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CA 2419748 C 2010/04/13

(11)(21) **2 419 748**

(12) **BREVET CANADIEN**
CANADIAN PATENT

(13) **C**

(86) Date de dépôt PCT/PCT Filing Date: 2001/08/29
(87) Date publication PCT/PCT Publication Date: 2002/03/14
(45) Date de délivrance/Issue Date: 2010/04/13
(85) Entrée phase nationale/National Entry: 2003/02/20
(86) N° demande PCT/PCT Application No.: NZ 2001/000178
(87) N° publication PCT/PCT Publication No.: 2002/020905
(30) Priorité/Priority: 2000/08/29 (NZ506600)

(51) Cl.Int./Int.Cl. *E02B 3/04* (2006.01), *E02B 3/06* (2006.01)

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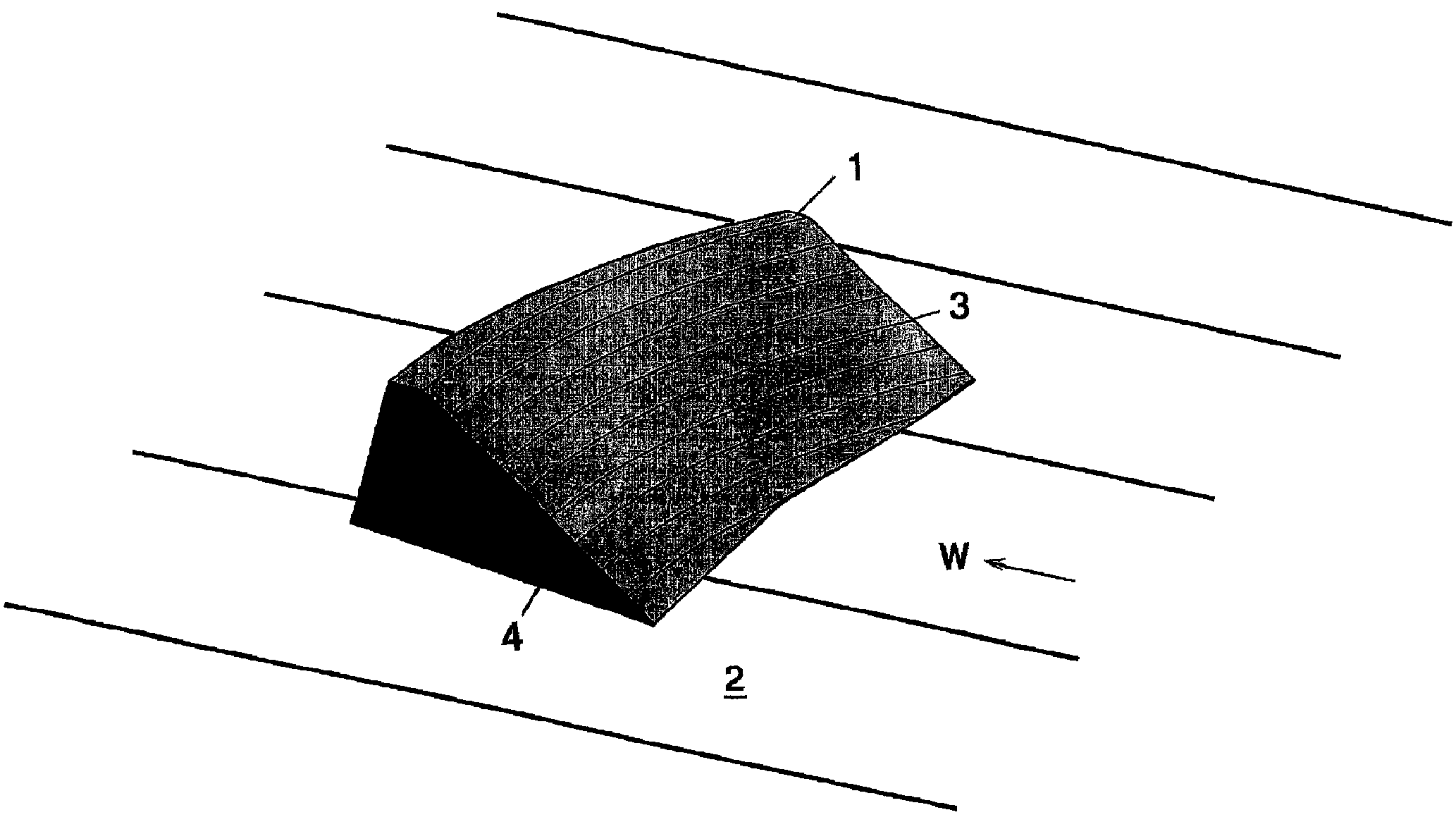
(54) Titre : PROCEDE DE PROTECTION DU LITTORAL
(54) Title: METHOD OF SHORE PROTECTION



(57) Abrégé/Abstract:
A method of shore protection is provided which includes determining a required direction of travel of incoming waves to a shore or shore portion to protect the shore and locating at least one elongate reef (1) on the sea bed (2). The reef (1) is oriented at a pre-selected angle relative to an average or mode direction of travel of incoming waves (W) and having pre-selected dimensions selected to modify the direction of travel of incoming waves to the required direction after passing over the reef (1).

