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(54) MODULAR DIKE FOR SHORE PROTECTION

(57) Abstract: The invention relates to a modular dike which is intended for shore protection. The inventive dike is based on a reduced number of different prismatic, tubular modules (1), (2), (3), (4), including one quadrangular-section module, two triangular-section modules and a straight trapezoidal-section module. The aforementioned modules are equipped with tongue-and-groove coupling means (5-6) for the stacking thereof and lateral fixing means (10-11), such that it is possible to produce a dike of any width, height and section. Moreover, the modules have a thickness of the order of 2.5 metres, a similar height and a length of between 6 and 12 metres. In this way, the dimensions of the modules are suitable for the standard containers that are used to transport goods by road and, more specifically, the constituent modules of the dike can be transported by road on the standard transport network used for said containers. Furthermore, the modules are provided with large lightening holes (8) and, following installation, said modules can be stabilised using, among other means, sand-filled geotextile bags (14) which are disposed therein.

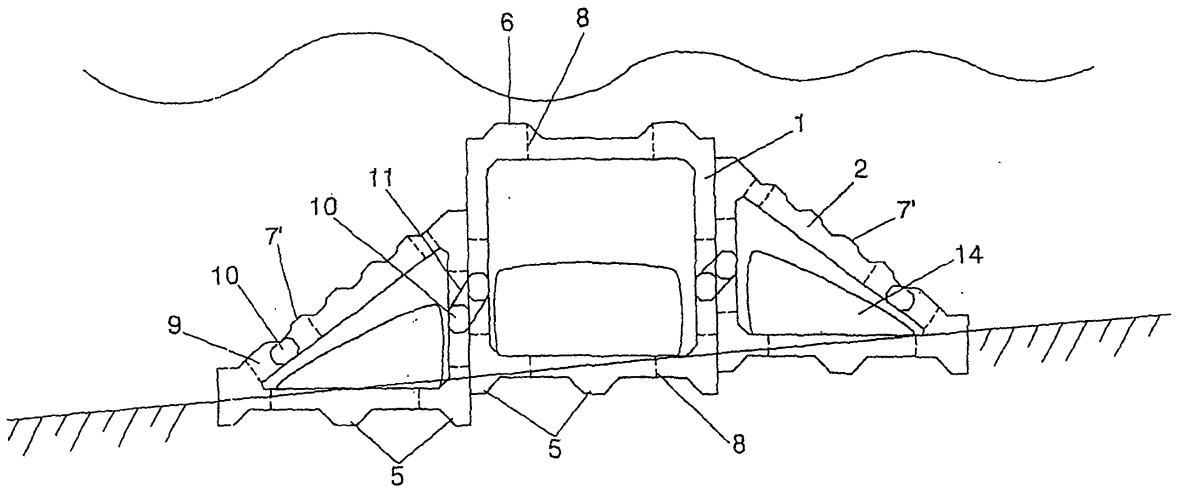

FIG.11

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Description

OBJECT OF THE INVENTION

[0001] The invention relates to the field of shoreline maritime works, dikes and groynes for shore protection, designed to reduce shoreline wave energy so as to improve beach stability or to reduce overflow and improve conditions of coastal flooding due to storms. The precise object of the invention is the definition of modular units which afford construction, within a very short period of time, of shoreline maritime works, dikes or groynes of varying shapes and sizes, easy to dismantle, and with a reduced impact on the environment. The invention is especially recommended for shore protection works in situations of emergency following major storms, where the coast requires protection against waves and the construction of a conventional structure, effective and reliable from an environmental standpoint, is not an option, due to lack of habitual time and information.

BACKGROUND OF THE INVENTION

[0002] Storms cause erosion, flooding and damage of different descriptions to large swathes of coastal areas. In particular, enduring erosive processes and beach erosion due to storms frequently provoke significant social, economic and environmental damage. The effects of beach erosion, overflows, coastal flooding and other damage due to storms tend to worsen over time, since the looming climate change and intense urban development of coastal areas heighten foreseeable risks and damage in large swathes of coastal areas.

[0003] Beaches and low-lying coastal areas are especially vulnerable in terms of rises in average sea level and storm intensification. Parallely, in many regions, these spaces form the basis of the prime economic industry: sun and beach tourism. Indeed, the critical factor of production of the tourist industry is the beach, and erosion, albeit temporary, could potentially devastate local economies. Hence, the longstanding existence of different types of conventional maritime works for shore protection based on loose materials: common groynes and breakwaters, for example, which differ in shape and section and cover large swathes of coastal areas. Other less common dike typologies, also used in shore protection, are essentially based on concrete, purposefully shaped and generally designed to reduce costs in the construction phase or to enhance stabilisation of the nearby beach.

[0004] Thus, the practice of building rockfill groynes and dikes has been, and indeed is, commonplace for the purpose of decreasing wave energy and disrupting coastal currents as well as the dynamics of erosion and sediment deposition, so as to control stability and curb beach erosion. Nevertheless, each year, it is becoming increasingly difficult to use rockfill and loose materials in shoreline maritime works, owing to issues which relate, firstly, to the environmental impact of such structures during the construction phase and secondly, to their dismantling, in the long-run, as loose residual materials are left scattered about the submerged beach. From a social, economic and environmental viewpoint, the coastline has many vulnerable spaces, where each year it is proving evermore costly to assume environmental impacts from construction and operation of quarries, transport of loose materials, dumping of material into the sea, and so forth. Furthermore, recent Spanish recommendations on maritime works (ROM 0.0) newly require dismantling conditions of maritime works, generally ignored until now, to be envisaged in the corresponding maritime works project. The use of traditional rockfill and loose material-based typologies is being gradually hampered by these two sets of circumstances, and other typologies, easier to dismantle and with a lower environmental impact during construction, must progressively replace them. Given that a prefabrication process allows the bulk of the environmental impact on the area of the works site to be eradicated, it is recommendable to review the typologies of available prefabricated dikes.

