(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 896 755 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
22.07.2015 Bulletin 2015/30

(21) Application number: **13771903.5**

(22) Date of filing: **01.04.2013**

(51) Int Cl.:
E03B 3/03 *(2006.01)* ***E03B 11/14*** *(2006.01)*
E03F 1/00 *(2006.01)*

(86) International application number:
PCT/JP2013/059991

(87) International publication number:
WO 2013/151020 (10.10.2013 Gazette 2013/41)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **05.04.2012 JP 2012086822**

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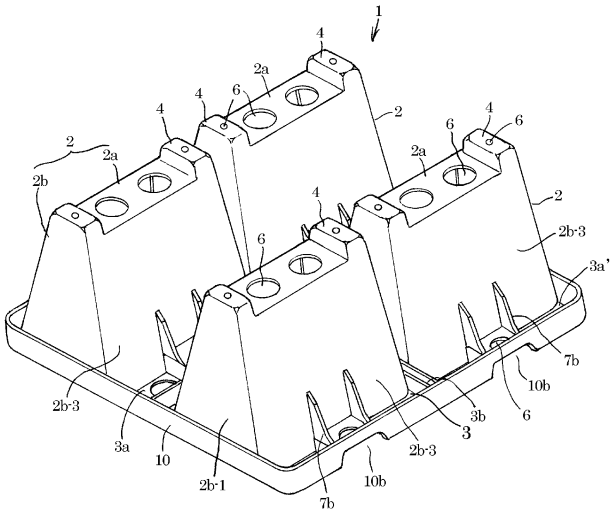
(54) STRUCTURAL MEMBER USED FOR RAINWATER STORAGE LAMINATED STRUCTURE

(57) A structural member for building a rainwater storage stack structure by being stacked up vertically in alternating orthogonal directions inside a water storage tank provided underground is provided, which enables precise and stable stacking, and formation of a rainwater storage stack structure with a small number of stacking and with a larger capacity for rainwater. The structural member 1 has hollow rectangular frusta 2 arranged front and back and right and left and coupled at lower ends thereof with a bottom plate part 3a of a constant width, each frustum having a rectangular top wall 2a and slanted peripheral wall plates 2b extending from four side edges of the top wall 2a. Protrusions 4 and 4 are protruded at both ends of the top walls 2a, so that the lower ends of the slanted walls on both sides of the rectangular frusta 2 of upper structural members 1 are supported on the top walls 2a of the lower structural members 1. The lower ends engage with the opposite inner faces at the lower ends of the protrusions 4 and 4 so as to support load from above. The bottom plate parts 3a are provided with engaging recesses 5 that are placed over the protrusions 4 and 4 of the structural members 1 arranged below to prevent unwanted forward, backward, leftward, or rightward displacement of the structural members 1.

Fig. 1



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Description

Technical Field

[0001] The present invention relates to a structural member used for a rainwater storage stack structure in rainwater storage facilities set into the ground of places where a park, car park, or roads are built.

Background Art

[0002] As has been known, rainwater storage facilities are built into the ground of parks, car parks, and so on, to prevent river or sewage from flooding due to heavy rains, or to utilize the collected rainwater as the need arises.

[0003] A rainwater storage facility is configured, for example, as described in Patent Document 1, such that a water storage tank is formed by digging down into the ground; a rainwater storage stack structure is formed inside this water storage tank with the stack structure formed by a matrix of synthetic resin-made structural members having internal spaces for storage of rainwater, several layers of them being stacked upon one another; this rainwater storage stack structure is covered by a covering material such as a sheet or a paving material; and a manhole is provided adjacent the water storage tank for introducing rainwater in heavy rains into the storage spaces to be stored.

[0004] The structural member forming the rainwater storage stack structure of such rainwater storage facilities, as described in the above-described Patent Document 1, includes a plurality of bottomed cylindrical legs having open upper ends regularly spaced front and back and right and left inside a square frame, with the upper ends of adjacent legs integrally connected via ribs and the upper ends of the outermost legs arranged along the inner periphery of the frame being integrally connected to the frame. The structural members are arranged in rows and columns inside a water storage tank, and stacked up to construct a rainwater storage stack structure, with the lower ends of the legs of upper layer structural members supported by the upper open ends of the legs of lower layer structural members.

