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(54) Title: DEVICE FOR REFLECTING A TSUNAMI WAVE AT SEA AND A METHOD FOR PROTECTING A QUANTITY OF COAST

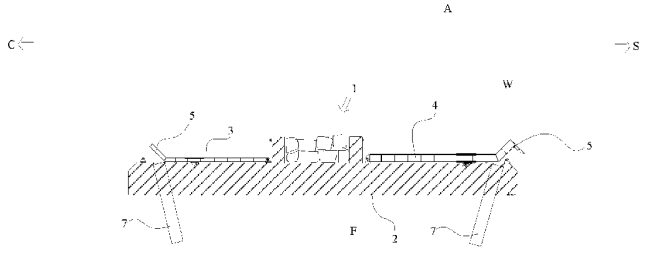

Fig. 1

(57) Abstract: The present invention relates to an installation for stemming a tsunami wave in a sea, the installation comprising: - a foundation for arranging the installation relative to a bottom of the sea, - an inflow barrier wall for stemming an incoming tsunami wave, which barrier wall is mounted with the hinge on the landward side of the foundation for upward pivoting relative to the bottom, - a stop for limiting a pivoting movement of the barrier wall, and - a drawback barrier wall provided for stemming a receding tsunami wave, which barrier wall is mounted with the hinge on the seaward side of the foundation for upward pivoting relative to the bottom.

DEVICE FOR REFLECTING A TSUNAMI WAVE AT SEA AND A METHOD FOR PROTECTING A QUANTITY OF COAST

The present invention relates to an installation for stemming a tsunami wave in a sea.

The present invention further relates to a method for protecting an extent of sea-coast such as a bay.

The present invention likewise relates to a combination of two or more installations according to the invention.

A tsunami is a series of waves which displaces a determined volume of water and an amount of energy. An example of a possible cause of a tsunami is for instance a seaquake, wherein a quantity of water is displaced within a short period of time. The displacement of the quantity of water can for instance be brought about by a vertical displacement of one tectonic plate relative to another tectonic plate. It is per se known that a tsunami can travel at speeds of up to 1000 kilometres per hour. The speed depends on the water depth. At the moment the tsunami reaches a rising coastline the leading edge slows down while the part of the tsunami lying behind continues to push forward.

Two different types of tsunami are generally known, the negative tsunami and the positive tsunami.

In a negative tsunami there first occurs an offshore flow of the water. This offshore flow has the result that the water at a coastline moves away from the land, whereby the sea appears to recede. Following the offshore movement of the water the crest of the tsunami, which comprises a large amount of energy, will reach land.

In a positive tsunami the crest of the tsunami strikes directly onshore.

In the context of the description of the present invention a negative wave should be understood to mean the offshore movement of the water, and a positive wave as a movement of the water in the direction of land.

A consequence of a tsunami reaching a shoreline is that the water flows several tens of metres to several kilometres onto the land at high speed. The water flowing onto the land often results in enormous destruction of nature and inhabited areas as well as fatal casualties.

The present invention has for its object to increase the safety of coastal areas. The invention provides for this purpose an installation for stemming a tsunami wave in a sea, the installation comprising:

- a foundation for arranging the installation relative to a bottom of the sea,
- an inflow barrier wall for stemming an incoming tsunami wave, which barrier wall is mounted with the hinge on the landward side of the foundation for upward pivoting relative to the bottom,
- a stop for limiting a pivoting movement of the barrier wall, and
- an outflow barrier wall provided for stemming a receding tsunami wave, which barrier wall is mounted with the hinge on the seaward side of the foundation for upward pivoting relative to the bottom.

An advantage of the installation according to the invention is that, in the case of a negative tsunami, wherein a large water mass is drawn back offshore, the drawback barrier wall limits the outflow of the water mass from the volume between the installation and the coastline, thereby preventing this water mass subsequently forming part of the water mass of the positive tsunami, and limiting the overall mass of the positive tsunami.

That is, the drawback barrier wall will limit the receding movement of the water. A result of the drawback barrier wall is that less water draws back, and the positive wave will thus comprise less water and therefore remain lower.

A further advantage of the installation according to the invention is that, in the case the positive wave approaches the installation, the inflow barrier wall will at least partially stem this positive wave and absorbs at least a part of the speed of the positive wave. A result hereof is that the water mass of the positive wave, greatly limited by the restricting of the drawback, is stemmed before it reaches the coastline. In other words, the coastline is safe since the tsunami will not reach the coastline.