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 March 2002 (14.03.2002)

PCT

(10) International Publication Number
WO 02/20905 A1

(51) International Patent Classification[7]: **E02B 3/04**, 3/06

(21) International Application Number: PCT/NZ01/00178

(22) International Filing Date: 29 August 2001 (29.08.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
506600 29 August 2000 (29.08.2000) NZ

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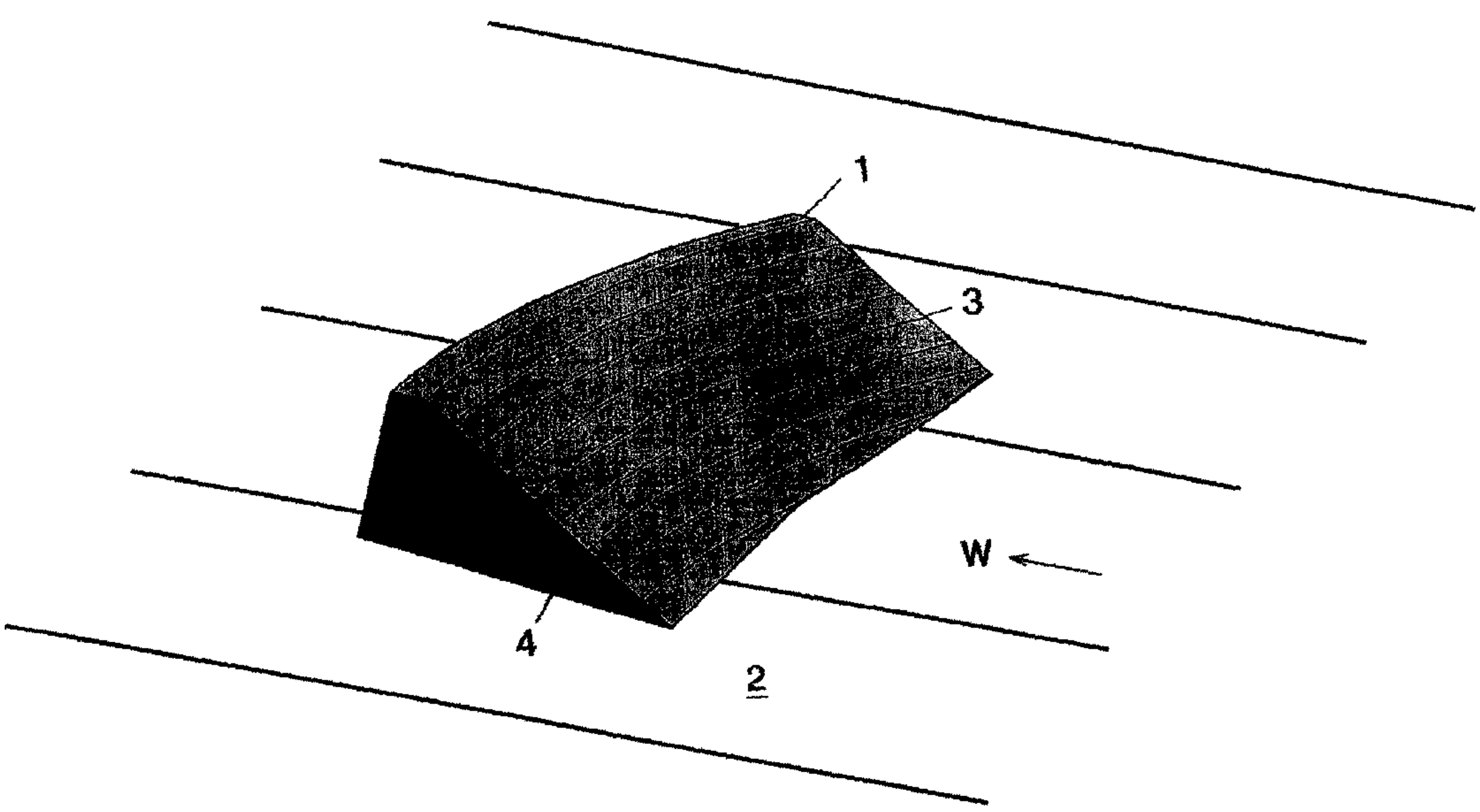
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) **Title:** METHOD OF SHORE PROTECTION



(57) **Abstract:** A method of shore protection is provided which includes determining a required direction of travel of incoming waves to a shore or shore portion to protect the shore and locating at least one elongate reef (1) on the sea bed (2). The reef (1) is oriented at a pre-selected angle relative to an average or mode direction of travel of incoming waves (W) and having pre-selected dimensions selected to modify the direction of travel of incoming waves to the required direction after passing over the reef (1).