[0005] Since the 80s, a series of submerged prefabricated dikes have been advanced for shore protection, among them, the "Shoreline breakwater" (patent US4502816, 1985) is worthy of mention. This submerged prefabricated dike is built by placing prismatic triangular prefabricated units, having a gently sloping seaward face, in a side-by-side relation; this dike, in the form of a reef or breakwater, is placed in the breaker zone to assist in the dissipation of wave energy and to encourage sediment deposition in the subsequent area. The "Prefabricated erosion prevention wall" (patent US4818141) proposes a dike made up of prefabricated units, virtually triangular in shape, but the concave side faces seaward, causing waves to break and sediment to deposit in the subsequent area; this breakwater is permanently positioned in the breaker zone to diminish and aid deflection of wave energy, serve as a foundation for the beach and improve stability conditions. The "Wave dissipation submerged dike" (patent JP2112512, 1990) is similar in type and behaviour. The "Submerged breakwater and barrier reef" (patent US5120156) proposes the construction of submerged reef dikes by combining concrete units, with the concave side facing the towards the seabed and convex side towards the sea and the shore, the crest having some gaps to dissipate and deflect energy for shore protection. The proposal includes tongue-and-groove systems to join the units in series, forming a compact longitudinal dike; there are certain variations on this patent. Lastly, the "Submerged breakwater and barrier reef" (patent US5238326, 1993) advances a triangular prismatic design, similar to the "Shoreline breakwater" but with a special wave guard-like crest, submerged and designed to reduce water energy and maintain sediment in the subsequent area.

[0006] The typologies described above attempt to realise works, in concrete, similar in function to convention-

al rockfill dikes. Constituted by reinforced concrete elements, these solutions ultimately aim to build a permanent dike, the characteristics and function having been perfectly designed in the project and the section of the concrete element matching that of the dike to be constructed. The effectiveness of these dikes depends to a large extent on the depth of the crest or freeboard, as a simple settling of the structure can drastically affect functioning and effectiveness; adaptation to unforeseen situation changes is very costly and reutilisation in different conditions is by no means easy.

DESCRIPTION OF THE INVENTION

[0007] The purpose of the invention is to define certain small modular elements - of lesser section than that of the dike to be constructed - which permit construction, reconstruction, relocation and/or speedy dismantling of maritime works and dikes for shore protection, of varying sections and sizes. For attainment of this new shoreline management tool, several types of basic modules are advanced which can be prefabricated and stored at a distance for use when appropriate. These modules, similar in size and weight or compatible with the dimensions of the containers (approximate dimensions: 8x8x20 or 40 feet), are designed for easy handling, storage and transport by the intermodal transport chain for said containers (lorries, container-carriers, railway, container cranes, transtainers, etc.). Furthermore, the design and geometry of the modules allows dikes to be constructed in different shapes and sizes, adapting to the specific characteristics of the site (depth, maritime climate, etc.). The invention also permits relatively easy change in the shape and site of modal dikes already constructed with these modules, as well as speedy and effective dismantling, the elements of the same being recoverable and available for reutilisation, without leaving undesirable remains in the sea. To such end, the module elements are fitted with hooking systems for crane manipulation, buoyancy bags and other equipment to be combined with other elements with rigid or resistant elastic systems which can be broken or cut for clean, speedy dismantling. Although it is possible to establish protection at the foot of the dikes to prevent foundation erosion, the typical application of the invention is to install the dike without auxiliary elements - not easily eliminated -, using techniques such as vibroflotation which allows liquefaction of the floor and structure settling prior to the arrival of storms; this way, dismantling is transformed into a very simple operation and has a minimal impact on the environment.

[0008] Unlike the typologies of prefabricated dikes described above, designed for conventional uses and free from restrictions in the project and construction phase, the proposed invention is essentially intended as a rapid intervention shoreline tool. It permits installation of maritime works and dikes for shore protection in a very short space of time, with limited impact on the environment. It is also easy to dismantle, reutilise and the site may be changed if circumstances so advice. The invention is particularly recommended for emergency actions following large storms, when beaches or neighbouring shoreline areas imperatively need protection and there is neither time nor the necessary technical and environmental information available to execute a conventional shoreline protection project. In this predicament, the invention permits the speedy construction of dikes using previously prefabricated modules, stored at a distance, and the dismantling, reutilisation or modification of the already constructed dikes with minimal effort and impact to the global environment.

[0009] The fundamental advantage of the invention is the ability to industrialise the construction of a large part of the dike and to optimise the logistical aspects of dike construction on land or sea. By being able to construct a large variety of dikes with a few basic modules, it is possible to optimise and industrialise the module manufacturing process in places suitably prepared for the purpose (premanufacturing plants), avoiding the environmental impact and cost increments involved in on-site and/or tailored to the site construction. The dismantling of a modular dike allows the modules to be reutilised in the construction of other dikes, reutilising and avoiding the production of residues, with the ensuing economic and long-term environmental advantage. Furthermore, as the basic modules have certain standardised weights and dimensions similar to or compatible with those of the containers (section of 8x8 feet and lengths of 20 and 40 feet) and can be transported by the intermodal container transport network, it is possible to efficiently manage large centralised stores of basic modules, to be transported in a short space of time, with a large degree of flexibility and at little cost, to the place on the shoreline requiring the construction of a groyne or protection dike. In this way, reductions are achieved in environmental impacts, prefabrication costs, installation and dike operability times. In addition, the elements resulting from the dismantling may be reutilised, minimising the impact on the global environment.

[0010] The invention permits change in the manner in which shoreline protection is currently managed. The ability to construct different types and sizes of dike for shoreline protection using few basic elements makes large-scale industrialised production of basic modules possible, to be stored in determined deposits prior to distribution. Industrial production, transport and storage would be very efficient processes from an economic and environmental stance, since it would be a matter of executing scheduled, repetitive tasks, continuous over time, and unconstrained by space. Once the need for rapid intervention has been established (for example, following a large storm), a construction project would be swiftly drawn up, adapted to the site (floor type, depth and maritime climate), the necessary modules would then be transported from the distribution deposits. The on-site construction would be simple, and at a later stage, the structure could be easily modified or dismantled, and

the basic elements reutilised. The logistical, economic and environmental advantages of the invention are evident.

[0011] In addition to the clear logical, economic and environmental advantages (if mass produced), the invention affords flexible shoreline management, reduced global environmental risks and shorter intervention times for shoreline protection. Furthermore, modular dikes permit a total separation, in time and space, of the prefabrication and installation processes; accumulated reserve modules may be used in situations of crisis (large storms simultaneously affecting extensive areas of shoreline). And furthermore, shoreline intervention times are clearly reduced, as the only requirements are for modules to be transported from the deposits to the dike site using the efficient intermodal container network and for maritime equipment to be available for the mounting and stabilisation of the dike. Lastly, the dike, made up of reutilisable basic modules of reinforced concrete, in addition to being easy to dismantle, has a residual value which underpins the economic interest in dismantling and reversing the end works; this means the environmental impact would be small, and a guarantee thereof would be offered, which does not accompany non-modular prefabrications.

[0012] The invention permits the construction of emerged or submerged modular dikes, with numerous gaps, to be used in all likelihood by abundant marine species, as occurs in artificial reefs. These modular dikes will generally be installed within the breaker zone (up to 7 metres deep) to support beaches or diminish waves reaching the shores. In their wave-reducing function, these dikes may be used to signal the limit of the bathing area, utilising the danger signals for boats to protect bathers. In this breaker zone, the gaps, with different levels of light as defined by the modular dike, allow different marine species to settle and shelter, and therefore to benefit from the new ecological space. Thus, in addition to contributing to beach and shoreline protection, these dikes may serve to heighten the productivity and stability of marine ecosystems.