Under conditions where there are no extreme situations as is the case when a tsunami occurs, the installation is in a rest position. In this rest position the inflow barrier wall and/or the drawback barrier wall are located substantially in a horizontal orientation. Owing to the flows caused by the tsunami the inflow barrier wall or the drawback barrier wall will pivot to a substantially vertical orientation, in which orientation the inflow barrier wall or the drawback barrier wall will stem the waves of the tsunami.

The invention has diverse preferred embodiments which will become apparent from the following description of several such embodiments. The advantageous inventive features of the invention in all its aspects, including the measures defined in the dependent claims, are by no means limited to the considerations stated above and/or below.

A first preferred embodiment of the installation according to the invention has the feature that a flap member is provided on the inflow barrier wall and/or the drawback barrier wall. It is advantageous here that in the rest position the drawback barrier wall and/or the inflow barrier wall rest on the foundation. In normal situations it is desirable that for instance shipping, such as fishermen going to sea in a fishing vessel, is not disrupted by the installation. Because the drawback barrier wall and/or the inflow barrier wall rests on the foundation of the installation in the rest position, the installation has minimal dimensions in the rest position.

An advantage of the flap member is that the flows brought about by the tsunami can engage on the flap member in order to bring about a pivoting movement of the inflow barrier wall or the drawback barrier wall.

A preferred embodiment of the installation according to the invention has the feature that a density of the inflow barrier wall and/or drawback barrier wall is chosen such that the drawback barrier wall and/or the inflow barrier wall remain at rest at a predetermined flow speed of surrounding water, such as a density substantially equal to that of the surrounding water, such as substantially slightly higher than the surrounding water, such as a maximum of 10% higher than the surrounding water, such as a maximum of 8, 5 or 3% higher than the surrounding water.

An advantage of this embodiment is that in the rest position the drawback barrier wall and/or the inflow barrier wall will remain in the rest position since the forces exerted on the installation by the flows in normal conditions are too low to bring about a pivoting movement

of the drawback barrier wall and/or the inflow barrier wall.

The density of for instance the drawback barrier wall can further determine how much force must be exerted on this drawback barrier wall before this drawback barrier wall will make a pivoting movement. That is, it is possible to adjust the magnitude of the forces exerted on the installation which will bring about a pivoting movement of the drawback barrier wall or the inflow barrier wall.

An embodiment of the installation according to the invention has the feature that the inflow barrier wall and/or drawback barrier wall is filled with a foam material, such as a closed-cell foam, such as a PUR foam. Such materials are well able to withstand the conditions occurring on a seabed. It is further possible with such materials to influence the density of the inflow barrier wall and/or the drawback barrier wall so that this density can be modified to the forces to be expected in the case a tsunami occurs.

A further preferred embodiment of the installation according to the invention has the feature that a diffuser is provided at an end of the inflow barrier wall, preferably at an end which during use is arranged close to or protrudes above the normal water level. An advantage of this embodiment is that the efficiency in respect of stemming the waves of the tsunami by means of the inflow barrier wall is increased. That is, a greater part of the waves of the tsunami will be stemmed by the inflow barrier wall in the case it is provided with a diffuser. An advantage hereof is that the discernible effects of the tsunami will be further reduced.

A further preferred embodiment of the installation according to the invention has the feature that a connecting means is provided between the inflow barrier wall and/or between the drawback barrier wall and the foundation or an additional foundation element. It is advantageous here for the connecting means to be adapted to limit a pivoting movement of the inflow barrier wall and/or the drawback barrier wall. A result of the tsunami coming into contact with the installation according to the invention is that great forces will be exerted on at least the inflow barrier wall or the drawback barrier wall as a consequence of the great mass of water striking against the installation at high speed.

An advantage of the connecting means is that the pivoting movement of the inflow barrier wall or the drawback barrier wall will be limited by the connecting means. Achieved in this way is that the inflow barrier wall or the drawback barrier wall will remain during use in the vertical orientation or other desired orientation.

It is advantageous here for the connecting means to be a tie member preferably selected from the group comprising a tie beam, cord and cable. An advantage of such tie members is that it is for instance known to a person skilled in the art how much force a cable of a determined thickness can withstand or how the cable reacts to the surrounding water. The skilled person will in this way select the tie member which is most suitable for the conditions in which this application will be used.