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METHOD OF SHORE PROTECTION

Technical Field

This invention relates to a method of shore protection and in particular, but not exclusively to a method of shore protection using a reef.

Background Art

The continual impact of water against shores often causes gradual erosion of the shores over time. This erosion, caused by currents along or away from the shore gradually reduce the usable land area in the vicinity of the shoreline as the rate of material extracted from the shore by currents exceeds the material deposited. The rate of erosion may vary widely depending on the particular characteristics of the water-to-shore interaction. In the worst cases, valuable properties are endangered due to the land between these properties and the sea being eroded away. As average temperatures continue to increase, sea levels are expected to rise, further compounding the effects of erosion.

Traditional methods of protecting a shoreline from erosion, which have achieved varying success, involve reflecting or absorbing the wave energy, either by providing a solid structure at the water to shore boundary or by inducing breaking offshore to reduce the energy of the waves as they contact the shoreline.

Many such coastal protection devices involve the formation of concrete or other resilient material blocks shaped in a particular form so as to dissipate the wave energy. These blocks are typically unattractive and may create reflection patterns in the water in the area surrounding the device, which can make the waves in the area undesirable for particular activities and even hazardous as the waves break on the structures. Furthermore, the current causing the eroding action of the water is still present, which may result in erosion at the base of the device and of the device itself, requiring periodic replacement or replenishment.

It is an object of the present invention to provide a method of shore protection which overcomes or alleviates problems in devices and methods of coastal protection at

PCT/NZ01/00178
Received 05 August 2002

present by providing a method to reduce or eliminate erosion by addressing and correcting the causes of the erosion and which is less obtrusive to the eye and requires less maintenance, or at least to provide the public with a useful choice.

Further objects of the present invention may become apparent from the following description.

Disclosure of the Invention

According to one aspect of the present invention, there is provided a method of shore protection including determining a required direction of travel of incoming waves to a shore to protect the shore or shore portion and locating at least one elongate reef on the floor of a body of water adjacent to the shore, wherein the reef is oriented at a pre-selected angle relative to an average or mode direction of travel of incoming waves and having pre-selected dimensions selected to refract waves travelling thereover to modify the direction of travel of incoming waves to said required direction after passing over the reef.

Preferably, the reef may be angled relative to the average or mode direction of travel of the incoming waves at an angle between 5° to 80°.

Preferably, the method may further include selecting between a reef having a convex, concave or linear profile along its length depending on the requirements for wave modification.

Preferably, the reef may have a front face generally oriented towards the incoming waves and a lee face generally oriented towards the shore, wherein the lee face is substantially shorter than the front face.

Preferably, the lee face may be substantially vertical and the front face may extend downwardly forward from the lee face generally in the direction of the incoming waves.

Preferably, the front face may be selected from a convex, concave or linear surface depending on a required shape of waves travelling over the reef.

Preferably, the method may include selecting the orientation and/or dimensions of the reef using refraction and diffraction analysis.

Preferably, the orientation of the reef may be determined using statistical analysis.

Preferably, the reef may have a height above the floor of the body of water of at least one metre.

Preferably, the method may include locating a plurality of reefs adjacent to the shore and spaced apart along the shore until a required portion of the shore has at least one elongate member substantially adjacent to it.

Preferably, the method may include locating a plurality of reefs adjacent to a shore portion, wherein the incoming waves pass over at least two of said reefs before reaching the shore, wherein the required wave direction modification is achieved cumulatively as the waves pass over the said at least two reefs.

Preferably, the method may include locating the reef in water having a depth substantially between 2 to 15 meters.

Preferably, the reef may have a height above the floor of the body of water of at least one meter.

According to another aspect of the present invention, there is provided a reef when provided for the method described in the preceding paragraphs above.

Preferably, the elongate member may be constructed from geotextile bags, which may be pumped full of particulate material, preferably sand.

Further aspects of the present invention, which should be considered in all its novel aspects, may become apparent from the following description, given by way of example only and with reference to the accompanying drawings.

Brief Description of Drawings

Figure 1: shows an orthographic view of a portion of a reef located on a sea bed according to one embodiment of the present invention.

Figures 2a-c: show a schematic representation of a plan view of a convex, concave and linear profile reef respectively.

Figure 3: shows a schematic representation of the range of angles which a reef may preferably be placed relative to the direction of travel of incoming waves.