[0005] However, the structural member including a plurality of cylindrical legs aligned in rows and columns in a square frame has the problem of bulkiness when stacked up during transportation or storage. It also has a problem in strength, since, if there is any unbalanced load applied on adjacent cylindrical legs, the thin ribs connecting the upper ends of these legs may crack or break due to the load.

[0006] The features required of the structural member include the ability to be stacked up compactly and neatly during transportation or storage, a large internal space with a large capacity for rainwater, an increased pressure resistance relative to the load from above despite a simplified structure, and the ability to allow for a precise and efficient operation of constructing a rainwater storage stack structure.

[0007] To meet these demands, the applicants of the present application have developed a structural member as described in Patent Document 2. This structural member 31 includes, as shown in FIG. 17, box-like parts 32 with an entirely open lower end, each formed by a rectangular top plate 32a and slanted walls 32b of a certain height integrally formed therewith to extend downwardly from four side edges of the top plate, these box-like parts 32 being arranged side by side at a distance; bottom plates 33 having a constant width and connecting the lower ends of the slanted walls 32b opposite each other; and outer edge bottom plate parts 33a extending from the lower ends of the slanted walls of the box-like parts 32 facing the outer peripheral edges of the structural member 31 toward the outer peripheral edges of the structural member. Both ends in the lengthwise direction of the top plates 32a of the box-like parts 32 are made lower than the central part to form lowered parts 34. The slanted walls 32b, from the bottom of which the bottom plates 33 extend horizontally, have a downwardly open engaging recess 35 in the center at the lower end, the recess having a shape that allows the slanted walls to fit onto the lowered parts 34 from the lower ends thereof over the entire width of the bottom plates.

[0008] The structural member 31 configured in this way not only has a simple structure, but also can form an internal space with a large capacity for rainwater, because of the box-like parts. Also, during transportation or storage, the structural members can be compactly and neatly stacked upon one another by placing the box-like parts 21 of an upper structural member 31 over the box-like parts 32 of the lower structural member 31.

[0009] When building a stack structure, the structural members 31 are arranged in alternating orthogonal directions such that the lower faces of the engaging recesses 35 at the lower ends of the slanted walls 32b and 32b on both sides of slanted peripheral walls of the box-like parts 32 of the structural member 31 located above are supported on the lowered parts 34 formed at both ends in the lengthwise direction of the top plates 32a of the box-like parts 21 of the structural member 31 located below by placing the engaging recesses 35 over the lowered parts 34. Thereby, advantageously, the structural members allow for precise and efficient stacking, as well as building of a stack structure with a high pressure resistance.

Citation List

Patent Literature

[0010]

Patent Literature 1: Japanese Patent Application Laid-Open No. 2006-342520

Patent Literature 2: Japanese Patent Application

Laid-Open No. 2009-24447

Summary of Invention

Technical Problem

[0011] According to the structural member described in Patent Document 2 mentioned above, both ends in the lengthwise direction of the top plates 32a of the box-like parts 32 are made lower than the center part to form the lowered parts 34; engaging recesses 35 are formed to open from the bottom at the center of the slanted walls 32b and 32b on both sides and to extend over the bottom plates; and the structural members are stacked upon one another, with the engaging recesses 35 of the structural member 31 located above are placed over the lowered parts 34 so that the lower faces of the engaging recesses 35 are supported thereon. Thus, top portions of the box-like parts 32, having a height corresponding to that of between the lowered parts 34 and the top plate 32a, of the lower structural member 31 protrude into the lower ends of the box-like parts 32 of the upper structural member 31, i.e., the top portions of the box-like parts 32 of the lower structural member 31 overlap the lower ends of the box-like parts 32 of the upper structural member 31. Accordingly, there are the following problems: The stack structure has a reduced capacity for rainwater inside the box-like parts 32, and, the stacking height of the box-like parts 32 is reduced by the overlapped portions every time another structural member 31 is stacked, so that the number of structural members 31 required to stack from the inner bottom to the upper end of the water storage tank is increased, which will not only cause an increase in cost but require more work in the stacking operation.