A preferred embodiment of the installation according to the invention has the feature that the installation is placed at a depth in the range of 2 to 100 metres, preferably 6 to 14 metres, preferably 8 to 12 metres, such as 10 metres. An advantage of placing the

installation at said depth is that waves of the tsunami have a limited height, this height of the waves increasing as the waves approach the coastline and the depth of the water decreases. It is further known that at such a depth of the water the waves are situated upstream of the point where these waves will begin to break. Since a great deal of energy is released during breaking of the waves, it is advantageous to stem the waves before they break.

A further preferred embodiment of the installation according to the invention has the feature that ballast is provided relative to the installation for the purpose of weighting the installation. An advantage of this embodiment is that the installation is prevented from being lifted relative to the seabed as a result of forces exerted on the installation by the tsunami. Achieved in this way is that the installation remains positioned at the desired location during the occurrence of a tsunami.

A preferred embodiment of the installation according to the invention has the feature that an anchoring is provided on the installation for anchoring the installation relative to a seabed. It is per se known that a tsunami is a displacement of a very large quantity of water, wherein the displacement takes place at great speed. When the tsunami is stemmed by the installation, great forces will be exerted on parts of the installation, such as for instance on the foundation. An anchoring is provided in order to achieve that the installation remains fixed at a fixed position relative to the seabed. The anchoring anchors the installation relative to the seabed so that the installation is able to withstand the forces occurring as a result of the tsunami.

A further aspect of the invention relates to a combination of two or more installations according to the

invention. One option is for the installations to be placed one behind another relative to a coastline, thereby reinforcing the advantages as stated above.

Another option is for the installations to be placed adjacently of each other in for instance an arcuate form. In this arrangement it is for instance possible to protect a straight part of a coast from a tsunami.

A further aspect of the present invention relates to a method for protecting an extent of sea-coast, such as a bay, comprising steps for:

- carrying out placing preparations on the seabed for the purpose of manufacturing and/or placing the installation according to one or more of the foregoing claims, and/or
- manufacturing and/or placing a part of an installation according to one or more of the foregoing claims.

The method has at least the same advantages as the advantages referred to above in relation to the installation according to the present invention.

A first preferred embodiment of the method according to the invention comprises steps for arranging the installation at the position of an entrance to a bay.

This embodiment of the method according to the present invention has at least one of the advantages as stated above.

Following below is a description of several embodiments which are shown in the accompanying drawings and given only by way of example and in which the same or similar parts, components and elements are designated with the same reference numerals, and in which:

Fig. 1 shows a schematic representation of a first embodiment of an installation according to the invention;

Fig. 2 shows a schematic representation of an embodiment of an installation during a negative wave; and

Fig. 3 shows a schematic representation of an embodiment of an installation during a positive wave.

Fig. 1 shows a schematic representation of a first embodiment of an installation 1 according to the invention. Installation 1 comprises a foundation 2 arranged in a seabed F. Arranged on foundation 2 is an inflow barrier wall 4 and a drawback barrier wall 3, both of which are pivotable relative to foundation 2. The inflow barrier wall 4 and drawback barrier wall 3 are surrounded by seawater W. Present above seawater W is the air A. In this figure the coastline is situated in the direction of arrow C and the sea is in the direction of arrow S.

Inflow barrier wall 4 and drawback barrier wall 3 are situated in this figure 1 in a rest position, and rest on foundation 2. In the case of a tsunami the water mass will engage on a flap member 5, with the result that wall 3, 4 pivots relative to foundation 2, so that wall 3, 4 moves to a substantially vertical orientation.

Fig. 2 shows a schematic representation of an embodiment of an installation 1 during a negative wave E. In this figure the tsunami is a negative tsunami, whereby the water mass moves in the direction of arrow E. That is, the water mass is drawn back from the area between installation 1 and the coastline C. The moving water mass engages on flap member 5 of drawback barrier wall 3, whereby this drawback barrier wall 3 takes on a substantially vertical orientation by means of a pivoting movement. The water mass between installation 1 and the coastline C is stemmed by the vertically oriented drawback barrier wall 3, so that the stemmed part of the mass

following the negative tsunami cannot form part of a positive tsunami. When the drawback movement E of water mass W stops, the drawback barrier wall 3 will return to the rest position thereof as shown in Fig. 1.