Figure 4a-c: show three possible cross-sections of reefs suitable for the present invention.

Modes for Carrying Out the Invention

The present invention relates to a method of protecting a shore from erosion. The method involves placing a reef on the water floor, the reef located, oriented and dimensioned to modify the direction of travel of waves destined for the shoreline. By modifying the wave direction, the water to shore interaction may be modified to reduce erosion.

Referring to the accompanying drawings, Figure 1 shows an orthographic view of a portion of a reef 1 located on a floor of a body of water. The floor may be a sea bed 2. The reef 1 includes an elongate member oriented so that its longitudinal axis is not parallel to or orthogonal to the direction of travel of the waves approaching the elongate member 1. The direction of travel of the waves is referenced in Figure 1 by arrow W. The reef 1 is located adjacent to the shore at a distance therefrom depending on the particular requirements for the shore. In practice, reefs may be typically placed anywhere from 20 to 1000 metres from the shore.

As a wave approaches the reef 1, the right hand side of the wave will contact the front end 3 of the elongate member 1 first. As the presence of the reef 1 acts to shallow the depth of water, the speed of the wave travelling over the end 3 begins to slow. The portion of the wave-front opposite end 4 continues travelling at the same speed until it reaches elongate member 1. The relative change in speed of travel of the portions wave-front causes the wave-front to be refracted towards the right as it travels towards the shore.

This change in direction of travel of the waves, properly selected, can result in less erosion of the shoreline. For example, if the waves approach the shoreline at an angle closer to the perpendicular, currents moving along the shoreline may be reduced.

Three important factors that influence the design of the structure are the offshore wave climate, water depth and coastal orientation. Because the wave refraction effect will vary with water depth and reef elevation above the seabed, it will be necessary to align the reef in each environment to achieve the desired outcome of aligning the waves more closely with the coastal orientation. Wave angle relative to the shoreline at the point where the wave breaks is a factor that determines the strength of the currents inside the surf zone. It may be necessary to use computer modelling to align the reef so that wave angles at the breakpoint are modified to achieve the desired aim of reducing or negating the longshore currents which cause erosion. It will be necessary to ensure that the problem of variability in the wave climate and variations in open coast wave heights and angles are accounted for by aligning the reef so that the average of all the longshore currents resulting from each natural condition is reduced or negated. The reef would normally be placed beyond the natural breakpoint so that the angles can be modified prior to reaching this zone. However, some reefs may be placed inside the breakpoint when the waves have widely varying heights.

The present invention can accommodate for varying shoreline angles relative to incoming wave direction by providing a plurality of reefs 1 located adjacent to each other and designing each reef to modify the direction of travel of the waves depending on the orientation of the shoreline relative to the direction of travel of the incoming waves. The plural reefs may be interconnected, but act as different reefs as the orientation and size varies along the shore.

When selecting the orientation of the reef 1, consideration should be given to any "end effects" which may result. For example, if the wave angle is modified so as to substantially eliminate erosion along a first portion of the shore, another portion of the shoreline may degrade due to no longer having a feed of material from the first portion. In this case, a balance may be struck, by reducing the erosion along one portion while still providing sufficient material for the second portion.

The reef 1 may be typically located in water depths of 2 meters to 15 meters and project upwards by at least 1 meter from the sea bed 2. The extent of projection upwards is selected according to the requirements for the shore and may project up to the surface of the water. The reef 1 should not normally extend above the water line, as this will create a block to the waves rather than modifying the direction of travel and optionally the shape of the waves as they pass over the reef.

The reef 1 may be constructed from any material that is stable on the sea bed 2. In a preferred form, the reef 1 may be formed from geotextile bags that are pumped full of sand or other particulate material and laid to form the required shape. Alternatively, the reef 1 may be constructed from rocks, concrete, or any other durable material.

Referring to Figures 2a-c, a schematic representation of 3 embodiments 1a, 1b and 1c of a reef are shown. Each reef 1 is oriented at a predetermined angle relative to the direction of travel of the wave W and act to change the direction of travel of the wave to a new direction W'. Figure 2a shows a convex reef 1a relative to direction W, Figure 2b shows a concave reef 1b and Figure 2c shows a linear reef 1c. The shape of the reef 1 may be selected according to whether the waves need to be diffracted, converged, or maintained at their current energy. It will be appreciated by those skilled in the art, that the profile of the elongate member 1 may be varied widely depending on the particular requirements of the shore to which the reef 1 is to protect.