[0012] In a stacked condition, when load is applied from above on the top plate 32a of the box-like part 32 of an upper structural member 31, there is generated a force in the horizontal direction that causes the divergent slanted walls 32b of this box-like part 32 to stretch outward. The slanted walls 32b and 32b opposite each other of adjacent structural members are connected to each other at their ends with a bottom plate 33, so that they can push each other via this bottom plate 33 and resist outward movement. However, the bottom plate part 33a at the lower end of the slanted walls 32b that face the outer peripheral edges of the structural member 31 lacks any structure that can prevent such movement of the bottom plate part 33a. Therefore, there is a problem that a stable stack condition may not be maintained, as the engaging recess 35 provided in the bottom plate part 33a may slide due to the above-mentioned load on the lowered part 34 outward and disengage therefrom.

[0013] As a measure against this problem, stopper ribs that engage each other are sometimes provided to the lowered part 34 of the top plate 32a, and the engaging recess 35 placed on this lowered part 34, of the structural member 31. However, there was a possibility that such engagement between the ribs may not be sufficient and the ribs may break because of the load, or they may ride over and disengage from each other.

[0014] The present invention was made in view of these problems and has as its object the provision of a structural member used for a rainwater storage stack structure, which can be stacked up compactly and neatly during transportation or storage, which has a simple structure suitable for mass-production, which allows for construction of a stack structure of a predetermined height with a large capacity for rainwater with a small number of stacks when stacked up to build a rainwater storage stack structure, which exhibits a high pressure resistance against the load from above, and which can maintain a stable stack configuration without displacement in stacked portions.

Solution to Problem

[0015] To achieve the above object, the present invention provides a structural member used for a rainwater storage stack structure as set forth in claim 1, which is a structural member to be arranged in rows and columns and vertically stacked upon one another in alternating orthogonal directions inside a water storage tank formed by digging down into the ground for constructing the rainwater storage stack structure, the structural member including hollow rectangular frusta having a certain height arranged front and back and right and left on a flat rectangular bottom plate, each rectangular frustum having a bottom completely open through the bottom plate downward, and including a rectangular top wall that is long in a front to back direction, downwardly divergent slanted peripheral wall plates extending from four side edges of the top wall, protrusions having a certain height at both ends in a lengthwise direction of the top wall, distanced from each other such that between the protrusions fittable are lower end parts of slanted walls on both sides of the slanted peripheral wall plate of a rectangular frustum of a structural member stacked up above, the lower ends of the slanted peripheral wall plates of adjacent rectangular frusta being coupled together with the floor board, and a downwardly open engaging recess formed in part of the bottom plate continuous with the lower ends of the slanted wall plates on both sides of the rectangular frusta to be placed over the protrusions protruded on the top walls of the rectangular frusta of a structural member arranged below.

[0016] According to the invention as set forth in claim 2, in the structural member used for a rainwater storage stack structure, the engaging recess formed in part of the bottom plate continuous with the lower ends of the slanted walls on both sides of the rectangular frusta is formed by making part of the bottom plate bulge upward in the same shape as that from the top surface of the protrusion to the slanted wall surfaces on both sides of the protrusion protruded on the top wall of the rectangular frusta, and the lower ends of the slanted walls on both

sides are protruded downward from both ends of the engaging recess with a length corresponding to a height of the protrusions.

[0017] According to the invention as set forth in claim 3, the slanted walls on both sides of the rectangular frusta are formed with reinforcing grooves extending between upper and lower ends.

[0018] According to the invention as set forth in claim 4, a reinforcing groove part having a U-shaped cross section is formed in a central portion in the lengthwise direction of the top walls of the rectangular frusta so as to be recessed downward, both ends of the reinforcing groove part being continuous with opposite walls of the slanted walls on both sides.

[0019] According to the invention as set forth in claim 5, vertically extending water passage holes are formed in the top walls, in the protrusions protruded at both ends of the top walls, and in the bottom plate parts around the lower ends of the slanted peripheral wall plates of the rectangular frusta.