Installation 1 is further provided with an anchoring 7 for anchoring the installation 1 relative to the seabed F. An advantage hereof is that installation 1 remains fixed relative to seabed F despite the forces resulting from the tsunami. A ballast 6 is also provided to hold installation 1 fixed relative to seabed F.

Fig. 3 shows a schematic representation of an embodiment of an installation 1 during a positive wave T. The positive tsunami moves in the direction of arrow T. Owing to the movement of the water mass in the direction T of the coastline C a force is exerted on flap member 5 of inflow barrier wall 4. A result hereof is that inflow barrier wall 4 displaces by means of a pivoting movement from the substantially horizontal orientation to a substantially vertical orientation. The water mass W coming from the direction of the sea S will strike against inflow barrier wall 4 and there be at least partially stemmed. A result of inflow barrier wall 4 is that a part of the positive tsunami will flow in the direction of arrow T, i.e. return in the direction of the sea S. Inflow barrier wall 4 further comprises a diffuser 8 which increases the efficiency of stemming the positive tsunami.

It is possible that a part of the positive tsunami will flow over inflow barrier wall 4 as indicated by means of arrow O. However, the effects of the overflowing part of the positive wave are significantly less than would be the case if no inflow barrier wall 4 were placed.

A connecting means 9 is further provided between inflow barrier wall 4 and the seabed F, this connecting

means 9 ensuring that the pivoting movement of inflow barrier wall 4 is limited. Inflow barrier wall 4 is hereby prevented from pivoting further as a result of the force of the positive tsunami T.

The present invention has been described in the foregoing on the basis of several preferred embodiments. Different aspects of different embodiments are deemed described in combination with each other, wherein all combinations which can be deemed by a skilled person in the field as falling within the scope of the invention on the basis of reading of this document are included. These preferred embodiments are not limitative for the scope of protection of this document. The rights sought are defined in the appended claims.

CLAIMS

1. Installation for stemming a tsunami wave in a sea, the installation comprising:

- a foundation for arranging the installation relative to a bottom of the sea,

- an inflow barrier wall for stemming an incoming tsunami wave, which barrier wall is mounted with the hinge on the landward side of the foundation for upward pivoting relative to the bottom,

- a stop for limiting a pivoting movement of the barrier wall, and

- a drawback barrier wall provided for stemming a receding tsunami wave, which barrier wall is mounted with the hinge on the seaward side of the foundation for upward pivoting relative to the bottom.

2. Installation as claimed in claim 1, wherein a flap member is provided on the inflow barrier wall and/or the drawback barrier wall.

3. Installation as claimed in any of the foregoing claims, wherein in the rest position the drawback barrier wall and/or the inflow barrier wall rest on the foundation.

4. Installation as claimed in any of the foregoing claims, wherein a density of the inflow barrier wall and/or drawback barrier wall is chosen such that the drawback barrier wall and/or the inflow barrier wall remain at rest at a predetermined flow speed of surrounding water, such as a density substantially equal to that of the surrounding water, such as substantially slightly higher than

the surrounding water, such as a maximum of 10% higher than the surrounding water, such as a maximum of 8, 5 or 3% higher than the surrounding water.

5. Installation as claimed in claim 4, wherein the inflow barrier wall and/or drawback barrier wall is filled with a foam material, such as a closed-cell foam, such as a PUR foam.

6. Installation as claimed in any of the foregoing claims, wherein a diffuser is provided at an end of the inflow barrier wall and/or the drawback barrier wall, preferably at an end which during use protrudes above a water surface.

7. Installation as claimed in any of the foregoing claims, wherein a connecting means is provided between the inflow barrier wall and/or between the drawback barrier wall and the foundation or an additional foundation element.

8. Installation as claimed in claim 7, wherein the connecting means is adapted to limit a pivoting movement of the inflow barrier wall and/or the drawback barrier wall.

9. Installation as claimed in claim 7 or claim 8, wherein the connecting means is a tie member preferably selected from the group comprising a cord and cable.

10. Installation as claimed in any of the foregoing claims, wherein the installation is placed at a depth

in the range of 2 to 100 metres, preferably 6 to 14 metres, preferably 8 to 12 metres, such as 10 metres.

11. Installation as claimed in any of the foregoing claims, wherein ballast is provided relative to the installation for the purpose of weighting the installation.

12. Installation as claimed in any of the foregoing claims, wherein an anchoring is provided on the installation for anchoring the installation relative to a seabed.

