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(71) Applicants and
(72) Inventors: **STORDIAU, Marc** [BE/BE]; Jef De Pauwstraat 1, B-9100 Sint-niklaas (BE). **KERCKAERT, Piet** [BE/BE]; Patrijzenweg 26, B-8200 Sint-andries Brugge (BE).

(74) Agents: **BRANTS, Johan Philippe Emile** et al.; De Clercq Brants & Partners, E. Gevaertdreef 10a, B-9830 Sint-martens-latem (BE).

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(54) **Title**: HARBOUR CONSTRUCTION REDUCING NAUTICAL PERTURBATIONS CAUSED BY THE TIDE FLOW

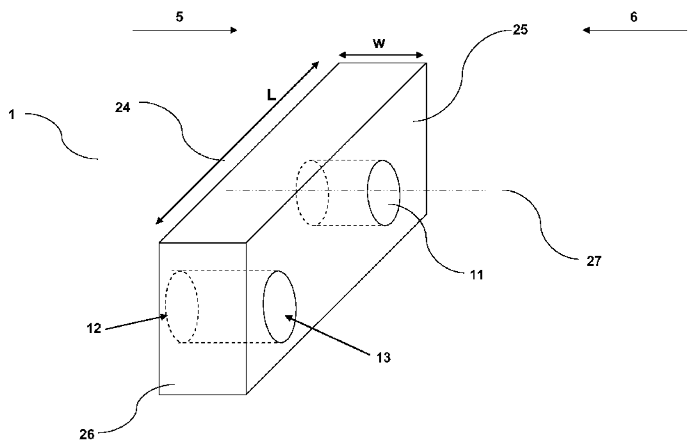

FIG. 1

(57) **Abstract**: The invention relates generally to a longitudinal perforated seawall (1) suitable for reducing nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast and having a harbour-facing side and a sea-facing side, said longitudinal perforated seawall (1) comprising at least one pipe (11) located below the water level and disposed with an inlet (12) at the sea-facing side and at least one outlet (13). The invention also relates to a method for reducing nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast. The invention also relates to the use of at least one longitudinal perforated seawall in a harbour construction and to a harbour construction suitable for reducing nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast. The invention has the advantage to reduce silt and sedimentation in the port.

WO 2010/017841 A1

HARBOUR CONSTRUCTION REDUCING NAUTICAL PERTURBATIONS CAUSED BY THE TIDE FLOW

Field of the invention

The invention relates to a seawall equipped with a special device able to reduce nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast, and optionally able to generate power such as electricity from the movement of the sea such as tide. The invention also relates to a method for reducing nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast, and a harbour construction suitable for reducing nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast. Furthermore, the seawall according to the invention is able to reduce the amounts of sedimentation in harbours.

Background of the invention

Nowadays, with the increase of the marine trade and navigation, ports try to find a way to enlarge their basins to allow ships to come alongside the quay. However, one of the major problems when enlarging a harbour towards the sea is to take care of the tidal current effects, i.e. a kind of Venturi effect or contraction of the sea currents which takes place across the fair-way of the harbour or near the harbour entrance, thus rendering sailing hazardous. The Venturi Effect is defined in the art as a drop in fluid pressure that results when an incompressible fluid flows through a constricted section of pipe. The Venturi Effect may be derived from a combination of Bernoulli's principle and the equation of continuity. The fluid velocity must increase through the constriction to satisfy the equation of continuity, while its pressure must decrease due to conservation of energy: the gain in kinetic energy is supplied by a drop in pressure or a pressure gradient force.

The tidal current is usually parallel or almost parallel to the coast. Marine seawalls and harbour dams, which have been built for several decades, are not parallel to the tidal current, thus perturbing the natural flow of the tide. This results in increasing the perturbation of the sea flow such as the velocity of the flow across fair-way of harbours or harbour entrances. It is well-known that the water velocity across an access channel can reach high values in case of very large marine seawalls or harbour dams.

The sailing in the fair-way or near entrances of a harbour appears to be very challenging and even dangerous when the velocity of the flow goes over values of 4 to 5 $m.s^{-1}$.

It is also known in the art that tidal currents can be also used to produce power such as electricity. There are few tidal power stations in use today. The most well-known is a large plant in La Rance in France with 24 turbines. For example, JP10115279 discloses a seawater turbine generation by dam formed by utilizing high/low tide of seawater. Katsura divulges a device wherein the water is temporally stored within the dam at a high tide.

WO2005/017349 discloses an energy generator powered by tidal currents and comprises a turbine in turbine housing for rotation therein about a substantially vertical axis.

WO2005/026535 discloses a tidal energy system which is capable of extracting energy from the potential and kinetic energies of the ocean tides, ocean waves and offshore wind and which integrates the hydrogen fuel cell with tidal energy.

US 6,792,753 discloses a system for generating power using natural tidal effects and the pressure difference of localised area of water. The system intends to equalize the sea level of both localised area of water and to produce electricity when equalization of the sea level takes place.

However, the prior art lacks of examples of harbour constructions that avoid or at least lower nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast, and that are optionally able to generate power such as electricity. Nautical perturbations, as previously mentioned, can be an increasing of the tide velocity, the erosion in harbour entrance, the sedimentation or the presence of silt inside harbours or harbour entrances.

Summary of the invention

The above-mentioned problem is solved by implementing such constructions with at least one longitudinal perforated seawall according to the invention. Optionally, the longitudinal perforated seawall according to the invention can be configured to produce power such as electricity from the tide.

In a first aspect, the present invention provides a longitudinal perforated seawall suitable for reducing nautical perturbations caused by the tide-flow which is generated by the presence of marine seawalls and harbour dams across the coast, having a harbour facing side and a sea facing side, said longitudinal perforated seawall comprising at least one pipe located below the water level and disposed with an inlet at the sea-facing side and at least one outlet.

In a further aspect, the present invention provides a method for reducing nautical perturbations caused by the tide-flow which is generated by the presence of marine seawalls and harbour dams across the coast comprising the steps of:

- providing a longitudinal perforated seawall according to the invention to an existing harbour or to the shore, having a harbour-facing side and a sea-facing side, and comprising at least one pipe located below the water level and disposed with an inlet at the sea-facing side and at least one outlet,
- such that water from the sea flows within said pipe from the inlet,
- such that water from the sea exits of said pipe from the outlet, and
- so reducing nautical perturbation caused by the tide-flow which is generated by the presence of marine seawalls and harbour dams across the coast.

In another aspect, the present invention provides the use of at least one longitudinal perforated seawall according to the invention for reducing nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast.

The present invention also provides a harbour construction suitable for reducing nautical perturbations caused by the tide-flow which is generated by the presence of marine seawalls and harbour dams across the coast, comprising at least one longitudinal perforated seawall according to the invention, which comprise at least one pipe located below the water level and disposed with an inlet at the sea-facing side, at least one outlet and optionally wherein at least part of the harbour-facing side of said longitudinal perforated seawall is juxtaposed to the marine seawalls and harbour dams.

Brief description of the drawings

FIG. 1 represents a schematic view of a longitudinal perforated seawall according to the invention having a width **w** and a length **L**.

FIG. 1b represents a schematic view of a harbour construction comprising one longitudinal perforated seawall.

FIG. 2 represents a schematic view of a harbour construction comprising two longitudinal perforated seawalls wherein the length of at least one pipe is equal to the width of the longitudinal perforated seawall according to an embodiment of the invention.

FIG. 3 represents a schematic view of a harbour construction comprising two longitudinal perforated seawalls wherein the length of the pipe is greater than the width of the longitudinal perforated seawall according to another embodiment of the invention.

FIG. 4 represents a schematic view of a harbour construction comprising two longitudinal perforated seawalls wherein the outlet of at least one pipe is located on the sea-facing side of the longitudinal perforated seawall according to further embodiment of the invention.

FIG. 5 represents a schematic view of a harbour construction comprising two longitudinal perforated seawalls wherein the length of at least one pipe is greater than the width of the seawall and at least one inlet is located outside the longitudinal perforated seawall of the pipe according to an embodiment of the invention.

FIG. 6 represents a schematic view of a harbour construction comprising two longitudinal perforated seawalls wherein pipes of said longitudinal perforated seawalls are connected to each other according to another embodiment of the invention.

FIG. 7 represents a schematic view of a harbour construction comprising two longitudinal perforated seawalls wherein the outlet of at least one pipe is located outside the harbour construction according to a further embodiment of the invention.

FIG. 8 represents a schematic view of a harbour construction whereby the invention is applied in an existing harbour without seawall extensions

FIG. 9 represents a cross section of part of a harbour construction comprising one longitudinal perforated seawall juxtaposed to marine seawalls and harbour dams according to an embodiment.

FIG. 10 represents a cross section of a pipe comprising optionally one tide-turbine according to an embodiment.

FIG. 11 represents a cross section of a pipe comprising optionally one tide-turbine according to a further embodiment.

Detailed description of the invention

The present invention provides a longitudinal perforated seawall suitable for reducing nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast, and having a harbour-facing side and a sea-facing side, said longitudinal perforated seawall comprising at least one pipe located below the water level and disposed with an inlet at the sea-facing side and at least one outlet.

In the present invention, the term “harbour” refers to a construction extending to the sea and protected by seawalls or harbourdams. The term “seawall” or “breakwater” refer to all constructions to protect a harbour.

The term “sea-facing side” is the side of the seawall facing the open sea or the facing the tide. The term “harbour-facing side” is the side of the seawall located inside the harbour.

The terms “fair-way” or “harbour entrance” as presently used in the invention refer to a corridor only used for the sailing of ships. The “fair-way” or “harbour entrance” are located between the ends of two longitudinal seawalls.