[0020] According to the invention as set forth in claim 6, the structural member is configured to be square or rectangular in plain view, with at least two rectangular frusta arranged in the lengthwise direction and in the width direction of the bottom plate, respectively, the lower ends of the slanted peripheral wall plates of adjacent rectangular frusta being connected by parts of the top plate, and an outer frame rim having a certain height integrally formed along four peripheral edges of the bottom plate.

Advantageous Effects of Invention

[0021] According to the invention as set forth in claim 1, the structural member used for a rainwater storage stack structure includes rectangular frusta having a certain height and arranged front and back and right and left on a flat rectangular bottom plate, each rectangular frustum having a bottom completely open through the bottom plate downward. Therefore, the structure is simple and obviously suited to mass-production, and also it can be neatly and compactly stacked upon one another with opposite rectangular frusta deeply nested in each other during transportation or storage. To build a rainwater storage stack structure, the structural members are stacked up in alternating orthogonal directions stably, precisely, and efficiently up to a certain height, with the lower ends of the slanted walls on both sides of the slanted peripheral wall plates of rectangular frusta of upper structural members being supported on the top walls of the rectangular frusta of the structural members arranged below.

[0022] Further, according to the present invention, protrusions having a certain height are provided at both ends in a lengthwise direction of the top walls that are long in the front to back direction of the rectangular frusta, distanced from each other such that between the protrusions fittable are lower end parts of slanted walls on both sides of the slanted peripheral wall plates of a rectangular frustum of a structural member stacked up above, as well as downwardly open engaging recesses formed in part of the bottom plate continuous with the lower ends of the slanted walls on both sides of the slanted peripheral wall plates of the rectangular frusta to be placed over the protrusions protruded on the top walls of the rectangular frusta of a structural member arranged below. Thus, the structural members can be stacked up stably by placing the engaging recesses provided in part of the bottom plate continuous with the lower ends of the slanted walls on both sides of the rectangular frusta of structural members arranged above over the protrusions protruded at both ends in the lengthwise direction of the top walls of the rectangular frusta of structural members arranged below. Also, a stack structure can be built wherein the rectangular frusta of upper structural members are stacked upon the top walls of the rectangular frusta of lower structural members such that the entire rectangular frusta of the upper structural members is placed above the top walls, so that the internal spaces of the rectangular frusta can entirely be used as the space for storing rainwater, and thus the capacity for rainwater can be increased, and also a rainwater storage stack structure of a predetermined height can be configured with a small number of stacks, and the efficiency of the assembling operation of the rainwater storage stack structure can be improved.

[0023] In addition, as mentioned above, protrusions having a certain height are protruded at both ends in a lengthwise direction of the top wall of the rectangular frustum, distanced from each other such that between the protrusions fittable are lower end parts of slanted walls on both sides of the slanted peripheral wall plates of a rectangular frustum of a structural member stacked up above. Therefore, the structural members can be stacked up such that the lower ends of the slanted walls on both sides of the rectangular frusta of structural members stacked up above engage with lower end corners at the opposite inner faces of the protrusions protruded at both ends in the lengthwise direction of the top walls of the rectangular frustums of the lower structural members, so that the outward stretching of the lower ends of the slanted walls on both sides of the upper structural members at both ends of the top walls of the rectangular frusta of the lower structural members due to the load from above can be reliably stopped, and thus the structural members can exhibit a high pressure resistance against the load from above, and a stable stack configuration can be maintained without any displacement in stacked portions.

[0024] According to the invention as set forth in claim 2, an engaging recess is formed in part of the bottom plate continuous with the lower ends of the slanted walls on both sides of the rectangular frusta by making part of the bottom plate bulge upward in the same shape as that from the top surface of the protrusion to the slanted wall surfaces on both sides of the protrusion protruded on the top wall of the rectangular frusta, and the lower ends of the slanted walls on both sides are protruded downward from both ends of the engaging recess with a length corresponding to the height of the protrusions. Therefore, the structural members can be stacked up easily and

precisely, by placing the engaging recesses of the upper structural members over the protrusions at both ends of the top walls of the lower structural members such that the lengthwise direction of the rectangular top plates of the rectangular frusta of upper structural members are oriented orthogonal to the lengthwise direction of the rectangular top plates of the rectangular frusta of lower structural members. Also, as the lower ends of the slanted walls on both sides of the upper structural members engage with the opposite inner faces of the protrusions protruded at both ends in the lengthwise direction of the top walls of the lower structural members, a stable stack configuration can be formed without the possibility of unwanted displacement.

