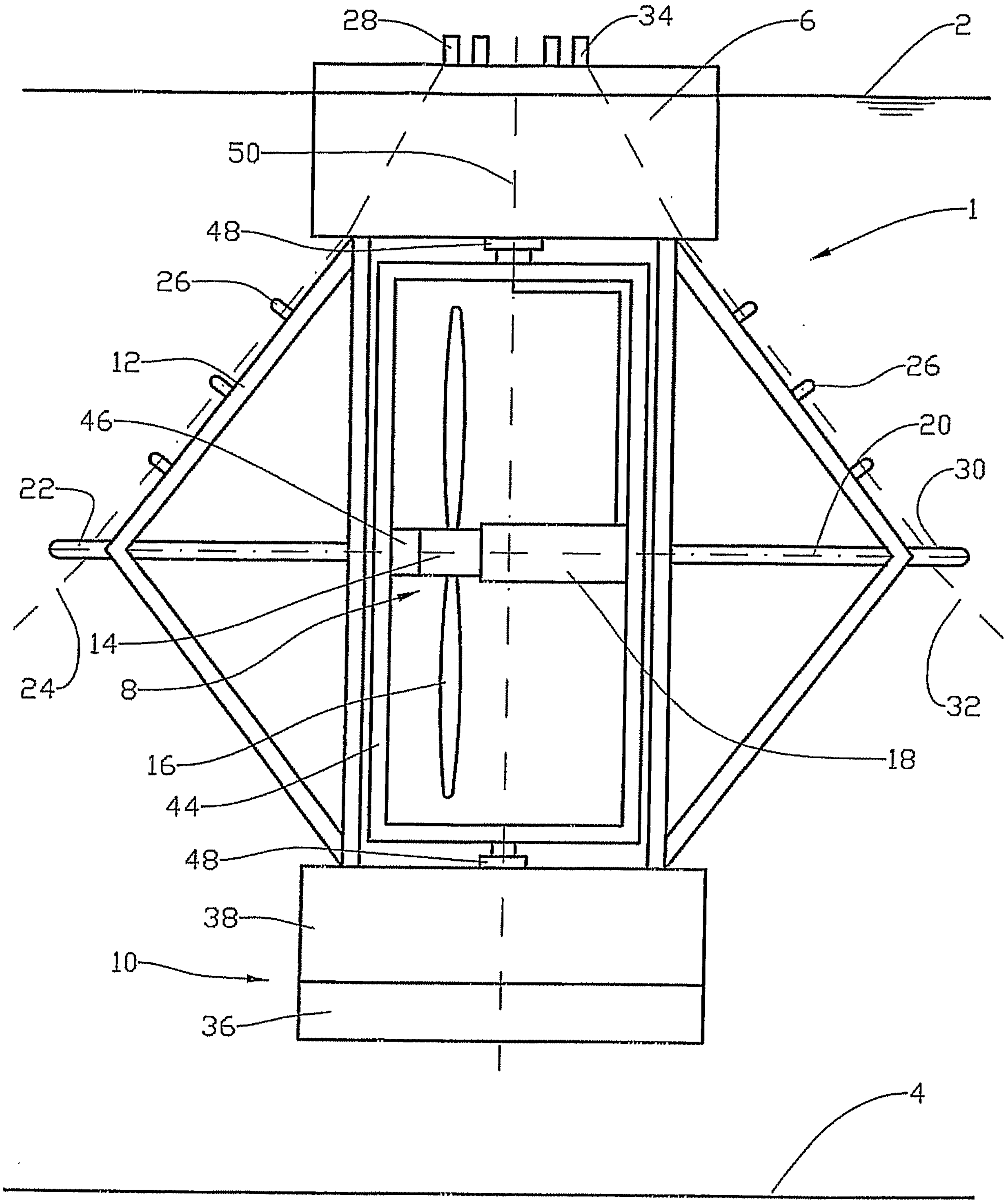

Fig. 4