Figure 3 shows a preferred range of orientations which the reef 1 may be oriented relative to the direction of travel of the wave W. The actual angle selected depends on the required direction of the wave after it passes over the reef 1, but as shown in Figure 3 will typically be selected from angles between 5° to 80° relative to direction of travel of the wave W. Generally, the more the elongate member is angled towards the orthogonal to the direction of travel along the wave front, the less the direction of travel of the wave will be changed. Variations in the height of the reef 1 along its length may also be used to influence the direction of travel of the waves. In an extreme case, the reef may be oriented substantially orthogonal to the direction of travel of the waves so as to rely solely on the height variation (or depth change) to refract the waves. However, less options for wave shape modification are available if such a reef were used.

Multiple reefs 1 may be placed in series to fine-tune the wave direction or wave shape or to provide a cumulative effect if larger changes are required. Also, multiple reefs 1 may be provided in parallel along the shore until the required portion of the shore has a reef substantially adjacent to it. This may be useful for protecting extended portions of shore.

Figures 4A-C show three examples of possible cross-sections of the reef 1. The cross-section of reef 1 may be varied depending on the required wave shape. For example, the reef 1 may have a cross-section, which is selected to encourage the formation of waves suitable for surfing. The height of the reef 1 may also be varied along its length to influence the direction of travel of the wave and modify the properties of the wave as required. The reef shown in Figure 4A will cause the wave breaking to be most intense on the steepest segment at the deeper part of the reef, and this will act primarily on larger waves. The reef shown in Figure 4B will cause the wave to shoal slowly, but break abruptly on the steeply rising segment, thereby creating an intense breaking wave during smaller wave conditions. The reef shown in Figure 4C will result in the breaking intensity to not vary due to seabed slope factors, but the wave height and period will separately determine wave breaking intensity.

To protect a shoreline from erosion, an appropriate reef 1 needs to be selected and its orientation also selected. This may be achieved by performing computer modelling of the shore line and wave patterns to find the required orientation, profile and cross-section of the reef 1. As wave direction is variable, a statistical analysis may be performed to establish the optimum orientation. In a simple form, the method of determining the orientation of the reef 1 may be dependent on the average or mode direction of travel of incoming waves.

By way of example, a shoreline may be experiencing erosion adjacent to a natural headland. The currents generated by the waves may sweep down the headland and along the beach, carrying sand away and causing erosion. A solution would be a reef that rotates the waves at the downstream end of the beach. This rotation would negate the currents and cause a block to the sediment movement. The sediment would then be expected to collect in the zone of low flows and to create a beach salient (like a bulge in the width of the beach). Further build up of sand would then collect on the upstream side of the salient. The input variables may include the wave climate describing the long-term distributions of wave angles in deep water offshore and the corresponding wave height. Usually computer models would be used to account for refraction and height transformation over the natural seabed contours to the offshore tip of the reef. The same models would then be used to assess the rotation and height modification over the reef, and the reef would be adjusted (e.g. reef angle, height above the seabed, volume, width, length, offshore positioning and depth of reef crest) to achieve the desired outcome of negating the currents in the surf zone along the shoreline.

Thus, there is provided a method of shore protection which modifies the direction of travel of waves and/or wave properties using a reef and which may be located below the water line.

Although this invention has been described by way of example and with reference to possible embodiments thereof, it is to be understood that modifications or improvements may be made thereto without departing from the scope of the appended claims.

Claims

1. A method of shore protection from erosion by altering wave orientations and thereby reducing longshore currents resulting from incoming waves including determining a required direction of travel of incoming waves in a body of water to a shore or shore portion to protect the shore and locating at least one elongate reef on a floor of the body of water adjacent to the shore, wherein the reef has a height above the floor of the body of water so that the reef is usually submerged below the surface of the body of water and wherein the reef is oriented at a pre-selected angle between 5° and 80° relative to an average or mode direction of travel of incoming waves, and has pre-selected dimensions, said angle and said dimensions being selected to refract waves travelling thereover to modify the direction of travel of incoming waves to said required direction after passing over the reef.

2. The method of claim 1 further including selecting between a reef having a convex, concave or linear profile along its length depending on the requirements for wave modification.

3. The method of of claim1 or 2, wherein the reef provided has a front face generally oriented towards the incoming waves and a lee face generally oriented towards the shore, wherein the lee face is substantially shorter than the front face.

4. The method of claim 3, wherein the lee face is substantially vertical and the front face extends downwardly forward from the lee face generally in the direction of the incoming waves.

5. The method of claim 4, wherein the front face is selected from a convex, concave or linear surface depending on a required shape of waves travelling over the reef.

6. The method of any one of claims 1, 2, 3, 4 or 5 , further including selecting the orientation and dimensions of the reef using refraction and diffraction analysis.

7. The method of any one of claims 1, 2, 3, 4, 5 or 6, wherein the orientation of the reef is determined using statistical analysis.

8. The method of any one of claims 1, 2, 3, 4, 5, 6 or 7, including providing a reef having a height above the floor of the body of water of at least one metre.