[0025] According to the invention as set forth in claim 3, the slanted walls on both sides that extend downward from longer sides of the top walls of the rectangular frusta are provided with reinforcing grooves extending between upper and lower ends. Accordingly, the reinforcing groove obviate the provision of reinforcing ribs or the like and enhances the pressure resistance of the rectangular frusta, as well as allows the structural members to be deeply nested in each other when stacked up during transportation or storage, and enables the rectangular frusta to be as thin as possible to increase the rainwater storage space.

[0026] According to the invention as set forth in claim 4, a reinforcing groove part having a U-shaped cross section is formed in a central portion in the lengthwise direction of the top walls of the rectangular frusta so as to be recessed downward, both ends of the reinforcing groove part being continuous with the opposite walls of the slanted walls on both sides. When the slanted walls on both sides of the rectangular frusta try to deform inward and outward in an arcuate shape due to the load from above, the reinforcing groove part can firmly resist such a deformation, and thus enhance the buckling resistance of the slanted walls on both sides.

[0027] According to the invention as set forth in claim 5, vertically extending water passage holes are formed in the top walls, in the protrusions protruded at both ends of the top walls, and in the bottom plate parts around the lower ends of the slanted peripheral wall plates of the rectangular frusta. Thus rainwater enters or drains from the rectangular frusta smoothly, and can be stored in the frusta entirely without any air left inside.

[0028] According to the invention as set forth in claim 6, the structural member is configured to be square or rectangular in plain view, with at least two rectangular frusta arranged in the lengthwise direction and in the width direction of the bottom plate, respectively, the lower ends of the slanted peripheral wall plates of adjacent rectangular frusta being connected by parts of the top plate, and an outer frame rim having a certain height integrally formed along the four peripheral edges of the bottom plate. Thus, structural members can be readily and correctly aligned in rows and columns, with their outer frame rims abutted and joined together inside a water storage tank formed by digging down into the ground. A large size structural member having a large number of rectangular frusta arranged in rows and columns and an outer frame rim along the four side edges, and a small size structural member having a small number of rectangular frusta arranged in rows and columns and an outer frame rim along the four side edges, can be combined, which facilitates construction of a rainwater storage stack structure in accordance with the space of the water storage tank.

Brief Description of Drawings

[0029]

FIG. 1 is a perspective view of a structural member.
FIG. 2 is a front view of the same.
FIG. 3 is a side view.
FIG. 4 is a plain view.
FIG. 5 is a longitudinal cross-sectional front view along line X1-X1 of FIG. 4.
FIG. 6 is a longitudinal cross-sectional front view along line X2-X2 of FIG. 4.
FIG. 7 is a longitudinal cross-sectional front view along line X3-X3 of FIG. 4.
FIG. 8 is a longitudinal cross-sectional front view along line Y1-Y1 of FIG. 4.
FIG. 9 is a longitudinal cross-sectional front view along line Y2-Y2 of FIG. 4.
FIG. 10 is a longitudinal cross-sectional front view of structural members fitted upon one another.
FIG. 11 is a longitudinal cross-sectional side view of the same.
FIG. 12 is a simplified cross-sectional view of a rainwater storage facility built with the structural members.
FIG. 13 is a partial cross-sectional view of the rainwater storage stock structure formed by stacking up the structural members.
FIG. 14 is a perspective view illustrating a modified example of the structural member according to the present invention;
FIG. 15 is a partially sectional view illustrating another modified example of the structural member according to the present invention in a stacked condition;
FIG. 16 is a perspective view of a plurality of structural members with different sizes; and
FIG. 17 is a partially sectional view illustrating conventional structural members in a stacked condition.