[0013] More concretely, the invention advances the construction of dikes based on a series of basic modules, which are essentially prismatic and have varying sections. For illustrative purposes, four prisms of different sections have been defined, namely, a quadrangular prism, a rectangular triangular prism with little difference between catheti, a straight trapezoidal rectangular prism with considerable difference between catheti and a straight trapezoidal prism. All these modules have a width comparable to that of a conventional container (8 feet), and a direct or combined height roughly similar to that of a conventional container, for transport by semitrailer, free from clearance issues. The length of the modules may vary, but would ideally be as long as the most usual conventional container length, to facilitate transport by the usual means for such containers.

[0014] For easy dock crane manipulation, the weight of the basic module must not exceed 30 tons. Using these basic modules, modular dikes can be constructed from 4 up to 24 feet high with inclined vertical batters from 1/1 to 2/1, which covers the bulk of requirements of works for shoreline protection.

[0015] Therefore, the invention consists in constructing modular dikes using few types of basic modules with a container-like width. Unlike conventional loose material dikes and prefabricated single-section dikes, the modular dike concept permits construction of a wide variety of dikes and groynes using few types of basic modules, which may be manufactured and stored long before the dike is designed and may easily be reutilised after dismantling of the structure. The environmental and logistical advantages of the modular dike concept, object of the intervention, are evident. Otherwise, the modular dike, object of this invention, can have a similar function to that of conventional concrete dikes, as a wide variety of sections and shapes of shoreline dikes may be constructed with few basic modules. The modular structure will aid deflection of wave energy, being partly dissipated through friction, also through turbulence and breaking. The modular dike not only reduces wave energy attacking shores but can also change the regime of currents and deposition of sediment, like conventional dikes. Furthermore, the modular dike described here can be emerged or submerged, and may be completed with special elements such as wave guards, specially-shaped concave or convex pieces, providing the modular dike with greater hydraulic or sedimentary efficiency, or fitted with superstructures to make use of the crest in other ways. Modular dikes also may be used in settings which resemble marine environments, for similar functions, such as dikes in lakes and river areas; likewise, modular dikes may be used empty or filled at a later stage with loose non-pollutant elements such as sand from the natural setting itself or filled with other materials then acting as a container for loose materials or permanent formwork if concrete is used.

DESCRIPTION OF THE DRAWINGS

[0016] To complement the description in progress, and for the purpose of bettering understanding of the characteristics of the invention, in accordance with a preferential example of the practical realisation of the same, a set of drawings accompany said description as an integral part, where the following is illustrated, including but not limited to:

Figure 1. Illustrates an axial view of a quadrangular-section module, which will form a part of the dike of the invention.

Figure 2. Illustrates an elevated lateral view of the module.

Figure 3. Illustrates a transversal section of the module in the previous figures, coupled to another mod-

ule of identical characteristics.

Figure 4. Illustrates a detailed sectional perspective of the module in the previous figures.

Figure 5. This illustration is similar to figure 1, but the type of module is different; this is a triangular-section module.

Figure 6. Illustrates the module in figure 5, from a sectional perspective similar to figure 4.

Figure 7. Also similar to figure 1, this illustration shows a third type of module, also with a triangular section but far more unequal catheti.

Figure 8. Illustrates another detailed perspective with a similar section to the previous figure but corresponding to a straight trapezoidal section.

Figures 9 and 10. Illustrate respective mountings of modules to obtain dikes of maximum simplicity.

Figures 11 and 12. These illustrations are similar to figures 9 and 10. In the first case, the modules are filled with material to increase stability, and in the second, buoyancy bags have been incorporated in the same to facilitate manipulation of the modules in water.

Figure 13. Finally, illustrates another example of practical realisation of the modular inventive dike; in addition, the dike is used as permanent formwork in a promenade.

PREFERENTIAL REALISATION OF THE INVENTION

[0017] The figures outlined show that four different modules have been envisaged within the general concept of the invention, a quadrangular prismatic module (1), a triangular prismatic module (2) with little difference between catheti, other triangular prismatic modules (3) with a great difference between catheti, and a trapezoidal prismatic module (4), which is straight, like the aforementioned triangular modules.

[0018] As stated earlier, the dimensions of these modules will be apt for transport in vehicles commonly used to transport containers. In view of the foregoing, the width will preferably be of the order of 2.5 metres, the height closely resemble the width, and length also equivalent to that of conventional containers, that is, between 6 and 12 metres long.

[0019] In any case, these modules are hollow, with an adequate wall thickness to maintain optimal mechanical resistance with a minimum weight such as, for example, a thickness of 20cm, which facilitates transport and handling, incorporating in the lower base, in any case, a plurality of tongues, intended to aid stability of the module and of the structure as a whole in view of potential sliding in relation to the floor and between modules located on superimposed layers, tongues which are logically designed in concordance with the grooves (6) located in the opposite area and with the obvious purpose of determining a tongue-and-groove coupling between modules.

[0020] Evidently the tongues (5) and grooves (6) can adopt multiple configurations and arrangements, as shown by the figures, providing that in the case of those walls of the modules (2-3-4) intended to adopt an inclined plane, specifically the upper bases, the tongues (7-7') are adequately configured to allow for the inverted mounting of one module on another, as shown in figures 5 and 8, to attain, with two of them, a higher prismatic block.

[0021] Modules (1), (2), (3), (4) additionally incorporate in their bases wide orifices (8), which reduce their weight, facilitate handling and penetration in the sea floor. They also incorporate in their walls lateral openings (9) with a cross piece or intermediary fixing bar (10), so that in the lateral coupling of modules, as shown in figures 9 and 10, these fixing bars (10) are laterally adjacent to effect the fixing between modules with the assistance of bonding elements (11), which may be rigid but will preferably have certain elasticity to allow for relative displacement between modules, as shown for example in figure 11.

[0022] As flows from the foregoing and from observation of the figures, the possible combinations of the different modules are virtually unlimited, attaining dikes of any width and opening, which can even act as permanent formwork in the shaping of a promenade (12), as illustrated by figure 13. In this specific case, after mounting, the different modules have been filled with sand (13) to increase their weight and stability. On the other hand, sand-filled geotextile bags (14) are disposed in the modules of dikes to be dismounted at a later stage, as shown in figure 11; these sacks will provide the modules with greater stability while allowing the dike to be easily constituted and dismantled.