9. The method of any one of claims 1, 2, 3, 4, 5, 6, 7 or 8 including locating a plurality of reefs adjacent to the shore and spaced apart along the shore until a required portion of the shore has at least one elongate member substantially adjacent to it.

10. The method of any one of claims 1, 2, 3, 4, 5, 6, 7, 8 or 9, further including locating a plurality of reefs adjacent to a shore portion, wherein the incoming waves pass over at least two of said reefs before reaching the shore and wherein the required wave direction modification is achieved cumulatively as the waves pass over the said at least two reefs.

11. The method of any one of claims 1, 2, 3, 4, 5, 6, 7, 8, 9 or 10 including locating the reef in water having a depth substantially between 2 to 15 metres.

12. The method of any one of claims 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 or 11 wherein the required wave direction is more closely perpendicular to the line of the shore than said average or mode direction of travel of the incoming waves.

13. The method of any one of claims 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 or 12 wherein the reef has an interior filled with a particulate material.

14. The method of claim 13 including wherein the reef includes a geotextile material containing the particulate material.

15. The use of a reef for performing the method of any one of claims 1 to 14.

16. The reef of claim 15, wherein the reef is constructed from geotextile bags.

17. The reef of claim 15 or 16, when dependent on claim 14, wherein the particulate material is sand.

18. An elongate reef for shore protection located on a floor of a body of water adjacent a shore or shore portion so as to be at least usually submerged, the reef is oriented at a pre-selected angle between 5° and 80° relative to an average or mode direction of travel of incoming waves not substantially parallel or substantially perpendicular with the shore or shore portion, the reef having preselected dimensions, wherein the angle and dimensions of the reef are selected to modify by refraction the direction of travel of incoming waves passing over the reef and destined for the shoreline to approach the shore in a required direction relative to the shore which is predetermined to reduce shore erosion by reducing longshore currents.