Description of Embodiments

[0030] Specific embodiments of the present invention will now be described with reference to the drawings. The rainwater storage facility has a water storage tank 20 formed by digging down into the ground of a park, road and the like as shown in FIG. 12. The bottom and four side walls of the tank 20 are covered by a water shield

sheet (not shown). A large number of structural members 1 having water storage spaces inside are aligned in rows and columns on the bottom of this water storage tank 20, and vertically stacked upon one another to construct a rainwater storage stack structure 21. A spacer member 22 having a certain thickness is provided to cover the upper surface of the rainwater storage stack structure 21, and a cover layer 23 such as a protection sheet or concrete pavement is further provided. A manhole 24 is provided adjacent one end of this rainwater storage facility in fluid communication with one end portion or elsewhere of the water storage tank 20 to allow for storing of rainwater in the rainwater storage stack structure 21 or drainage from the rainwater storage stack structure 21 through the manhole 24.

[0031] The structural member 1 that constitutes the rainwater storage stack structure 21 is a synthetic resin molded product. As shown in FIG. 1 to FIG. 9, rectangular frusta 2 having a certain height are regularly spaced apart front and back and right and left on a flat rectangular bottom plate 3 having a certain thickness, with the bottoms of the rectangular frusta completely open downward through the bottom plate 3, and the bottom ends of adjacent rectangular frusta 2 are connected to one another via bottom plate parts 3a and 3b of the bottom plat 3. While the structural member 1 shown in these drawings has a square bottom plate 3 and four rectangular frusta 2 arranged front and back and right and left, it should not be limited to this example and may have two or more rows of rectangular frusta 2 arranged front and back and right and left as will be described later.

[0032] The rectangular frustum 2 is made up of a top wall 2a that is rectangular in plain view and long in the front to back direction, which is the up and down direction in the top view of FIG. 4, and downwardly divergent slanted peripheral wall plates 2b having a certain height extending from the four front, back, left, and right side edges of the top wall 2a, and formed in the shape of a truncated isosceles triangle, i.e., an isosceles trapezoid, when viewed from the front, with protrusions 4 formed at both ends in the lengthwise direction of the top wall 2a, i.e., at both ends at the front and back, having the same shape with a certain height and a constant width in the front to back direction. Rectangular frusta 2 formed as described above are arranged in rows and columns, i.e., front and back and right and left on the bottom plate 3, as mentioned above, with the lengthwise direction of their top plates 2a oriented in the front to back direction.

[0033] The downwardly divergent slanted peripheral wall plates 2b extending diagonally outwards from the four side edges of the top wall 2a of the rectangular frustum 2 are made up of front-side and rear-side slanted walls 2b-1 and 2b-2 and slanted walls on both sides 2b-3 and 2b-4 continuous at right angles with both sides of the front-side and rear-side slanted walls 2b-1 and 2b-2 over the entire length at front and rear ends thereof. The slanted wall on one side 2b-3 of one of the rectangular frusta 2 and 2 arranged adjacent each other right and left, and the slanted wall on the other side 2b-4 opposite the slanted wall on one side 2b-3 of the other rectangular frustum 2 are connected to each other between the lower ends of these side walls 2b-3 and 2b-4 by a center bottom plate part 3a, which is part of the bottom plate 3 extending long in the front to back direction with a constant width. The front-side slanted wall 2b-1 and the rear-side slanted wall 2b-2 opposite each other of the rectangular frusta 2 adjacent each other front to back are connected to each other at the lower ends thereof by a bottom plate part 3b that is thin and long in the left-right direction.

[0034] On the other hand, of the rectangular frusta 2 and 2 adjacent each other right and left, from the lower ends of the slanted wall on the other side 2b-4 of one of the rectangular frustum 2 and the slanted wall on one side 2b-3 of the other rectangular frustum 2, which face both side edges of the bottom plate 3, bottom plate parts on both sides 3a' and 3a', which are part of the bottom plate 3, protrude horizontally outward, these bottom plate parts on both sides 3a' and 3a' forming both side edge parts of the structural member 1. These bottom plate parts on both sides 3a' have a width of about one half of the width of the center bottom plate part 3a connecting the lower ends of the rectangular frusta 2 adjacent each other right and left.