In the present invention, the term “nautical perturbations” refers to a phenomenon taking place near a harbour, the fair-way of a harbour, or all harbour entrance and based on the Venturi effect or contraction of the sea. Due to a pressure increasing of the water on the seawall of a port, a funnel is created near the port, thus increasing the velocity of the tidal currents at this place. The “nautical perturbations caused by the tide flow” refers to changes in the velocity and the direction of the natural flow of the tide near the coast or the land when a harbour is present on said coast or land. The “nautical perturbations caused by the tide flow” also refers to the erosion in front of the harbour entrance, the sedimentation and the presence of silt inside the harbour entrances. In the present invention, the term “reducing nautical perturbations caused by the tide flow” refers to decreasing or lowering nautical perturbations caused by the tide flow for example the drop of tide velocity, the diminution of erosion in front of the harbour entrance, the reduction of sedimentation and silt inside the harbour entrances. The term “tide flow” as used in the present invention refers to the movement of the water influenced by the tide.

In the present invention, the term “pipe” refers to a tube or a hollow cylinder for the conveyance of fluid such as water. The pipe is located below the water level.

In the present invention, the term “tide-turbine” refers to a specific type of rotary engine that extracts energy, for example electrical energy from fluid flow, such as for example tide currents.

In one embodiment, the longitudinal perforated seawall comprises at least one pipe wherein the length of said pipe is equal or greater than the width of said longitudinal perforated seawall. In a preferred embodiment, the length of said pipe is equal to the width of said longitudinal perforated seawall. In another preferred embodiment, the length of said pipe is greater than the width of said longitudinal perforated seawall.

In another embodiment, the angle between the longitudinal axis passing though the centre of the inlet of said pipe and the flow of the sea is comprised between -30° and 30°, preferably between -15° and 15°. In a preferred embodiment, the longitudinal axis passing though the centre of the inlet of said pipe and the flow of the sea are parallel.

In one embodiment, the longitudinal perforated seawall comprises at least one pipe located within said longitudinal perforated seawall. The number of pipes depends on the length of the longitudinal perforated seawall and the increasing of nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast. The longitudinal perforated seawall can have 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 pipes, or a value in the range between any two of the aforementioned values; preferably between 1 and 10 pipes.

Diameter may be 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 meters, or a value in the range between any two of the aforementioned values; preferably between 1 and 12 meters and more preferably between 4 and 12 meters.

The longitudinal perforated seawall can have a length L of 10, 100, 500 meters, 10km, 20, 30, 40, 50, 60, 70, 80, 90, 100 kilometres or a value in the range between any two of the aforementioned values, preferably the length of the longitudinal perforated seawall ranges from 100 meters to 20 kilometres and more preferably from 100 meters to 5 kilometres.

The longitudinal perforated seawall can have a width w of 1, 10, 50, 100, 200, 300, 400, 500, 600, 700, 800, 900 meters, 1 kilometres or a value in the range between any two of the aforementioned values; preferably from 1 meter to 100 meters.

In one embodiment, the outlet of the pipe can be located either at the sea-facing side or at the harbour-facing side of the longitudinal perforated seawall. Optionally, the outlet and the inlet can be provided with a non-return valve. The inlet and the outlet of the pipe can be coupled with a filter, a screen or a trash-rack to stop at the entrance of the pipe being blocked with floating and submerged objects. The inlet and the outlet can also be coupled with a hatch suitable to isolate the pipe from water and to remove water from it for maintenance.

In another embodiment, the outlet of the pipe can be disposed outside of the longitudinal perforated seawall. In another embodiment, the inlet of the pipe can be disposed outside of the longitudinal perforated seawall. The outlet is located distal to the longitudinal perforated seawall. As used herein the term “distal” refers to a distance which may be 1, 5, 10, 50, 100, 500 meters, 1 kilometre, 2, 3, 4, 5, 6, 7, 8, 9, 10 kilometres or a value in the range between any two of the aforementioned values.

In another embodiment, the pipe can be connected to another pipe belonging to another longitudinal perforated seawall. In another embodiment, the pipe can be connected to another pipe from the same longitudinal perforated seawall.

In another embodiment, the longitudinal perforated seawall is configured to decrease the velocity of the tide across the coast or harbour entrance between 0.6 $m.s^{-1}$ and 4 $m.s^{-1}$, preferably between 0.6 $m.s^{-1}$ and 3 $m.s^{-1}$, more preferably between 1 $m.s^{-1}$ and 2 $m.s^{-1}$ and even more preferably is 1, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0 $m.s^{-1}$.

With reference to FIG. 1, a longitudinal perforated seawall **1** according to an embodiment of the invention is illustrated in more detail. The longitudinal perforated seawall **1** having a harbour facing side **25** and a sea facing side **24** comprises a pipe **11** below the water level wherein said pipe comprising one inlet **12** and one outlet **13**. The side **26** of the longitudinal perforated seawall is disposed either on the shore or on existing harbour dams or marine seawalls. The longitudinal perforated seawall **1** is not parallel to the direction of the tide **5** (flood tide) or **6** (falling tide or ebb). The direction of the tide **5** or **6** is almost parallel to the longitudinal axis **27** passing though the centre of the inlet of the pipe **11**. It will be understood that while the longitudinal perforated seawall **1** is illustrated with two pipes **11**, said longitudinal perforated seawall may be equipped with more pipes.

With reference to FIG. 1b, a harbour construction comprising one longitudinal perforated seawall **1** and a non-perforated seawall **30** is illustrated in more details according to an embodiment of the invention. The direction of the tide **5** (flood tide) and **6** (falling tide) are almost perpendicular to the longitudinal perforated seawall **1**. The longitudinal perforated seawall **1** is extended from the coast or the land **8**. The longitudinal perforated seawall **1**, having a sea facing side **24** and a harbour facing side **25**, comprises two pipes **11** located below the water level. The length of the pipes **11** is greater than the width of the longitudinal perforated seawall. The directions of the tide **5** and **6** are almost parallel to the longitudinal axis **27** passing though the inlet of the pipe **11**. The inlet and the outlet of the pipe **11**, as well as fluvial installation that can be optionally juxtaposed to the longitudinal perforated seawall **1** are not shown. It will be understood that while the longitudinal perforated seawalls **1** are illustrated with two pipes, said longitudinal perforated seawalls may be equipped with less or more pipes **11**, depending on the nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast. If the longitudinal perforated seawall **1** comprises more or less than two pipes **11**, it will be understood that the length of the others pipes can be greater than or equal to the width of the longitudinal perforated seawall and can be connect to each other. The harbour entrance **3** is located between the longitudinal perforated seawalls **1** and a non-perforated seawall **30**.

In a further aspect, the present invention provides a method for reducing nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast comprising the steps of:

- providing a longitudinal perforated seawall according to the invention to an existing harbour dam or to the shore, and having a harbour facing side and a sea facing side, comprising at least one pipe located below the water level and disposed with an inlet at the sea-facing side and at least one outlet,
- such that water from the sea flows within said pipe from the inlet,
- such that water from the sea exits of said pipe from the outlet, and
- so reducing nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast.

In one embodiment, the method is provided wherein the longitudinal perforated seawall comprises at least one pipe wherein the length of said pipe is equal or greater than the width of said longitudinal perforated seawall.

In another embodiment, the method is provided wherein the angle between the longitudinal axis passing though the centre of the inlet of said pipe and the flow of the sea is comprised between -30° and 30°, preferably between -15° and 15°, preferably the longitudinal axis passing though the centre of the inlet of said pipe and the flow of the sea are parallel.

In another embodiment, the method is provided wherein the diameter of the pipe is comprised between 1 and 15 meters, preferably between 1 and 12 meters and more preferably between 4 and 12 meters and even more preferably is 4, 5, 6, 7, 8, 9, 10, 11, 12 meters.

In another embodiment, a method is provided whereby the velocity of the tide near the coast or harbour entrance is decreased between 0.6 $m.s^{-1}$ and 4.0 $m.s^{-1}$, preferably between 0.6 $m.s^{-1}$ and 3 $m.s^{-1}$, more preferably between 1 $m.s^{-1}$ and 2 $m.s^{-1}$ and even more preferably is 1, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0 $m.s^{-1}$.

According to the invention, nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams is decreased when a longitudinal perforated seawall having a harbour facing side and a sea facing side, and comprising at least one pipe located below the water level and disposed with an inlet at the sea-facing side and at least one outlet is provided. The resulting velocity of the tide can depend on the position of the outlet side. The resulting velocity of the tide can also depend on the distance between the outlet and the fair-way of the harbour or harbour entrance. Applicants have shown also that providing a longitudinal perforated seawall according to the invention will lead to a diminution of erosion in harbour entrance and a reduction of sedimentation in outer harbour entrances. Thus, the need of maintenance dredging is reduced.

In a further aspect, the present invention provides the use of at least one longitudinal perforated seawall according to the invention for reducing nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast. The present invention also provides the use of at least one longitudinal perforated seawall for decreasing the velocity of the tide near harbour entrance. The present invention also provides the use of at least one longitudinal perforated seawall for the diminution of erosion in harbour entrance. The present invention also provides the use of at least one longitudinal perforated seawall for reducing sedimentation in outer harbour entrances. Optionally, the invention is also useful to produce electricity. Longitudinal perforated seawalls can be useful for the construction of a new harbour or for adapting an existing harbour.

In a further aspect, the present invention provides a harbour construction suitable for reducing nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast, comprising at least one longitudinal perforated seawall according to the invention, which comprises at least one pipe located below the water level and disposed with an inlet at the sea-facing side, at least one outlet and optionally wherein at least part of the harbour-facing side of said longitudinal perforated seawalls is juxtaposed to the marine seawalls and harbour dams.

In a preferred embodiment, the present invention provides a harbour construction comprising between 1, 2, 3, 4, 5, 6, 7, 8, 9 or 10 longitudinal perforated seawalls, or a value in the range between any two of the aforementioned values; preferably between 1 to 6 longitudinal perforated seawalls.

In one embodiment, a harbour construction is provided wherein the longitudinal perforated seawalls according to the invention comprise at least one pipe wherein the length of said pipe is equal or greater than the width of said longitudinal perforated seawalls.

In another embodiment according to the invention, a harbour construction is provided wherein the angle between the longitudinal axis passing though the centre of the inlet of said pipe and the flow of the sea is comprised between -30° and 30°, preferably between -15° and 15°. More preferably the longitudinal axis passing though the centre of the inlet of said pipe and the flow of the sea are parallel.