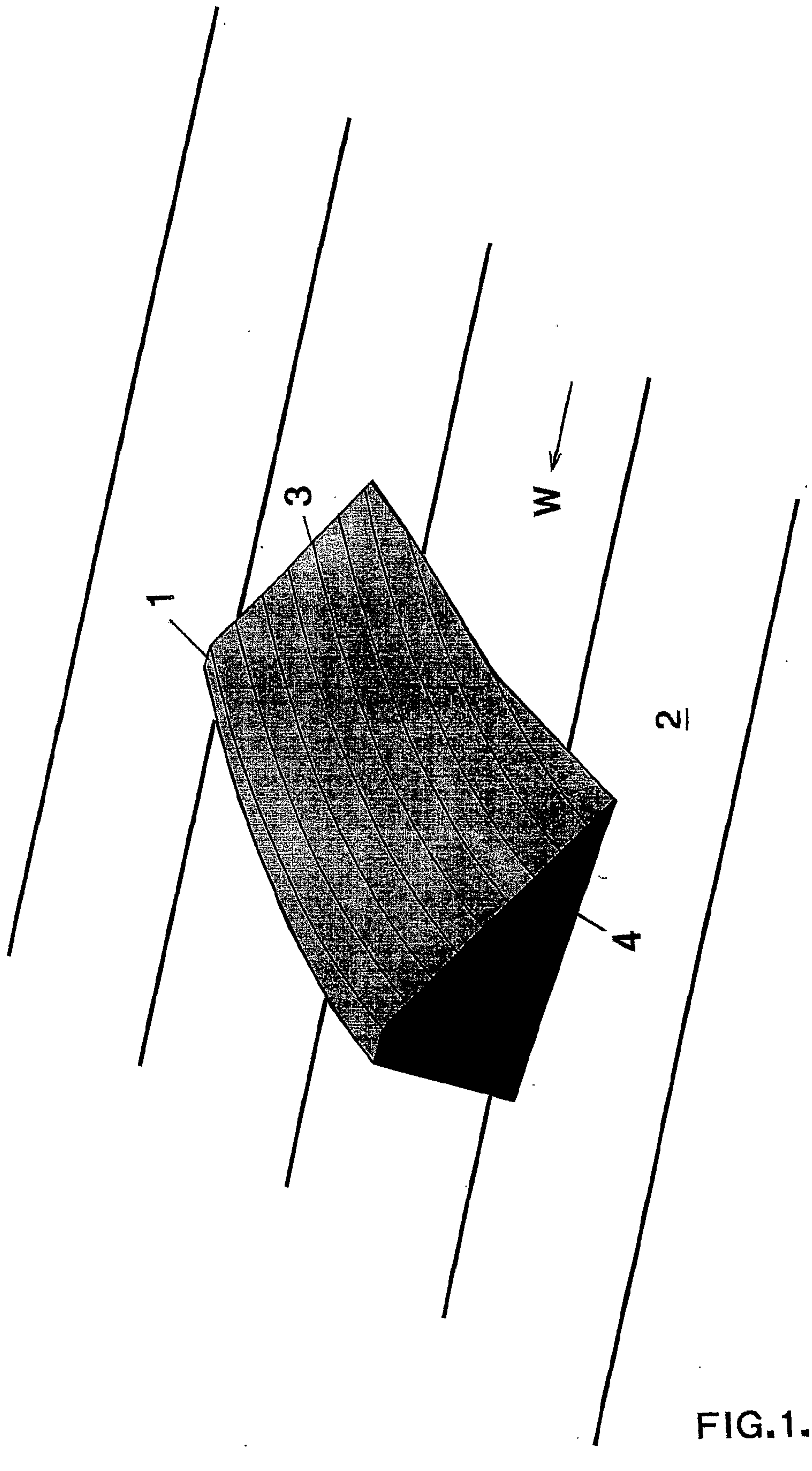

FIG.1.

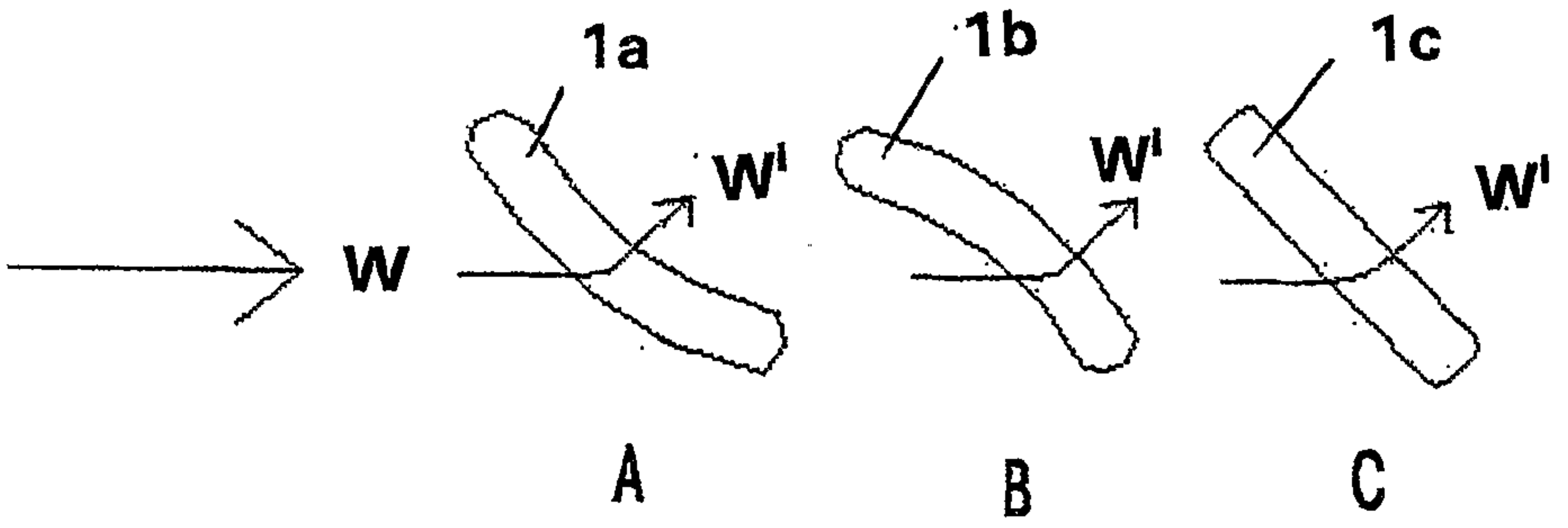

FIG.2.