13. Combination of two or more installations as claimed in at least one of the foregoing claims.

14. Method for protecting an extent of sea-coast, such as a bay, comprising steps for:

- carrying out placing preparations on the seabed for the purpose of manufacturing and/or placing the installation according to one or more of the foregoing claims, and/or
- manufacturing and/or placing a part of an installation according to one or more of the foregoing claims.

15. Method as claimed in the foregoing claim, comprising steps for arranging the installation at the position of an entrance to a bay.

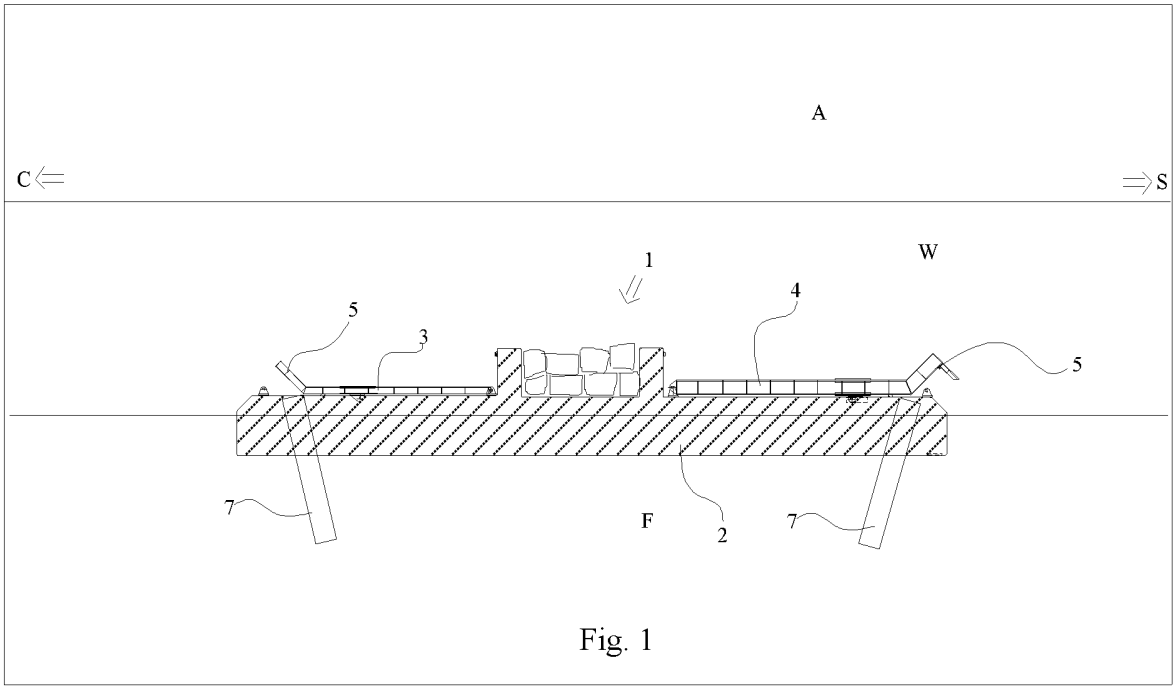

Fig. 1

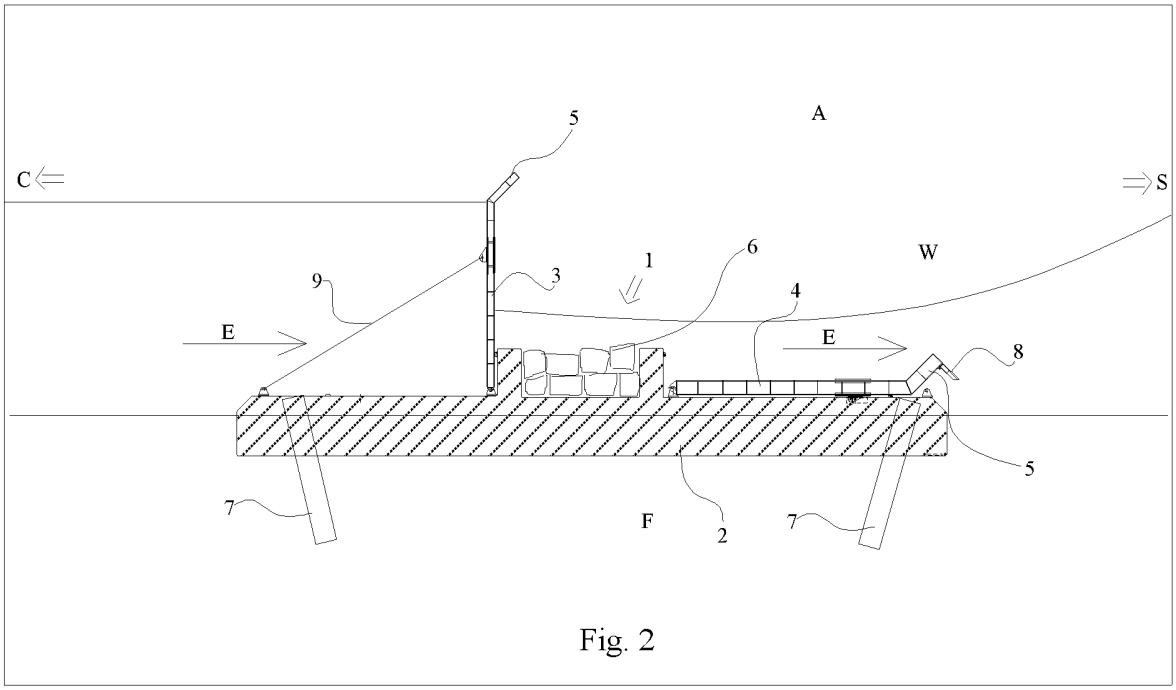

Fig. 2

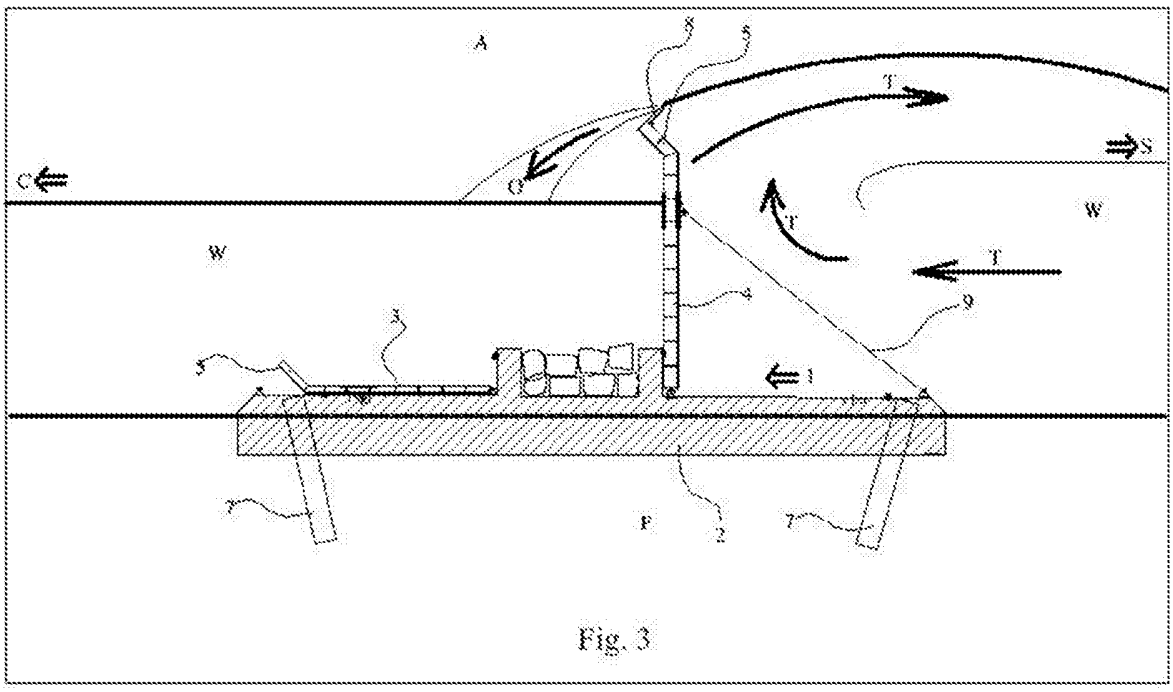

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2012/050251

A. CLASSIFICATION OF SUBJECT MATTER
INV. E02B3/06 E02B7/20 E02B7/44
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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 practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	NL 1 028 187 C1 (NOORT JOHANN HEINRICH REINDERT [NL]) 7 March 2006 (2006-03-07) the whole document	1-5, 10-15

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"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
23 November 2012	29/11/2012

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INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2012/050251

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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