In one embodiment, a harbour construction is provided wherein the longitudinal perforated seawalls comprise at least one pipe located within said longitudinal perforated seawall. The number of pipes depends on the length of the longitudinal seawall and the increasing of the nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast.

In one embodiment, a harbour construction is provided wherein the angle between a longitudinal axis passing though the centre of the outlet of the pipe and the fair-way or harbour entrance of said harbour construction is comprised between -60° and 60°. In another embodiment, the angle between a longitudinal axis passing though the centre of the outlet of the pipe and the fair-way or harbour entrance of said harbour construction is comprised between 45° and 135°.

The distance between the fair-way or harbour entrance and the outlet of the pipe will depend on the length of the longitudinal perforated seawall and the increasing of the nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast. The angle between a longitudinal axis passing though the centre of the outlet of the pipe and the fair-way or harbour entrances will depend on the length of the longitudinal perforated seawall and the increasing of the nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast.

In another embodiment of the invention, a harbour construction is provided wherein the longitudinal perforated seawalls are configured to decrease the velocity of the tide near the coast or harbour entrance between 0.6 $m.s^{-1}$ and 4 $m.s^{-1}$. Preferably, the velocity of the tide is decreased between 0.6 $m.s^{-1}$ and 3.5 $m.s^{-1}$, more preferably between 0.6 $m.s^{-1}$ and 3 $m.s^{-1}$, even more preferably between 1 $m.s^{-1}$ and 2 $m.s^{-1}$ and most preferably is 1, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0 $m.s^{-1}$.

In another embodiment according to the invention, a harbour construction is provided wherein said pipe comprises optionally at least one tide-turbine. Said tide-turbine is configured to produce electricity. In a preferred embodiment, a harbour construction is provided wherein said pipe comprises optionally between 1 and 10 tide-turbines, more preferably 1, 2, 3, 4, 5, 6, 7, 8, 9 or 10 tide-turbines.

In another embodiment, the tide-turbine comprises a generator and at least one rotor assembly. In one embodiment, the tide-turbine comprises between 1 and 10 rotor assemblies, preferably between 1 and 5 rotor assemblies, and more preferably comprises 1 or 2 rotor assemblies. The generator is mechanically connected to the rotor assembly.

In a preferred embodiment, the rotor assembly comprises at least one propeller having a diameter smaller than the diameter of the pipes. More preferably, said rotor assembly comprises from 1 to 10 propellers, even more preferably from 1 to 5 propellers and most preferably comprises 1, 2, 3, 4 or 5 propellers. The angle between the longitudinal axis passing though the centre of the rotor assembly and the longitudinal axis of the pipe is comprised between -45° and 45°, preferably between -25° and 25° and more preferably is between -5° and 5°.

In a further preferred embodiment, the rotor assembly comprises at least one longitudinal blade and at least one support material. The angle between the longitudinal axis passing though the centre of the rotor assembly and the longitudinal axis of the pipe is comprised between 45° and 135°, preferably between -75° and 105° and more preferably is between -85° and 95°. More preferably, said rotor assembly comprises between 1 and 20 longitudinal blades, even more preferably between 1 and 10 longitudinal blades, and most preferably comprises 1, 2, 3, 4, 5, 6, 7, 8, 9 or 10 longitudinal blades.

In another embodiment, said tide-turbines convert a rotational movement in electricity though the generator and are configured to produce at least 10kW, preferably between 10 and 1500 kW and more preferably between 500 and 1500 kW.

Therefore, in a particular embodiment, a harbour construction is provided comprising at least one longitudinal perforated seawall according to the invention, which comprises at least one pipe located below the water level and disposed with an inlet at the sea-facing side, at least one outlet and comprising at least one tide-turbine, and optionally wherein at least part of the harbour-facing side of said longitudinal perforated seawall is juxtaposed to marine seawalls and harbour dams.

In a particular embodiment, a harbour construction is provided wherein each pipe of the longitudinal perforated seawalls can be further provided with at least one hollow tube that connects said pipe to the top surface of the marine seawalls and harbour dams. The hollow tube is also disposed with a trap at the top surface of the marine seawalls and harbour dams. In a preferred embodiment, the angle between the longitudinal axis passing though the centre of said hollow tube and the longitudinal axis of the pipe is comprised between 45° and 135°, preferably between -75° and 105° and more preferably is between -85° and 95°. The diameter of the hollow tube is equal to or greater than the diameter of the pipe and can be equipped with means to go down to the pipe for maintenance of said pipe or maintenance of the tide-turbine. Optionally the hollow tube can be disposed above a tide-turbine.

Different embodiments of the invention will be now described in more details with reference to FIG. 2 to FIG. 11, but the invention is not limited to these embodiments.

With reference to FIG. 2, a schematic view of a harbour construction **4** comprising two longitudinal perforated seawalls **1** wherein the length of at least one pipe is equal to the width of said longitudinal perforated seawall according to an embodiment of the invention is illustrated. The direction of the tide **5** or **6** is almost perpendicular to the longitudinal perforated seawalls **1**. The longitudinal perforated seawalls **1** are built from existing fluvial installations **30** which extended from the coast or the land **8**. Each longitudinal perforated seawall **1** having a harbour facing side **25** and a sea facing side **24** comprises one pipe **11** located below the water level. The length of at least one pipe **11** is equal to the width of the longitudinal perforated seawalls. The directions of the tide **5** or **6** are almost parallel to the longitudinal axis **27** passing though the inlet of the pipe **11**. For clarity the longitudinal axis **27** is illustrated for only one pipe **11**. The inlet and the outlet of the pipe **11**, as well as fluvial installation that can be optionally juxtaposed to the longitudinal perforated seawall **1** are not shown. It will be understood that while each longitudinal perforated seawalls **1** are illustrated with one pipe, said longitudinal perforated seawalls may be equipped with more pipes **11**, depending on the nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast. If the longitudinal perforated seawall **1** comprises more than one pipe **11**, it will be understood that the length of the others pipes can be greater than the width of the longitudinal perforated seawall. The harbour entrance **3** is located between the two longitudinal perforated seawalls **1**.

With reference to FIG. 3, a schematic view of a harbour construction **4** comprising two longitudinal perforated seawalls **1** wherein the length of the pipes are greater than the width of the longitudinal perforated seawalls according to an embodiment of the invention is illustrated. The direction of the tide **5** or **6** is almost perpendicular to the longitudinal perforated seawalls **1**. The longitudinal perforated seawalls **1** are built from existing fluvial installations **30** which extended from the coast or the land **8**. Each longitudinal perforated seawall **1** having a harbour facing side **25** and a sea facing side **24** comprises one pipe **11** located below the water level. The length of the pipes is greater than the width of the longitudinal perforated seawalls. The directions of the tide **5** or **6** are almost parallel to the longitudinal axis **27** passing though the inlet **12** of the pipe **11**. For clarity the longitudinal axis **27** is illustrated for only one pipe **11**. The outlet of the pipe **11**, as well as marine seawalls and harbour dams that can be optionally juxtaposed to the longitudinal perforated seawall **1** are not shown. It will be understood that while each longitudinal perforated seawall **1** are illustrated with one pipe, said longitudinal perforated seawall may be equipped with more pipes **11**, depending on nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams near the coast. The harbour entrance **3** is located between the two longitudinal perforated seawalls **1**.

With reference to FIG. 4, a schematic view of a harbour construction **4** comprising two longitudinal perforated seawalls **1** wherein the outlet of at least one pipe is located at the sea-facing side of the longitudinal seawall according to an embodiment of the invention is illustrated. The direction of the tide **5** or **6** is almost perpendicular to the longitudinal seawalls **1**. The longitudinal perforated seawalls **1** are built from existing fluvial installations **30** which extended from the coast or the land **8**. Each longitudinal perforated seawall **1** having a harbour facing side **25** and a sea facing side **24** comprises one pipe located below the water level. The length of the pipe is greater than the width of the longitudinal seawall and the outlet of the pipe **13** is located at the sea-facing side of the longitudinal perforated seawall **1**. The directions of the tide **5** or **6** are almost parallel to the longitudinal axis **27** passing though the inlet of the pipe **11**. For clarity the longitudinal axis **27** is illustrated for only one pipe **11**. The inlet of the pipe **11**, as well as fluvial installation that can be optionally juxtaposed to the longitudinal perforated seawall **1,** are not shown. It will be understood that while each longitudinal perforated seawall **1** are illustrated with one pipe, said longitudinal seawall may be equipped with more pipes **11**, depending on the nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast. The harbour entrance **3** is located between the two longitudinal perforated seawalls **1**. Optionally, if the longitudinal seawall comprises more than one pipe, the outlet of the others pipes can be not located at the sea-facing side of the longitudinal perforated seawall. Optionally, if the longitudinal perforated seawall comprises more than one pipe, the length of the pipe can be equal to the width of the longitudinal perforated seawall.

With reference to FIG. 5, a schematic view of a harbour construction **4** comprising two longitudinal perforated seawalls **1** wherein the length of at least one pipe is greater than the width of the longitudinal perforated seawall and the inlet of at least one pipe is located outside the longitudinal perforated seawall according to an embodiment of the invention is illustrated. The direction of the tide **5** or **6** is almost perpendicular to the longitudinal perforated seawalls **1**. The longitudinal perforated seawalls **1** are built from existing fluvial installations **30** which extended from the coast or the land **8**. Each longitudinal perforated seawall **1** having a harbour facing side **25** and a sea facing side **24** comprises one pipe located below the water level. The length of the pipe is greater than the width of the longitudinal perforated seawall and the inlet of the pipe **12** is located outside the longitudinal perforated seawall **1**. The directions of the tide **5** or **6** are almost parallel to the longitudinal axis **27** passing though the inlet **12** of the pipe **11**. For clarity the longitudinal axis **27** is illustrated for only one pipe **11**. The fluvial installations that can be optionally juxtaposed to the longitudinal perforated seawall **1** are not shown. It will be understood that while each longitudinal perforated seawall **1** are illustrated with one pipe, said longitudinal perforated seawall may be equipped with more pipes **11**, depending on nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams near the coast. The harbour entrance **3** is located between the two longitudinal perforated seawalls **1**. Optionally, if the longitudinal perforated seawall comprises more than one pipe, the inlet of the others pipes can be not located outside the longitudinal perforated seawall. Optionally, if the longitudinal perforated seawall comprises more than one pipe, the length of the pipe can be equal to the width of the longitudinal perforated seawall.