[0023] To facilitate manipulation of modules (1), (2), (3), (4) during the installation process of the same, the intention is to use buoyancy bags (15), which, as shown in figure 12, are fixed to said modules by way of the fixing bars of the later, as shown in figure 12.

[0024] As flows from the foregoing, with a reduced number of different modules (1), (2), (3), (4) a very large range of dike shapes and sections can be achieved. In addition, these modules are easy to transport by land, easily intercouplable to attain a dike or groyne in the required shape, and easily dismountable when required.

[0025] Lastly, it only remains to point out that special modules will also be used in the dikes, such as, for example, modules with a trapezoidal, straight and isosceles base, for obtaining dikes with a generally arched layout or with an arched layout in a certain section of the same. There are also modules closed at one end, intended for use at the end or free end of dikes.

Claims

1. Modular dike for shoreline protection, **characterised by** the use in the same of prismatic modules, having a smaller section than that of the dike to be obtained, with the peculiarity that said modules have a maximum width of the order of 2.5 metres to allow for transport by land, a height which, by itself or in combination with that of the other superimposed module, is equivalent to its width, and a length of 6 or 12 metres. The volumetry of such modules is therefore equivalent to that of the standard containers used in the intermodal container transport network, a network which is thus valid for transporting the modules themselves.

2. Modular dike for shoreline protection, according to claim 1, **characterised by** the use in the same of essentially four types of modules, one quadrangular prismatic (1), another triangular prismatic (2), straight, little difference between catheti, a triangular prismatic (3), also straight but with a great difference between catheti, and another (4) straight, trapezoidal prismatic.

3. Modular dike for shoreline protection, according to the previous claims, **characterised by** the incorporation in the different modules (1), (2), (3), (4), in the lower base, of tongues (5) for location on the sea floor and for tongue-and-groove coupling in the stacking of modules. For such purpose, the quadrangular prismatic modules (1) incorporate, in the upper base, complementary tongues (6), while the triangular modules (2-3) and trapezoidal modules (4) incorporate, in the upper, inclined base, tongues (7-7') which permit mutual coupling of this type of module, through the inverse positioning of one on the other.

4. Modular dike for shoreline protection, according to the previous claims, **characterised by** the fact the different modules (1), (2), (3), (4) are tubular, that is, hollow, with openings (8) in their bases for lightening weight and facilitating integration in the seabed, and with openings (9) in their lateral walls, on which the respective fixing bars (10) are set, which are opposite in the lateral coupling of modules and permit the fixing of the same with the assistance of joints (11), preferably elastic, to permit certain relative displacement between modules.

5. Modular dike for shoreline protection, according to the previous claims, **characterised by** the fact buoyancy bags (15) work with the stated modules (1), (2), (3), (4), to facilitate manipulation of the same during installation in the water. These bags (15) are fixed to modules (1), (2), (3), (4) via the fixing bars (10) of the latter.

6. Modular dike for shoreline protection, according to the previous claims, **characterised by** the fact sand-filled geotextile bags (14) are disposed in modules (1), (2), (3), (4) to improve stabilisation.

7. Modular dike for shoreline protection, according to the previous claims, **characterised by** the fact modules (1), (2), (3), (4), intended to occupy end positions in the dike, are closed at one end, while those modules intended for location in areas of angulation or arching effect of the dike layout have a trapezoidal base.