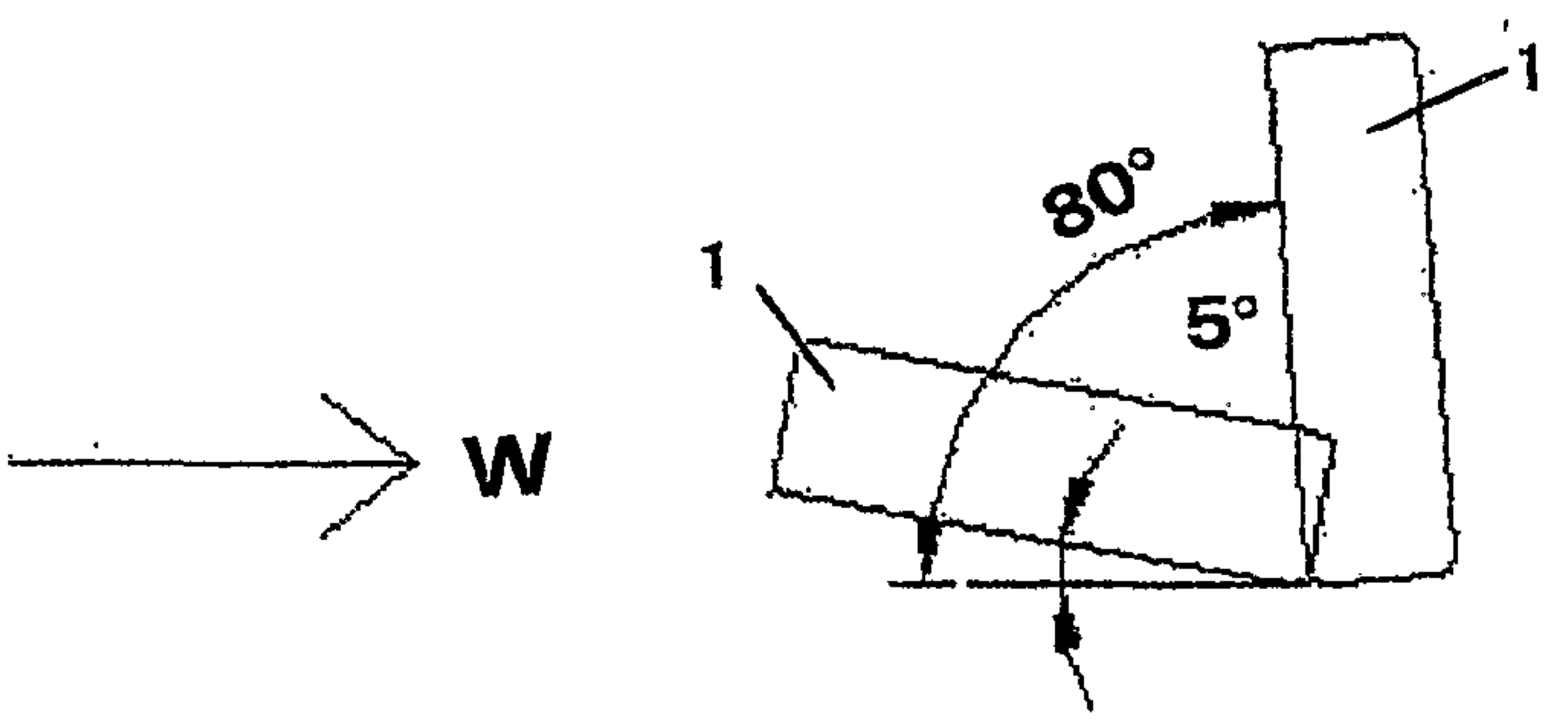

FIG.3.

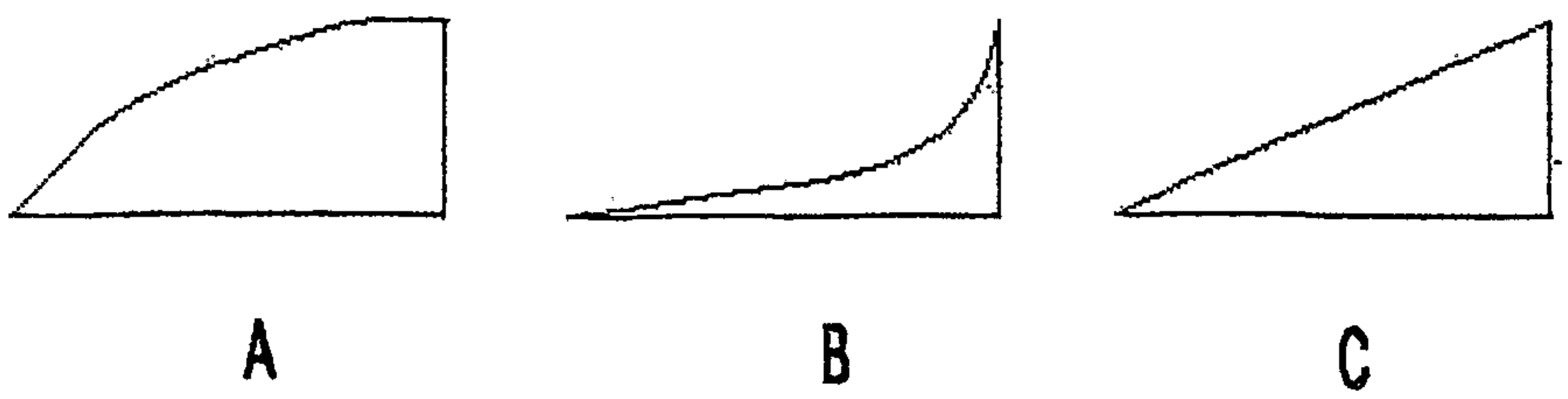

FIG.4.


1
3
W
4
2