With reference to FIG. 6, a schematic view of a harbour construction **4** comprising two longitudinal perforated seawalls **1** wherein pipes of said seawalls are connected to each other according to an embodiment of the invention is illustrated. The direction of the tide **5** or **6** is almost perpendicular to the longitudinal perforated seawalls **1**. The longitudinal perforated seawalls **1** are built from existing fluvial installations **30** which extended from the coast or the land **8**. Each longitudinal perforated seawall **1** having a harbour facing side **25** and a sea facing side **24** comprises one pipe **11** which are connected to each other, thus providing a single pipe between the two longitudinal perforated seawalls of the harbour construction. The length of the pipe is greater than the width of the longitudinal perforated seawall. The inlet **12** and the outlet **13** of the pipe **11** can be located or not outside the longitudinal perforated seawall **1**. The directions of the tide **5** or **6** are almost parallel to the longitudinal axis **27** passing though the inlet **12** of the pipe **11**. The fluvial installations that can be optionally juxtaposed to the longitudinal perforated seawall **1** are not shown. Following the direction of the tide **5** or **6**, the inlet **12** can be the outlet and the outlet **13** can be the inlet. It will be understood that while each longitudinal perforated seawall **1** are illustrated with one pipe, said longitudinal perforated seawall may be equipped with more pipes **11**, depending on nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams near the coast. The harbour entrance **3** is located between the two longitudinal perforated seawalls **1**.

With reference to FIG. 7, a schematic view of a harbour construction **4** comprising two longitudinal perforated seawalls **1** wherein the outlet of at least one pipe is located outside the harbour construction according to an embodiment of the invention is illustrated. The direction of the tide **5** or **6** is almost perpendicular to the longitudinal perforated seawalls **1**. The longitudinal perforated seawalls **1** are built from existing fluvial installations **30** which extended from the coast or the land **8**. Each longitudinal perforated seawall **1** having a harbour facing side **25** and a sea facing side **24** comprises one pipe located below the water level. The length of the pipe is greater than the width of the longitudinal perforated seawall and the outlet of the pipe **13** is located outside the harbour construction. The directions of the tide **5** or **6** are almost parallel to the longitudinal axis **27** passing though the inlet of the pipe **11**. For clarity the longitudinal axis **27** is illustrated for only one pipe **11**. The inlet of the pipe **11**, as well as fluvial installation that can be optionally juxtaposed to the longitudinal perforated seawall **1,** are not shown. It will be understood that while each longitudinal perforated seawall **1** are illustrated with one pipe, said longitudinal perforated seawall may be equipped with more pipes **11**, depending on nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast. The harbour entrance **3** is located between the two longitudinal perforated seawalls **1**. Optionally, if the longitudinal perforated seawall comprises more than one pipe, the outlet of the others pipes can be not located outside the harbour construction. Optionally, if the longitudinal perforated seawall comprises more than one pipe, the length of the pipe can be equal to the width of the longitudinal perforated seawall.

With reference to FIG. 8, a schematic view of a harbour construction **4** whereby two longitudinal perforated seawalls are applied in an existing harbour without seawall extensions according to an embodiment of the invention is illustrated. The direction of the tide **5** or **6** is almost perpendicular to the longitudinal perforated seawalls **1**. The longitudinal perforated seawalls **1** are built from the coast or the land **8** and are juxtaposed to existing fluvial installations **30**. Each longitudinal perforated seawall **1** comprises one pipe **11** located below the water level. The length of the pipes is equal to the width of the longitudinal seawall. The directions of the tide **5** or **6** are almost parallel to the longitudinal axis **27** passing though the inlet of the pipe **11**. For clarity the longitudinal axis **27** is illustrated for only one pipe **11**. The inlet and the outlet of the pipe **11**, as well as fluvial installation that can be optionally juxtaposed to the longitudinal perforated seawall **1** are not shown. It will be understood that while each longitudinal perforated seawall **1** are illustrated with one pipe, said longitudinal seawall may be equipped with more pipes **11**, depending on the nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast. If the longitudinal perforated seawall **1** comprises more than one pipe **11**, it will be understood that the length of the others pipes can be greater than the width of the longitudinal perforated seawall and the inlet and the outlet of the pipe can be disposed outside the longitudinal perforated seawall or outside the harbour construction or can be connected to each other. The harbour entrance **3** is located between the two longitudinal perforated seawalls **1**.

With reference to FIG. 9, a cross section of a harbour construction comprising one longitudinal perforated seawall juxtaposed to marine seawalls and harbour dams according to an embodiment of the invention is illustrated. The longitudinal perforated seawall **1** have a sea-facing side **24** and a harbour-facing side **25** comprises one pipe **11** located below the water level and disposed with an inlet **12**. The pipe **11** further comprises one tide turbine **16** and is provided with a hollow tube **15** connected to the top surface **14** of the fluvial installation **30**. The outlet of the pipe is not shown. The hollow tube **15** is located above the tide turbine **16**.

With reference to FIG. 10, a cross-section of a pipe comprising one tide-turbine **16** according to a particular embodiment of the invention is illustrated. The pipe **11** comprises an inlet **12**, one tide-turbine **16** and is connected to the top surface of the fluvial installation with a hollow tube **15** located above said tide-turbine **16**. The outlet of the pipe is not shown. The tide-turbine **16** comprises a rotor assembly **17** and a generator **18**. The rotor assembly comprises one propeller **19**. It will be understood that while the rotor assembly **17** is illustrated with one propeller **19**, said rotor assembly **17** may be equipped with more propellers, such as from 1 to 10 propellers, for example 1 propeller, 2 propellers, 3 propellers, 4 propellers or 5 propellers. Water passes though the pipe **11** from **20**.

With reference to FIG. 11, a cross-section of a pipe comprising one tide-turbine **16** according to a further particular embodiment of the invention is illustrated. The pipe **11** comprises an inlet **12**, one tide-turbine **16** and is connected to the top surface of the fluvial installation with a hollow tube **15** located above said tide-turbine **16**. The outlet of the pipe is not shown. The tide-turbine **16** comprises a rotor assembly **17** and a generator **18**. The rotor assembly **17** comprises four longitudinal blades **22** and at least one support material **23**. The support material is attached to an axis **21** in connection with the generator **18**. It will be understood that while the rotor assembly **17** is illustrated with four blades **22** and at least one support material **23**, said rotor assembly **17** may be equipped with more or less blades or support material, such as from 1 to 20 blades. Water goes though the pipe **11** from **20**.

Claims

1. A longitudinal perforated seawall suitable for reducing nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast, and having a harbour facing side and a sea facing side, said longitudinal perforated seawall comprising at least one pipe located below the water level and disposed with an inlet at the sea-facing side and at least one outlet.
2. Longitudinal perforated seawall according to claim 1 wherein the length of said pipe is equal or greater than the width of said longitudinal perforated seawall.
3. Longitudinal perforated seawall according to claim 1 or 2, wherein the angle between the longitudinal axis passing though the centre of the inlet of said pipe and the flow of the sea is comprised between -30° and 30°, preferably between -15° and 15°.
4. Longitudinal perforated seawall according to any of the previous claims 1 to 3, wherein the longitudinal axis passing though the centre of the inlet of said pipe and the flow of the sea are parallel.
5. Longitudinal perforated seawall according to any of the previous claims 1 to 4, wherein said longitudinal perforated seawall is configured to decrease the velocity of the tide across the coast or the harbour entrance between 0.6 $m.s^{-1}$ and 4 $m.s^{-1}$.
6. A method for reducing nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast comprising the steps of:
   - providing a longitudinal perforated seawall to an existing harbour or to the shore, having a harbour facing side and a sea facing side according to any of previous claims 1 to 5, comprising at least one pipe located below the water level and disposed with an inlet at the sea-facing side and at least one outlet,
   - such that water from the sea flows within said pipe from the inlet,
   - such that water from the sea exits of said pipe from the outlet, and
   - so reducing the nautical perturbation caused by the tide flow generated by the presence of marine seawalls and harbour dams across the coast.
7. A method according to claim 6, whereby the velocity of the tide across the coast or harbour entrance is decreased between 0.6 $m.s^{-1}$ and 4 $m.s^{-1}$.
8. Use of at least one longitudinal perforated seawall according to claims 1 to 5 for reducing nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast.

9. Harbour construction suitable for reducing nautical perturbations caused by the tide flow which is generated by the presence of marine seawalls and harbour dams across the coast, comprising at least one longitudinal perforated seawall according to any of previous claims 1 to 5, which comprises at least one pipe located below the water level and disposed with an inlet at the sea-facing side, at least one outlet and optionally wherein at least part of the harbour-facing side of said longitudinal perforated seawall is juxtaposed to the fluvial installation.
10. Harbour construction according to claim 9, wherein the length of said pipe is equal or greater than the width of the longitudinal perforated seawall.
11. Harbour construction according to claims 9 or 10, wherein the angle between the longitudinal axis passing though the centre of the inlet of said pipe and the flow of the sea is comprised between -30° and 30°, preferably between -15° and 15°.
12. Harbour construction according to claims 9 to 11, wherein the longitudinal perforated seawalls are configured to decrease the velocity of the tide flow near the coast or harbour entrance between 0.6 $m.s^{-1}$ and 4 $m.s^{-1}$.
13. Harbour construction according to claims 9 to 12, wherein said pipe comprises optionally at least one tide-turbine.