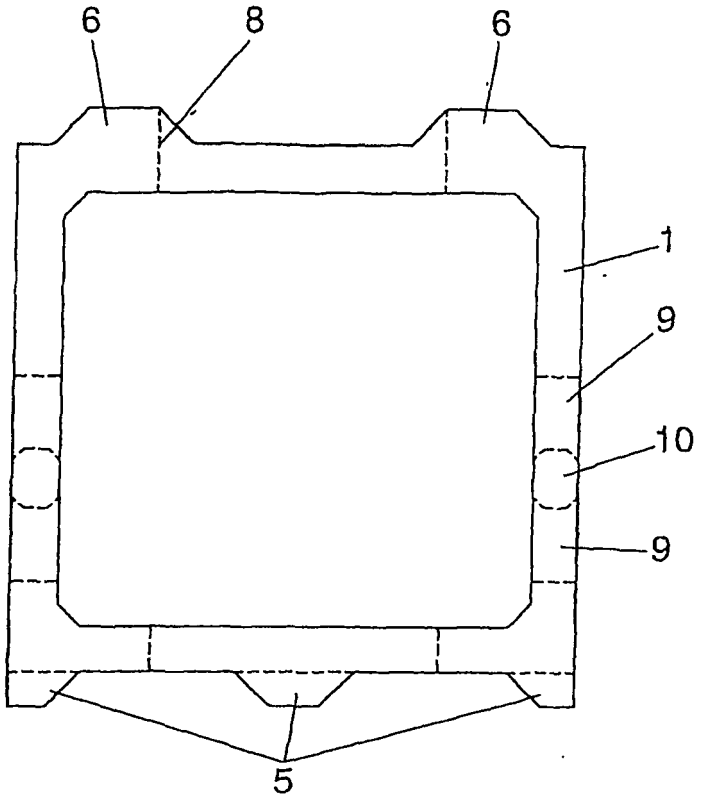

FIG.1

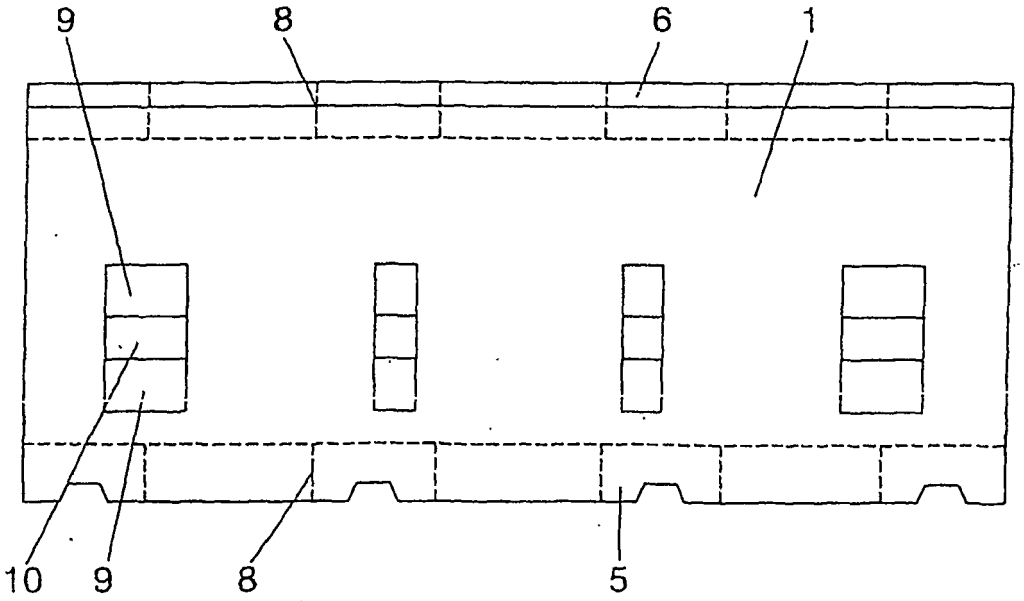

FIG.2

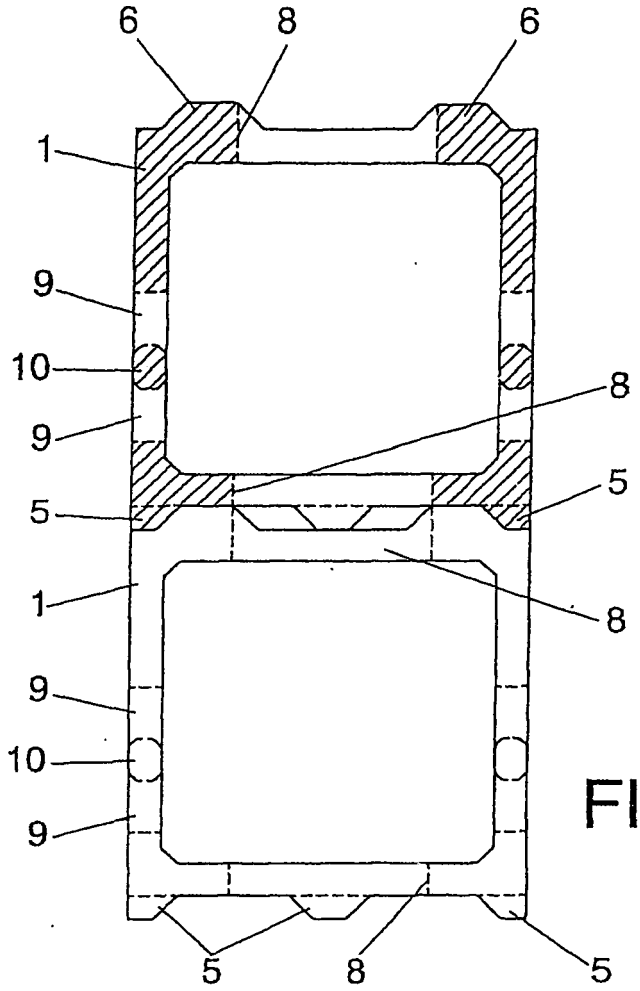

FIG.3

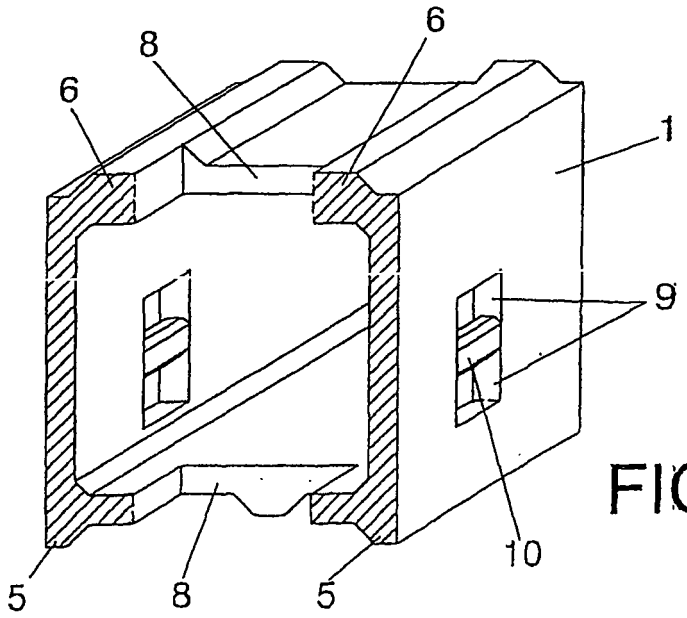

FIG.4

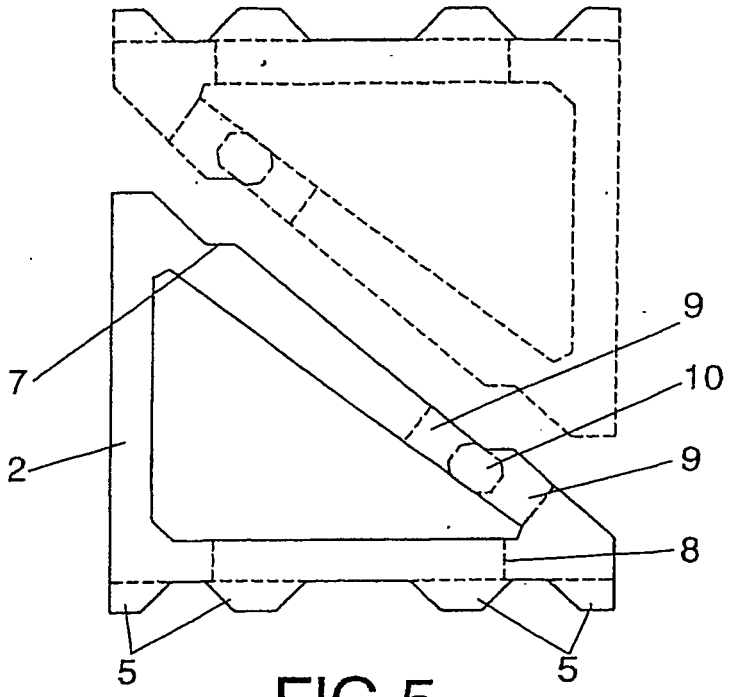

FIG.5

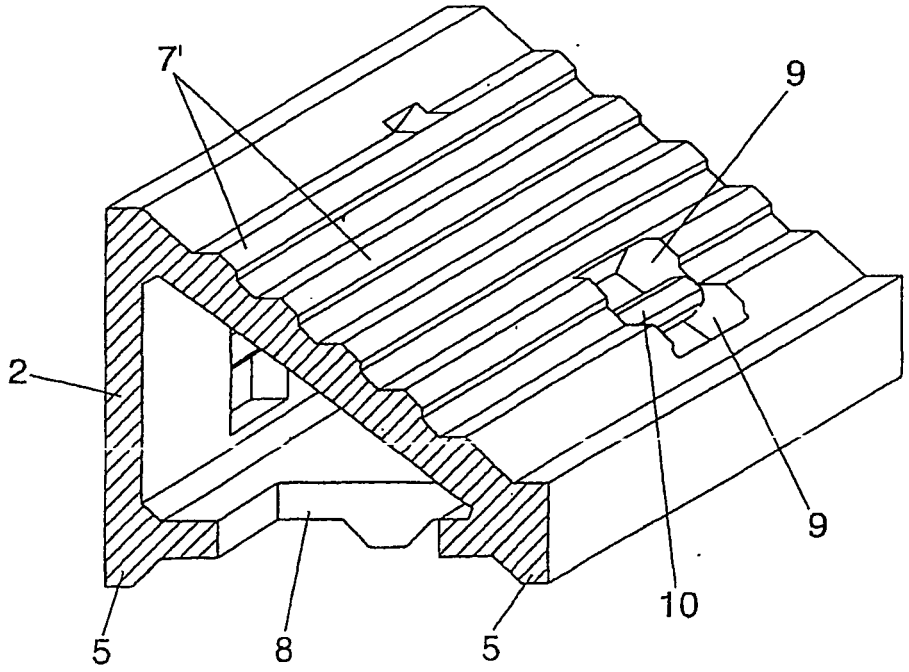

FIG.6

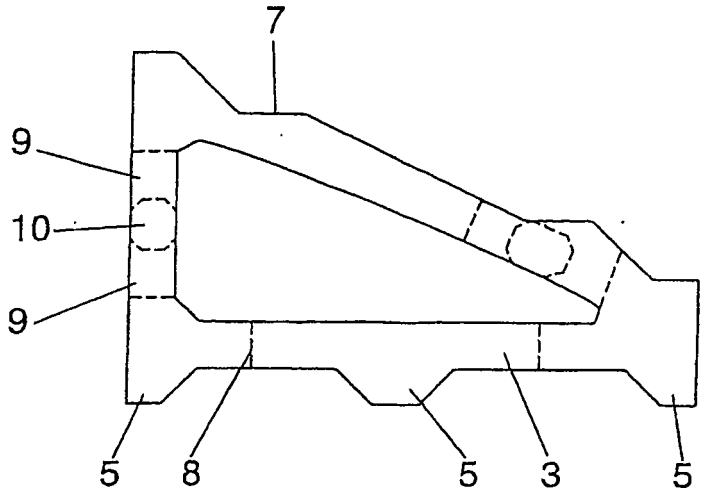

FIG.7

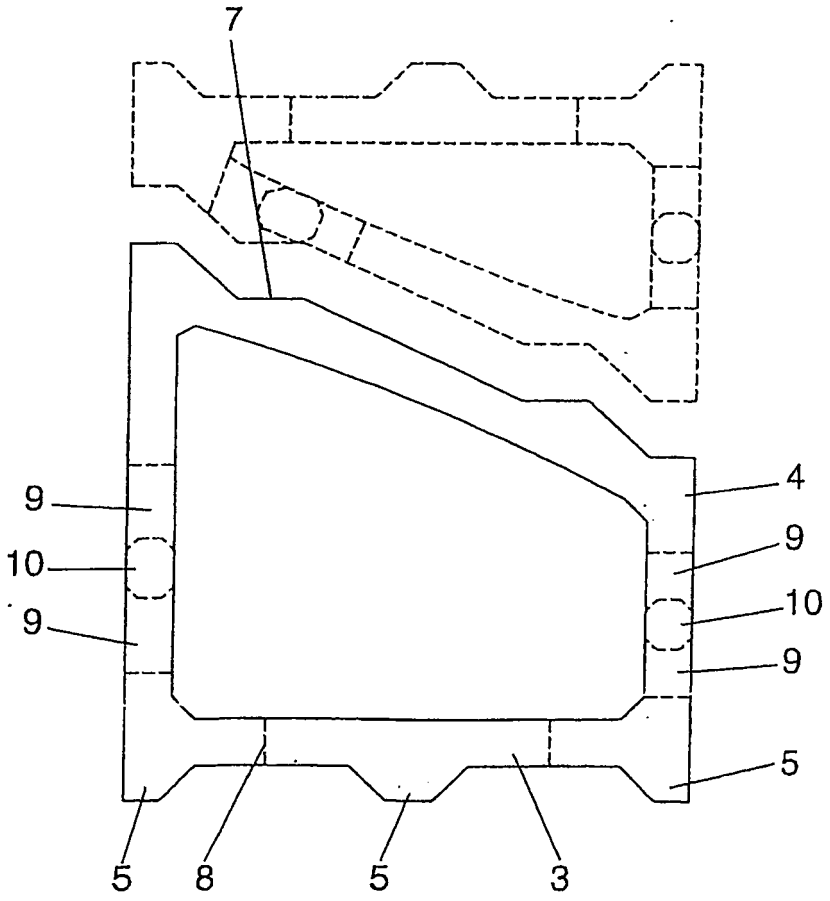

FIG.8

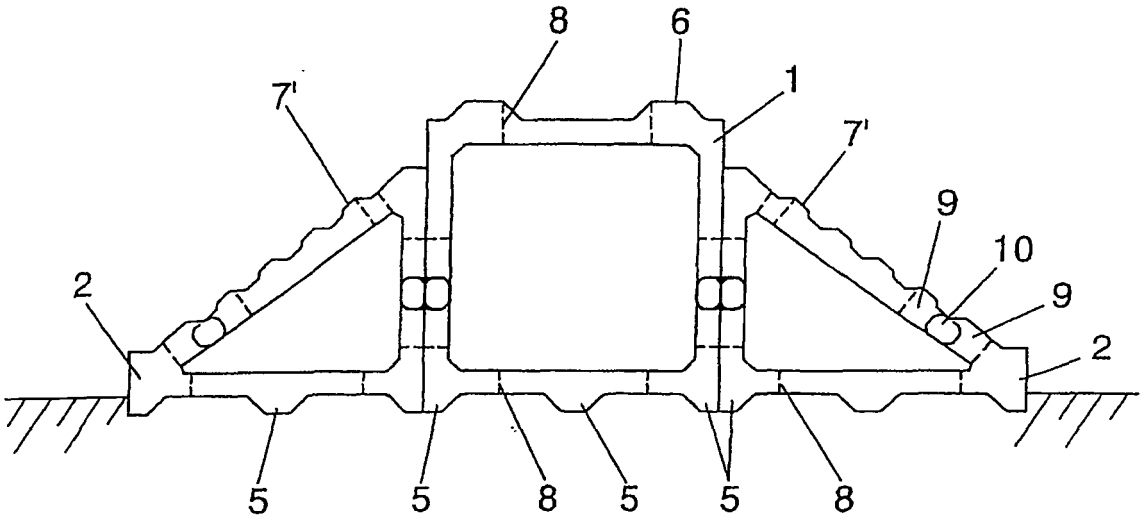

FIG.9

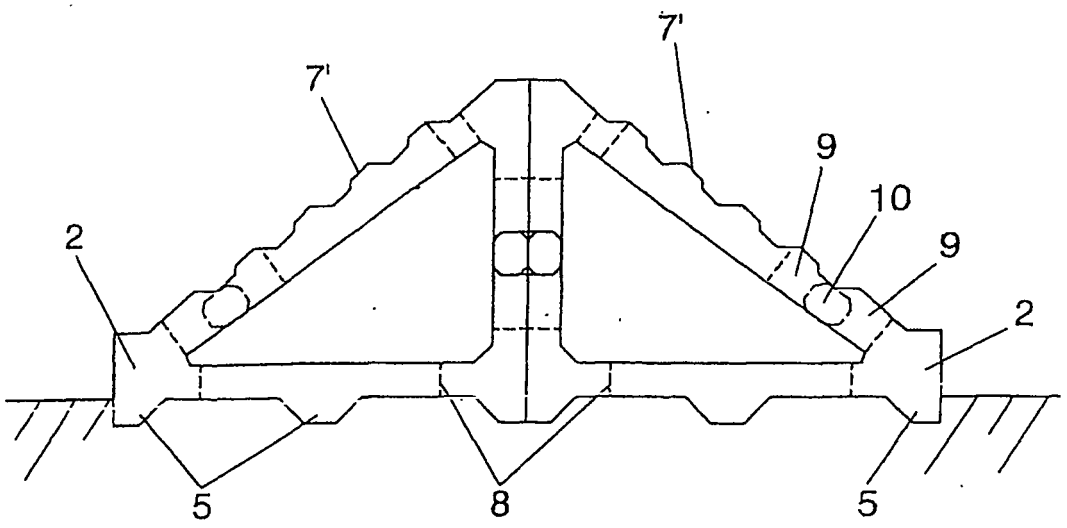

FIG.10

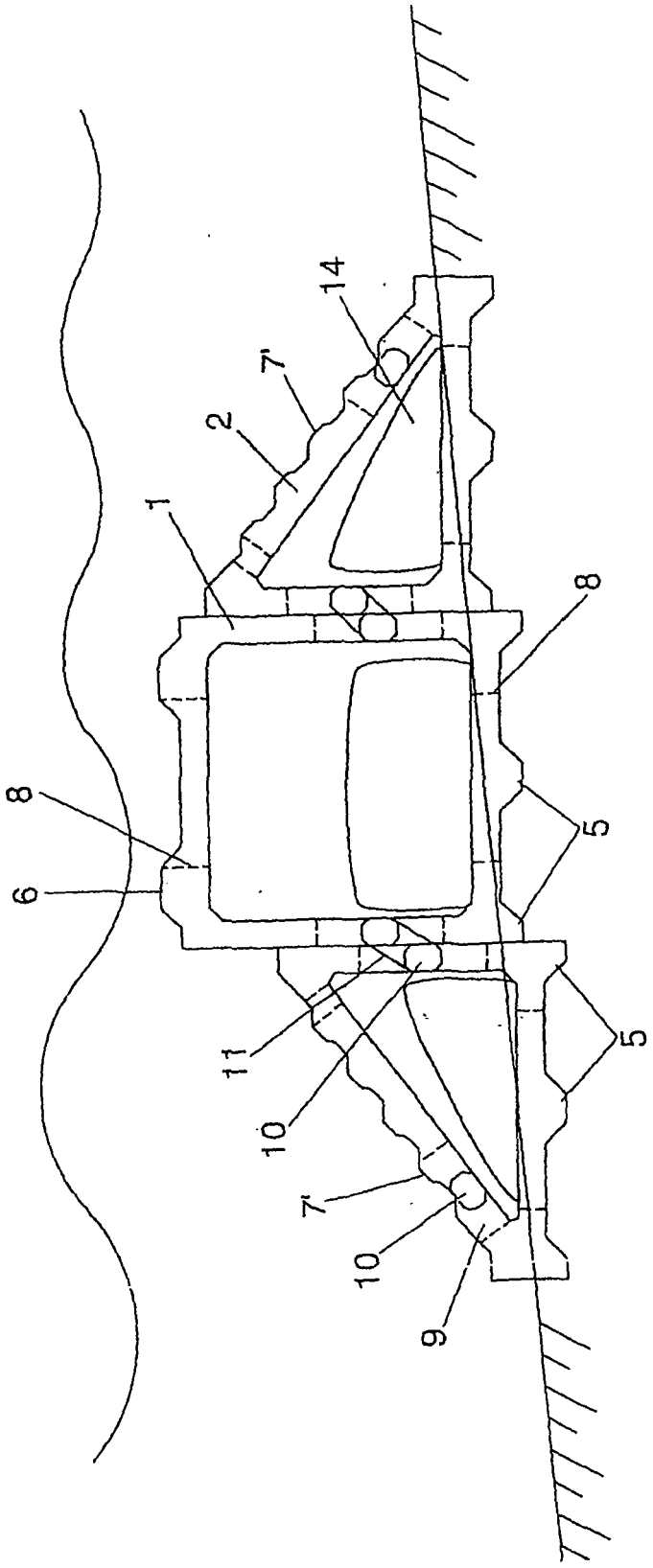

FIG.11

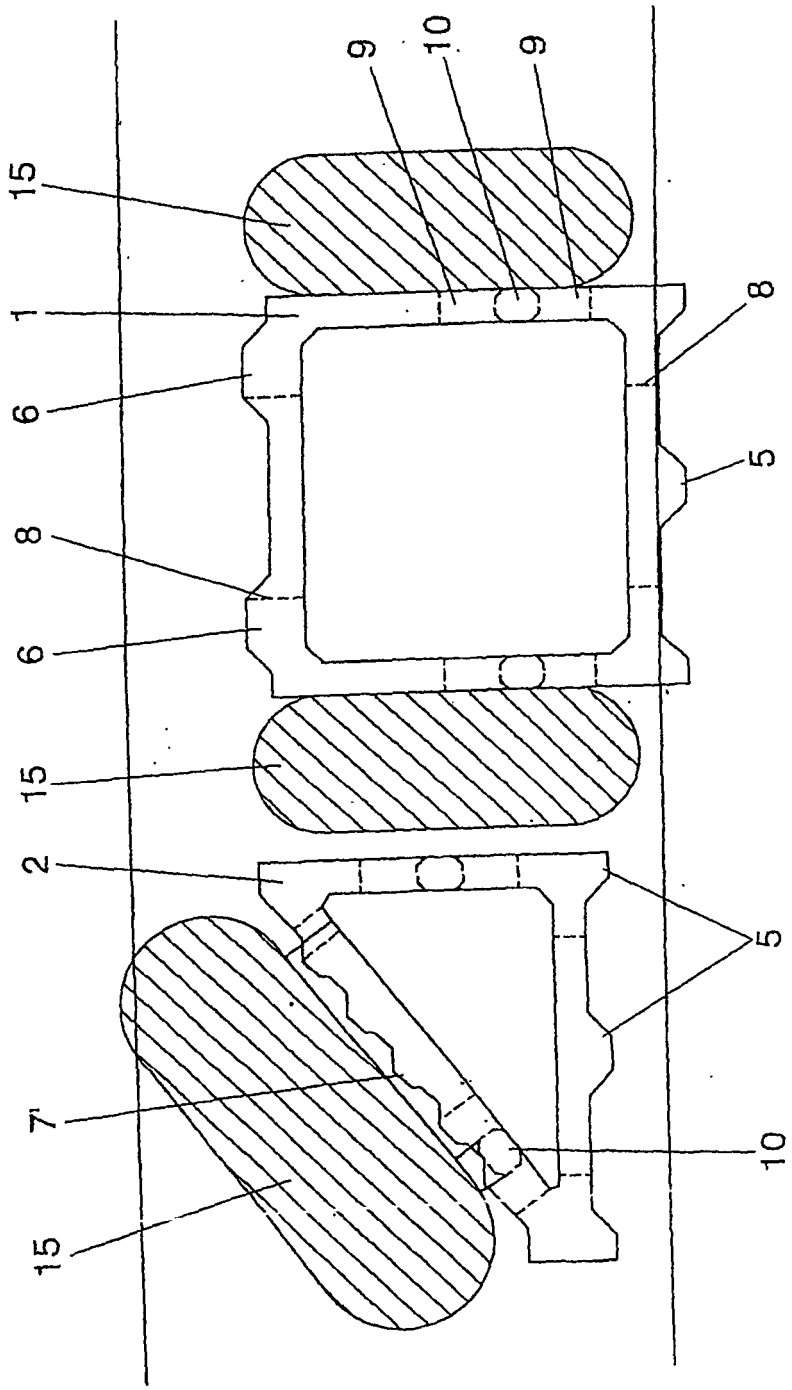

FIG.12

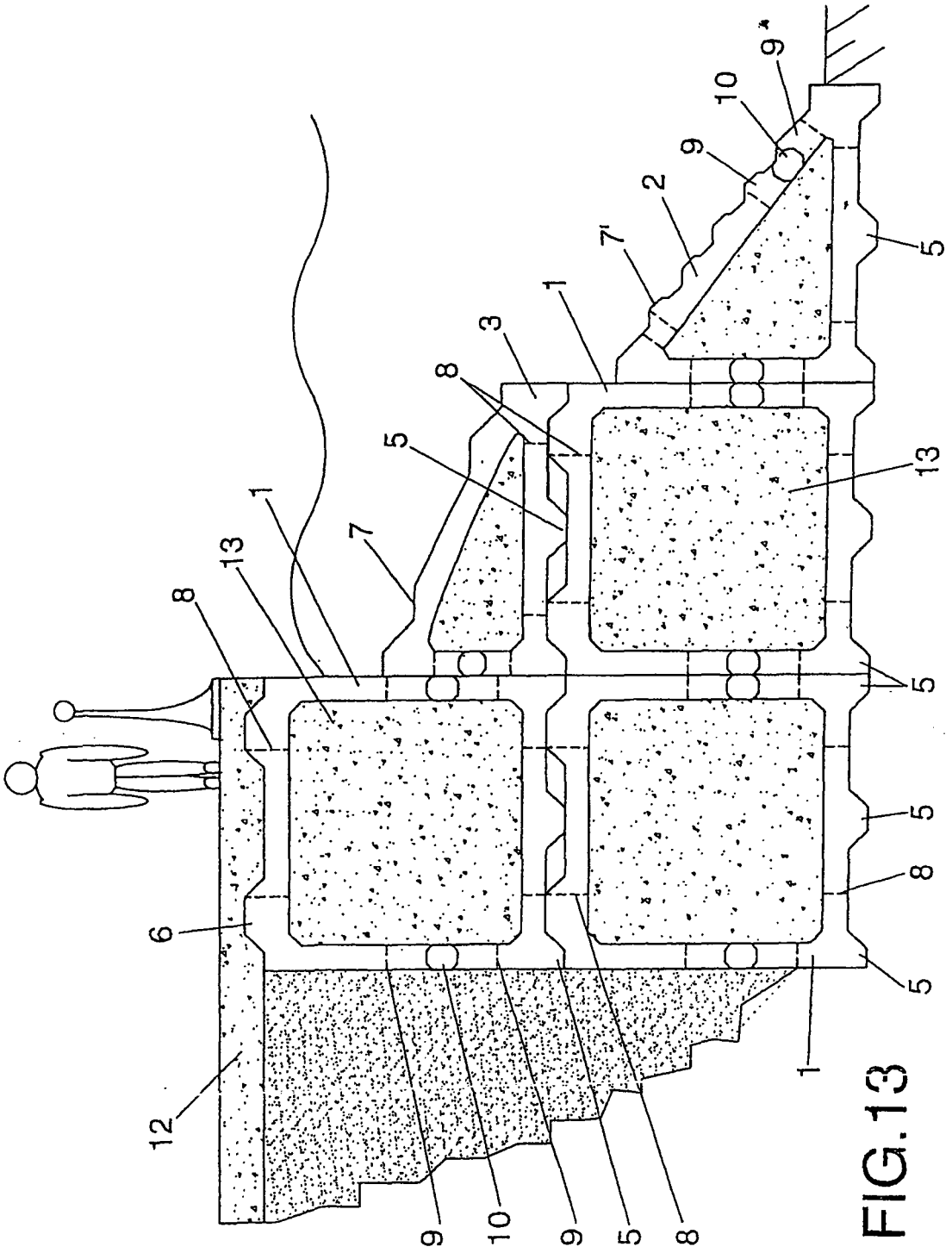

FIG.13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/ ES 2004/000215

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 E02B 3/06

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)

IPC 7 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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Patent Abstracts of Japan, vol.018, num.265 (M-1608) 20.5.1994 & JP 06-041934 A (RINKAI TSUSHO K.K.) 15.02.1994, **abstract, figures**	1,2
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
23 August 2004 (23.08.04)	**17 September 2004 (17.09.04)**
Name and mailing address of the ISA/ **S.P.T.O.** Facsimile No.	Authorized officer Telephone No.

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