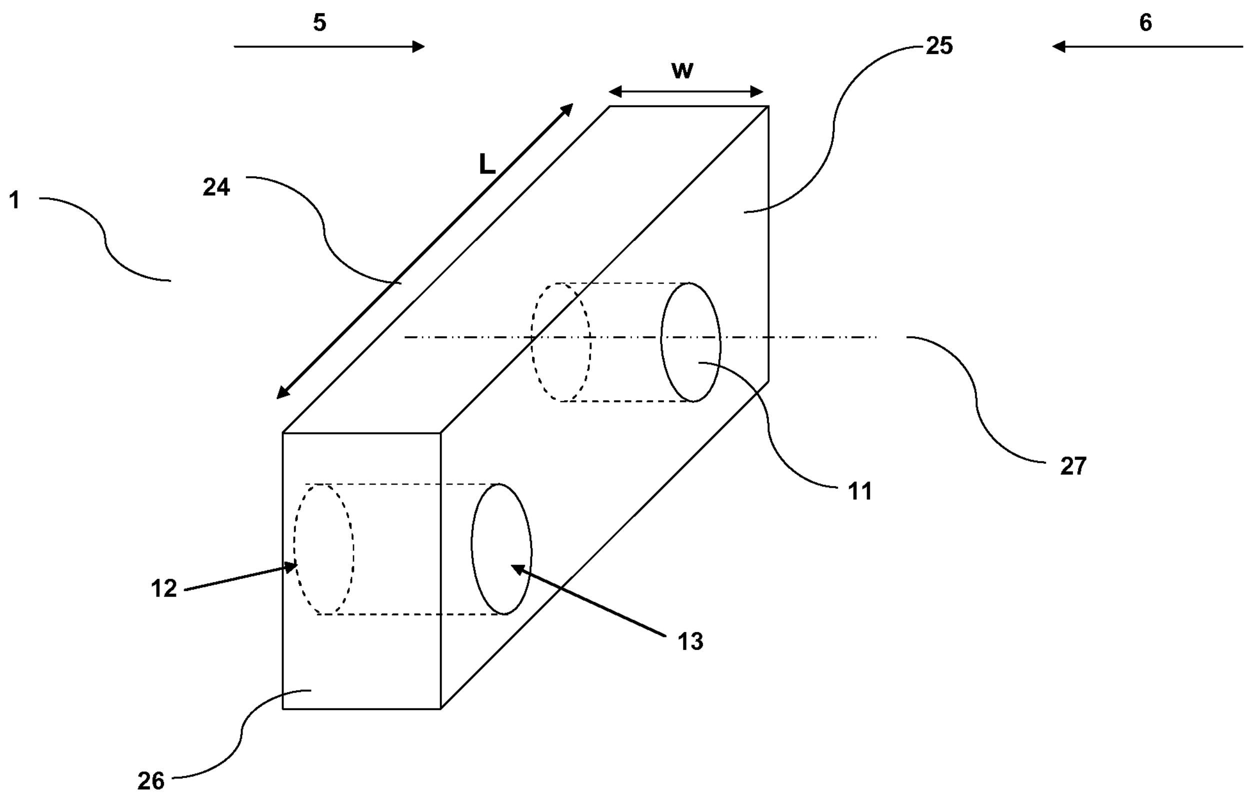

FIG. 1

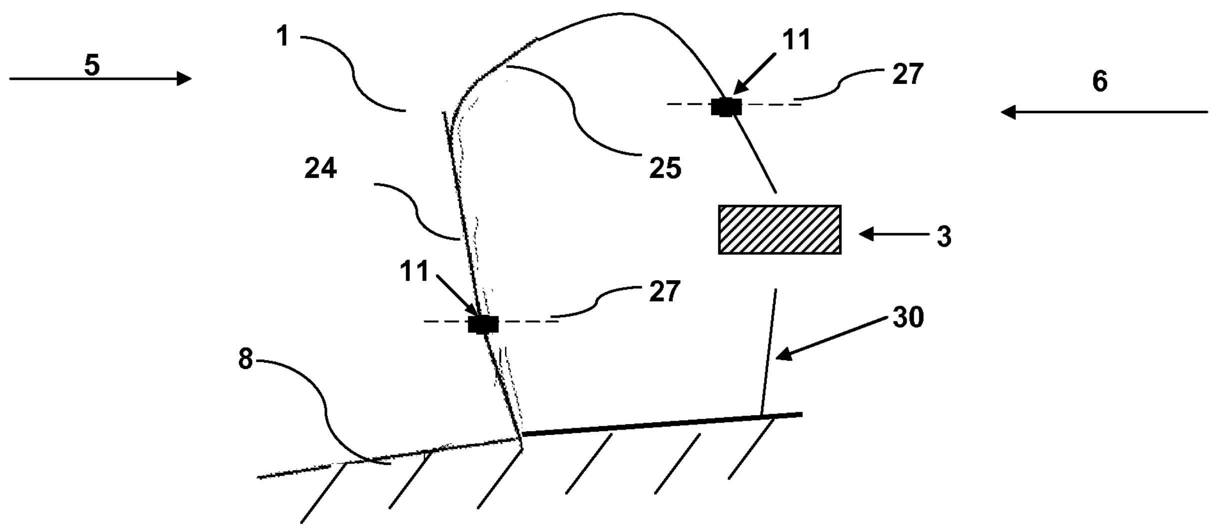

FIG. 1b

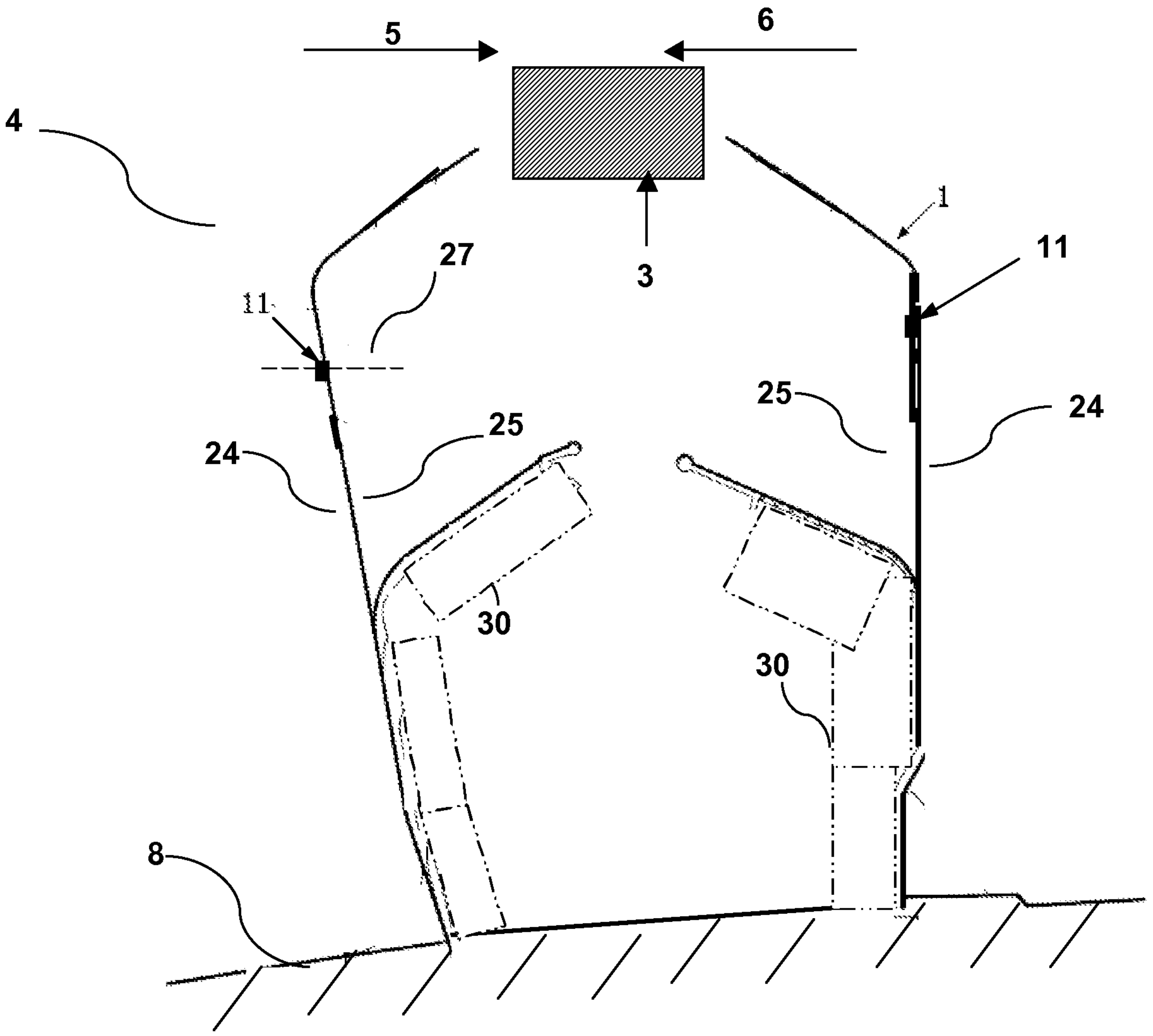

FIG. 2

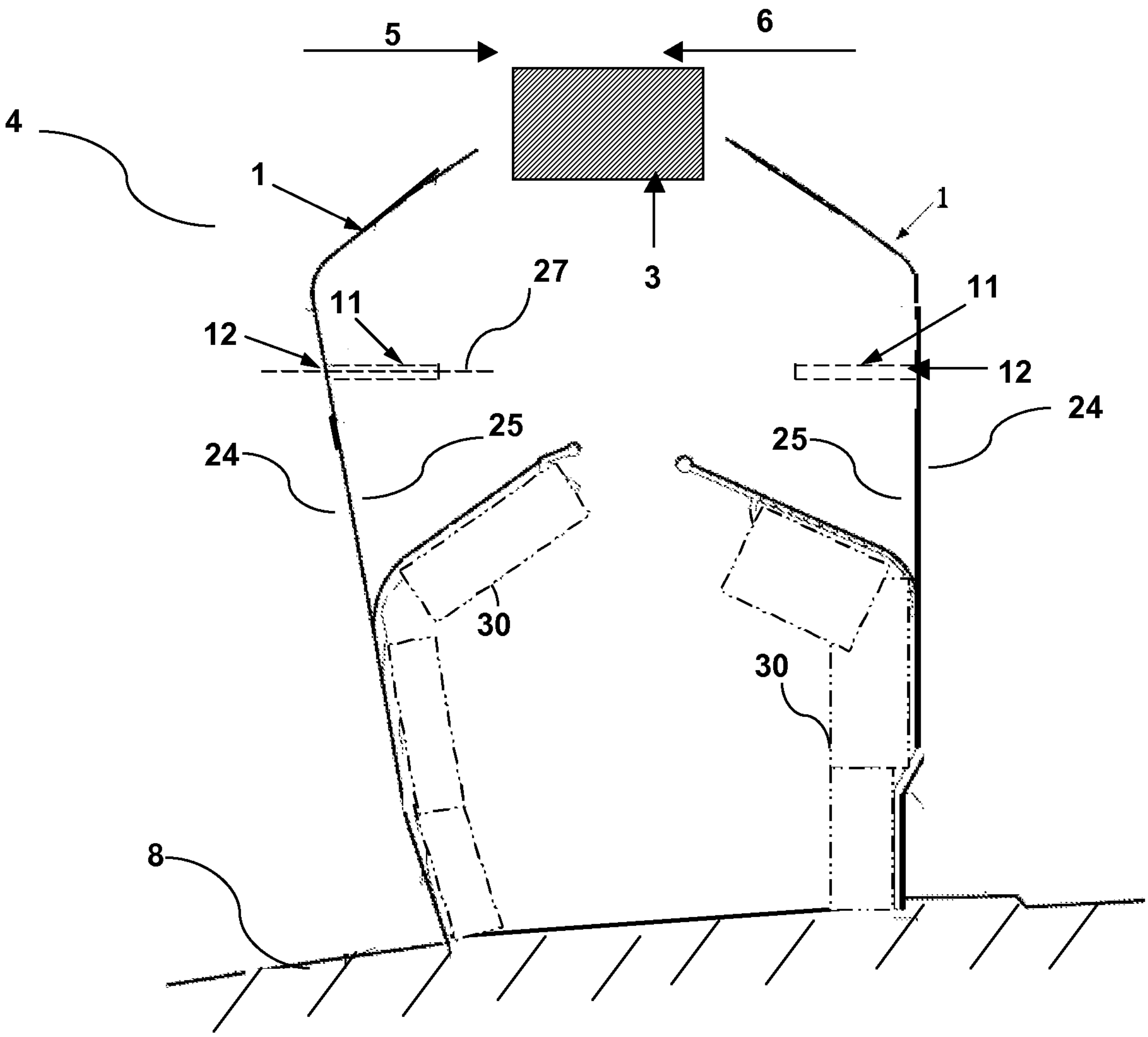

FIG. 3

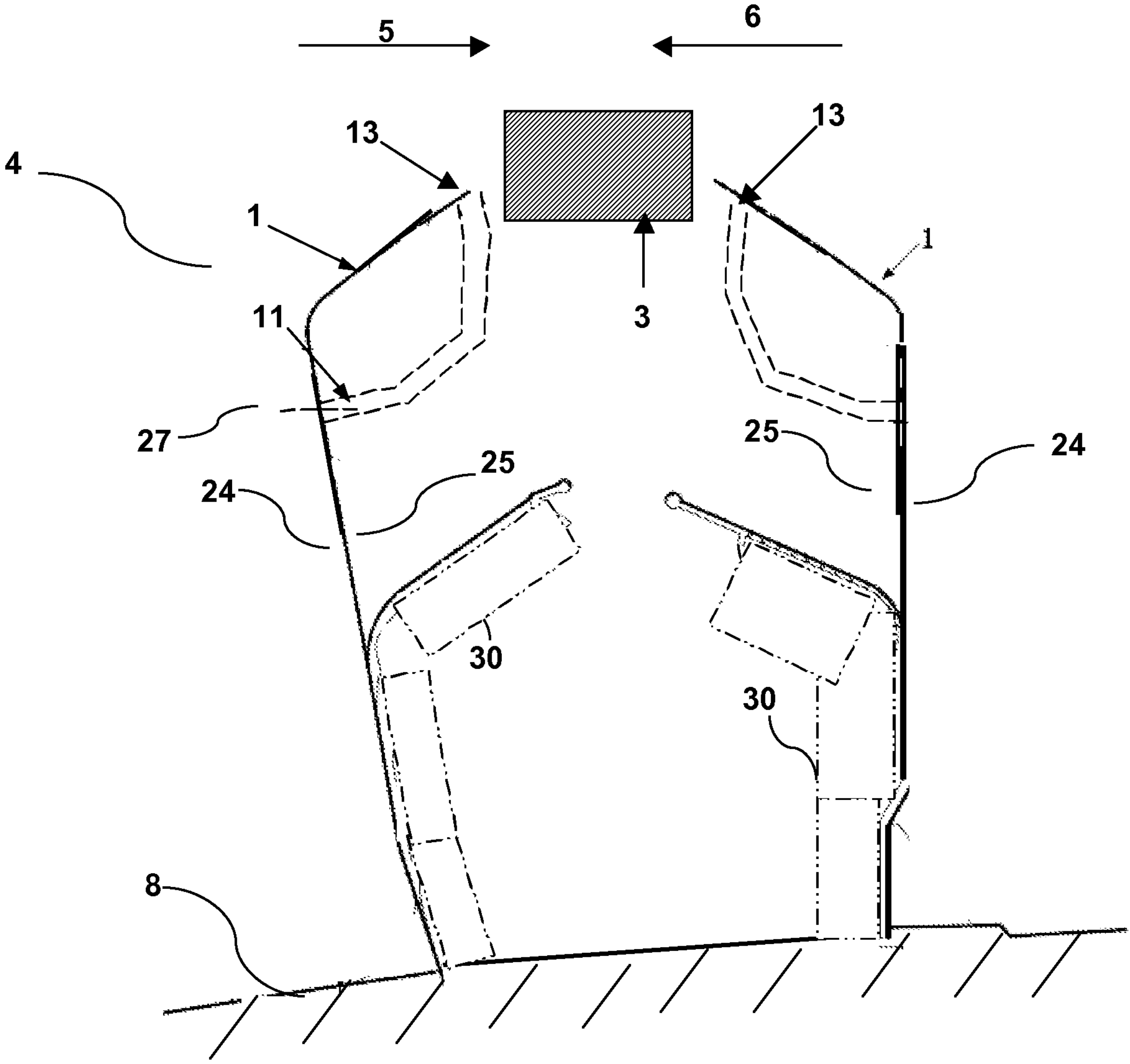

FIG. 4

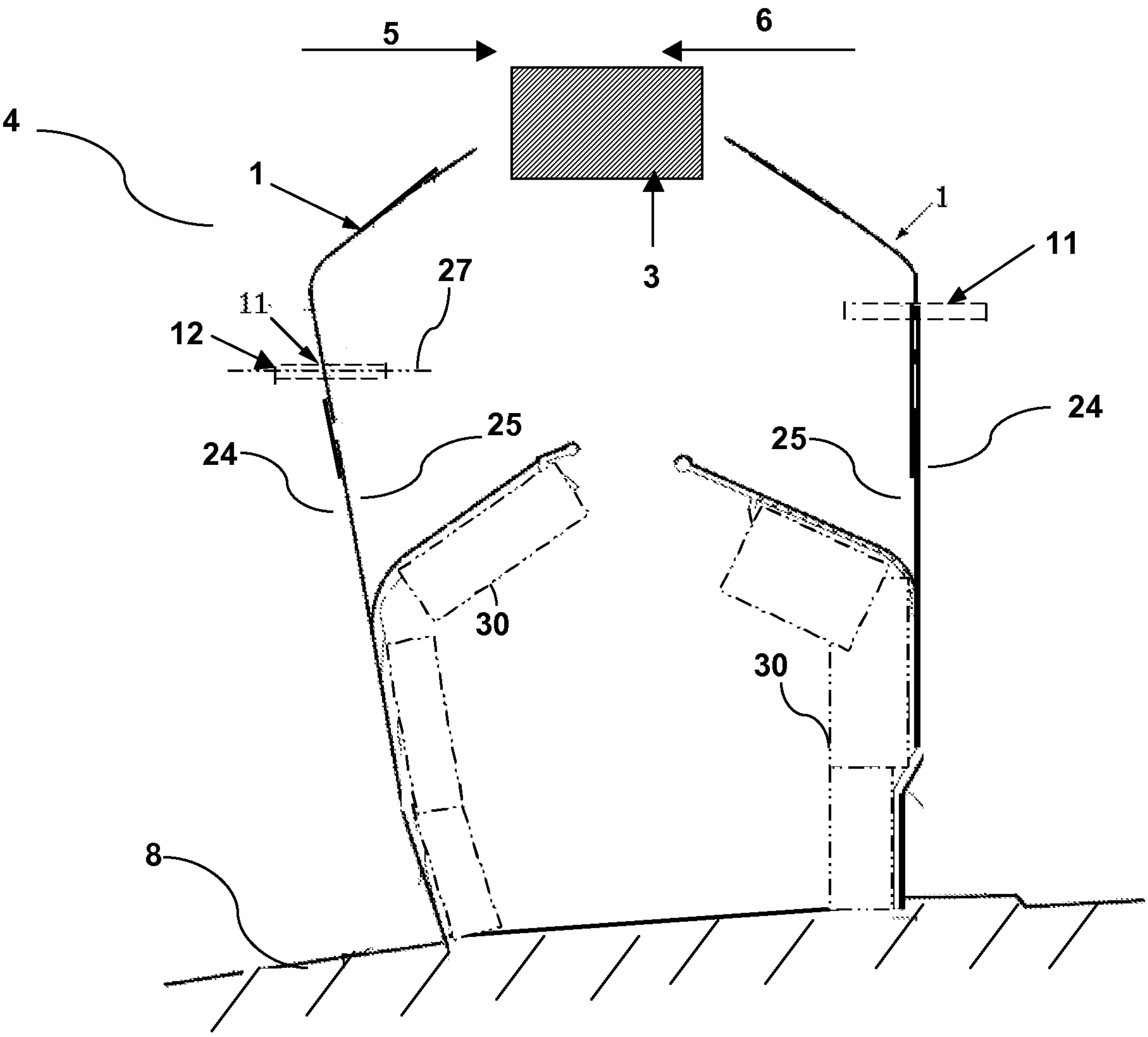

FIG. 5

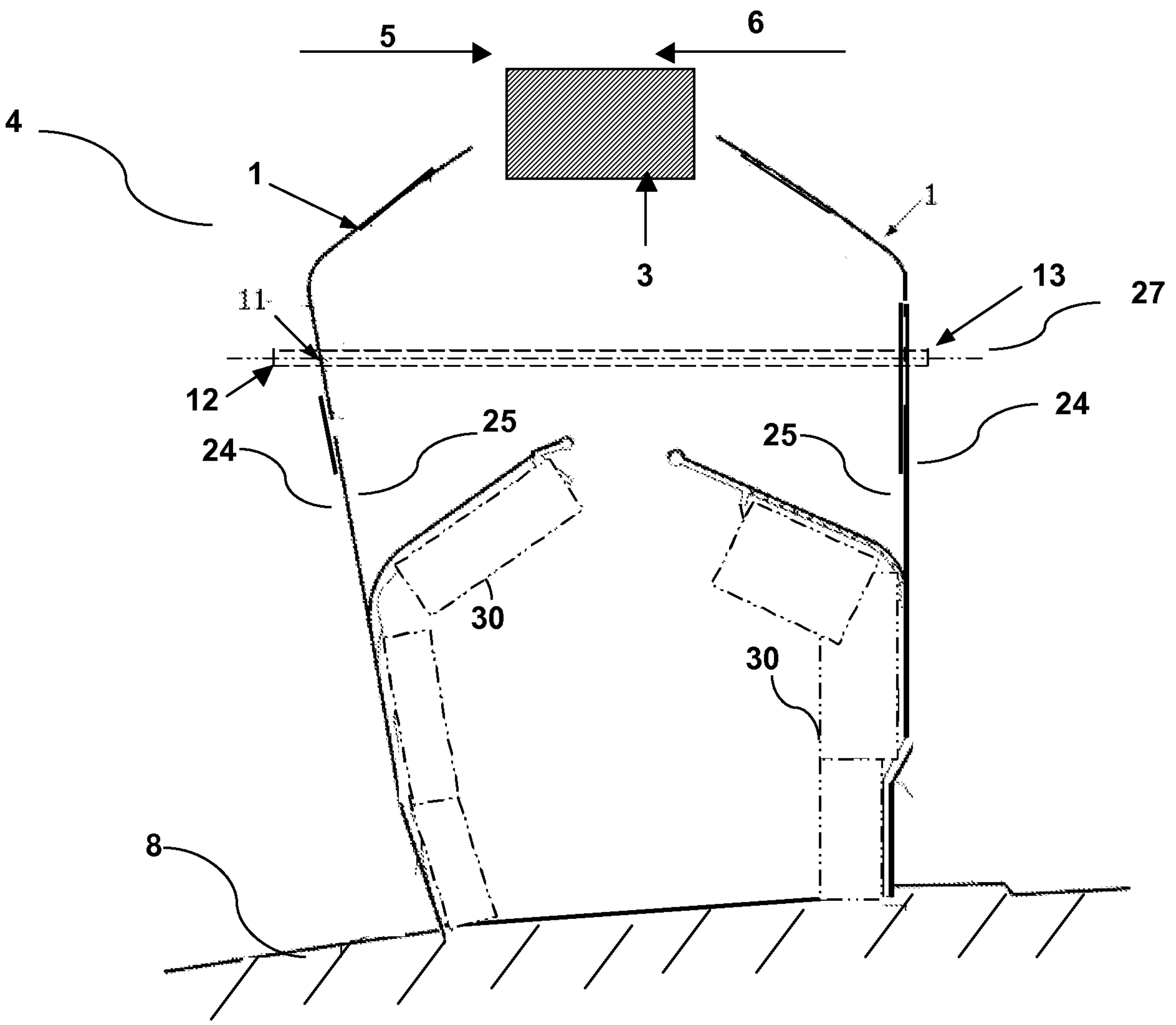

FIG. 6

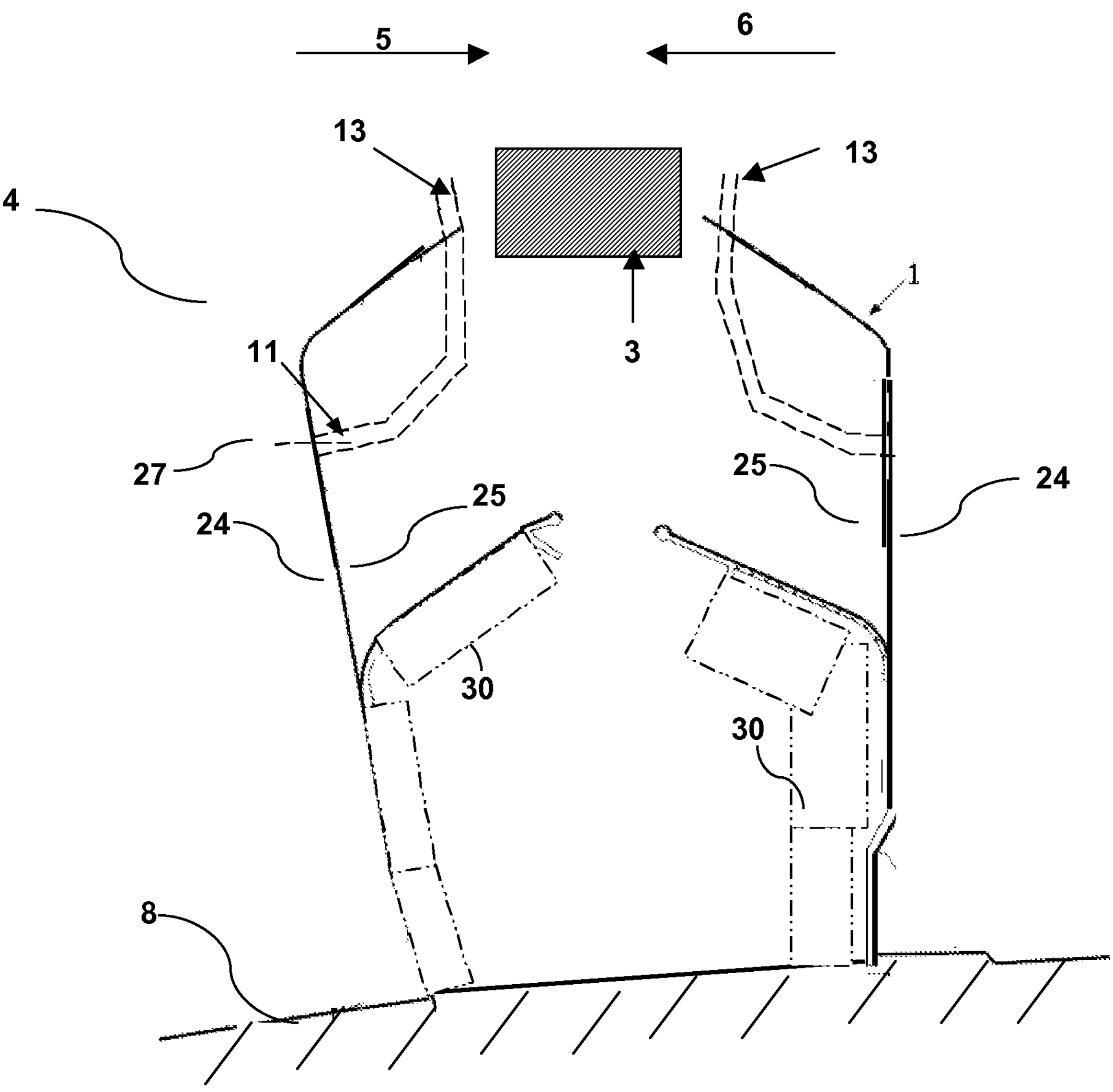

FIG. 7

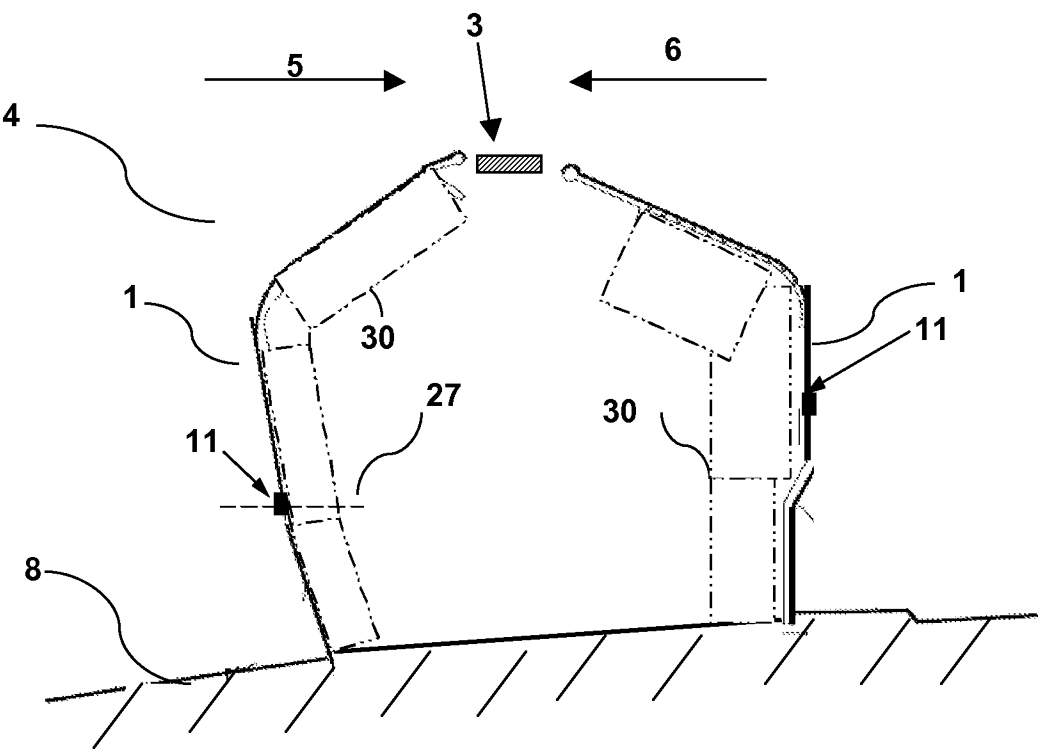

FIG. 8

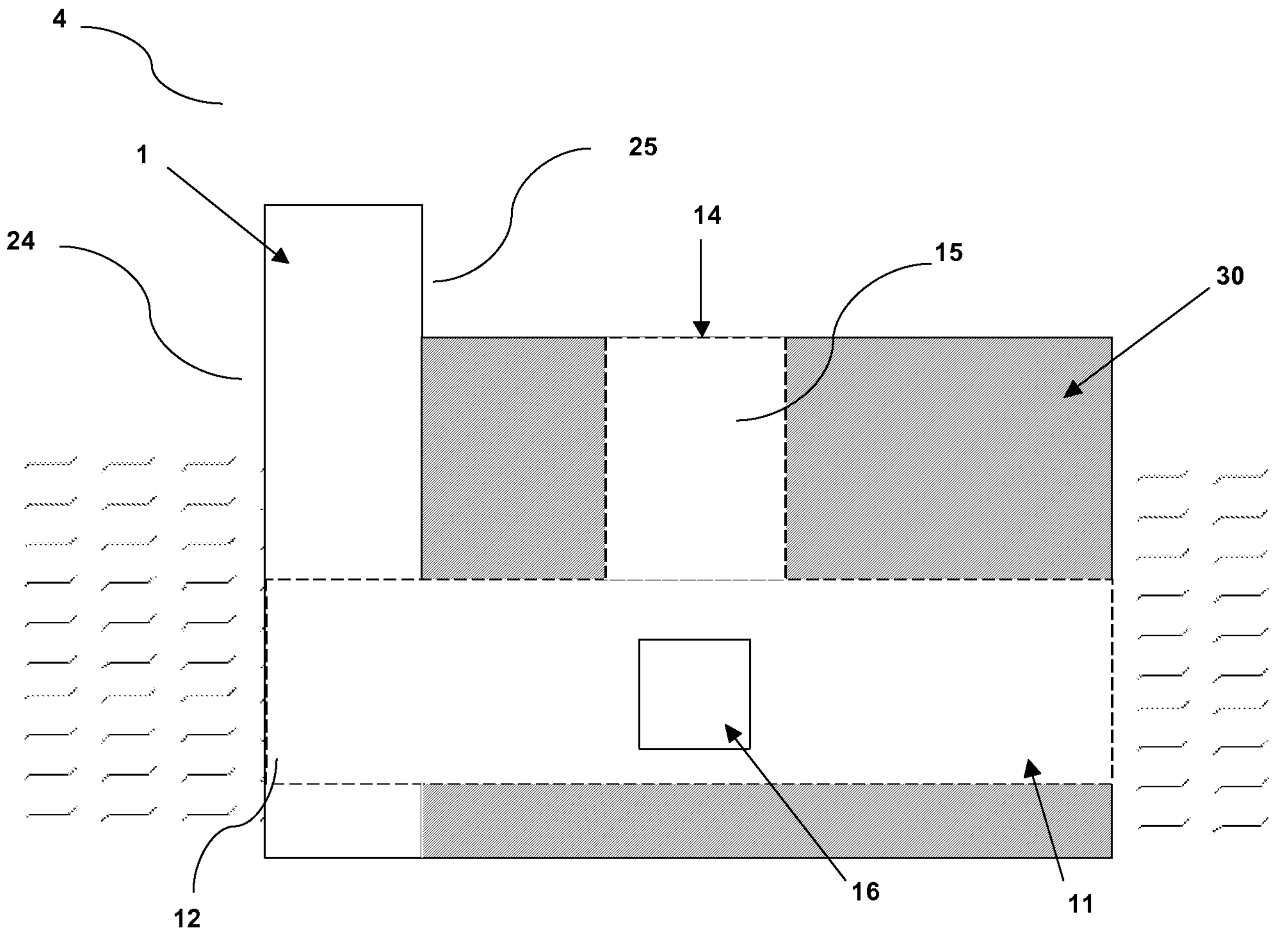

FIG. 9

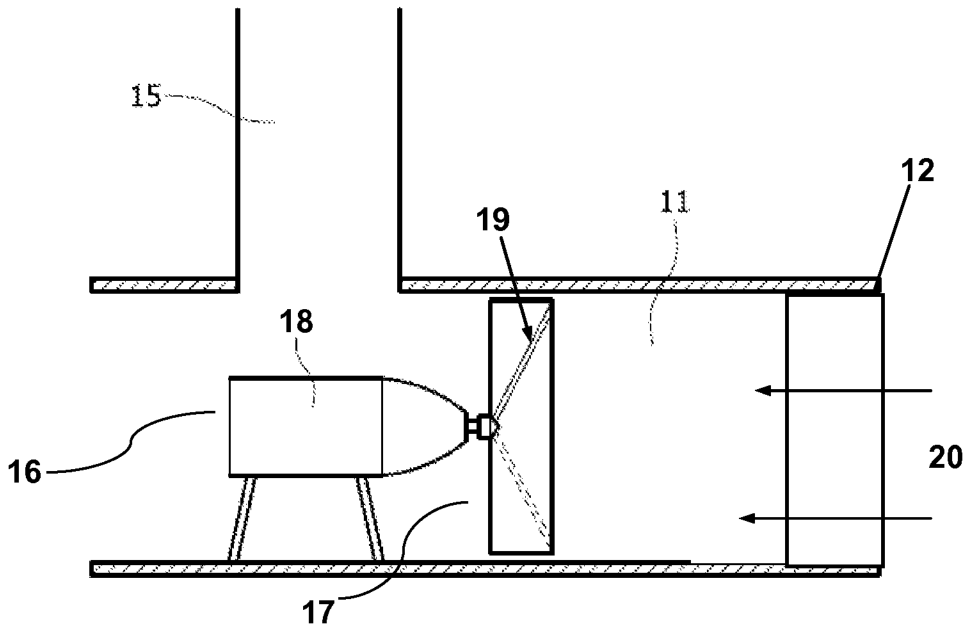

FIG. 10

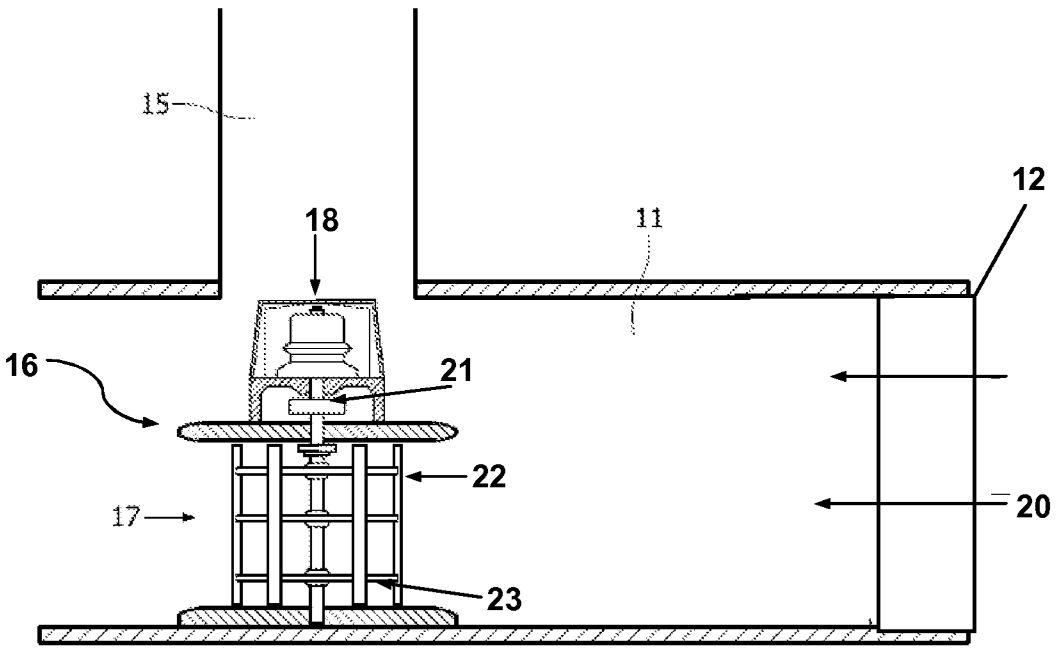

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2008/060677

A. CLASSIFICATION OF SUBJECT MATTER
INV. E02B3/06 E02B9/08

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)
E02B

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 263 516 A (PAPADAKIS GEORGE M) 21 April 1981 (1981-04-21) the whole document	1-13
X	US 3 118 282 A (G.E. JARLAN) 21 January 1964 (1964-01-21)	1,2
A	column 1, line 9 - line 14; figures 3-8	3-12
X	WO 89/09308 A (GRANT MICHAEL JOHN [AU]; DORRELL DONALD EDWARD [NZ]) 5 October 1989 (1989-10-05)	1,2
A	abstract; figure 1	3-12
X	US 2006/056913 A1 (HERZOG KENNETH H [US]) 16 March 2006 (2006-03-16)	1,2
A	abstract figure 4	3-12

☐ 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 document but published on or after the international filing date

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 May 2009	08/06/2009

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Flygare, Esa

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2008/060677

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US 3118282	A	21-01-1964	NONE			
WO 8909308	A	05-10-1989	AU	630605	B2	05-11-1992
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			DE	68924421	T2	23-05-1996
			EP	0407432	A1	16-01-1991
			NZ	222653	A	26-07-1991
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