[0035] The bottom plate 3 includes the center bottom plate part 3a that connects the lower ends of the opposite slanted peripheral wall plates 2b-3 and 2b-4 of rectangular frusta 2 adjacent each other in the left-right direction, and the thin, long bottom plate part 3b that connects the lower ends of the opposite slanted walls 2b-1 and 2b-2 of rectangular frusta 2 adjacent each other in the front to back direction, as well as a rectangular outer frame rim 10 surrounding the lower ends of the rectangular frusta 2 arranged front and back and right and left along the four peripheral edges of the bottom plate 3 and protruded upward to a certain height. The outer ends of the bottom plate parts on both sides 3a' and 3a' that protrude horizontally from the lower ends of the slanted walls 2b-3 and 2b-4 of the rectangular frusta 2 arranged right and left and facing frame parts on both sides 10a and 10a of the rectangular outer frame rim 10 are integrally connected to the inner face at the lower ends of the frame parts on both sides 10a and 10a. The lower ends of the rear-side slanted walls 2b-2 of rectangular frusta 2 on one side located at the rear edge, and the lower ends of the front-side slanted walls 2b-1 of rectangular frusta 2 on the other side located at the front edge, of the outer rim of the bottom plate 3 of the structural member 1, are integrally connected to the inner face of the front and back frame parts of the rectangular outer frame rim 10 without the bottom plate parts.

[0036] The protrusions 4 and 4 protruding at both ends in the front and back of the lengthwise direction of the top wall 2a of each rectangular frustum 2 extend over the entire width of the top wall 2a and are hollow so that the inside thereof communicates with the inside of the rectangular frustum 2. The protrusions 4 and 4 have flat

horizontal top surfaces, and end faces on both sides that are inclined at the same angles with those of the slanted walls on both sides 2b-3 and 2b-4 of the rectangular frustum 2 and are continuous with the upper ends of these slanted walls on both sides 2b-3 and 2b-4.

[0037] The inner faces of the protrusions 4 and 4 protruding at both ends in the front and back of the top wall 2a of the rectangular frustum 2 opposite each other in the front and back are distanced from each other equally to or slightly wider than the width between the lower ends of the slanted walls on both sides 2b-3 and 2b-4 of the rectangular frustum 2. The protrusions are thus configured in a stacked condition so that, when the structural members 1 are stacked upon one another in alternating orthogonal directions to build a rainwater storage stack structure 21, the lower ends of the slanted walls on both sides 2b-3 and 2b-4 oriented in the front to back direction of an upper structural member 1 are fitted onto the top walls 2a between the protrusions 4 and 4 in the front and back of the lower structural member 1, so that the lower ends of these slanted walls on both sides 2b-3 and 2b-4 engage with the corners formed by the lower ends of the inner faces of the front and back protrusions 4 and 4, and the front and back ends of the top wall 2a continuous with these lower ends of the inner faces, respectively.

[0038] The dimension in the lengthwise direction between the centers of the top walls 2a and 2a of rectangular frusta 2 and 2 adjacent each other front to back of the structural member 1 is equal to the dimension between the centers in the width direction of the top walls 2a and 2a of rectangular frusta 2 and 2 adjacent each other right and left. In addition, the width of the center bottom plate part 3a connecting the lower ends of the rectangular frusta 2 and 2 adjacent each other right and left is substantially equal to the length between the inner faces of the front and back protrusions 4 and 4 facing each other over the thin, long bottom plate part 3b of the rectangular frusta 2 and 2 adjacent each other front to back.

[0039] Further, in the center bottom plate part 3a and the bottom plate parts on both sides 3a' and 3a' extending horizontally to the sides from the lower ends of the slanted walls on both sides 2b-3 and 2b-4 of each rectangular frustum 2, downwardly open center engaging recess 5 and engaging recesses on both sides 5' and 5' are respectively formed in parts that will overlap the protrusions 4 and 4 when structural members 1 are stacked upon one another, with the lengthwise direction of the top walls 2a being oriented in orthogonal directions. Namely, bottom plate parts overlapping the protrusions 4 and 4, namely, the bottom plate parts connecting the lower ends in the center in the front to back direction of the opposite slanted walls on both sides 2b-3 and 2b-4 of rectangular frusta 2 and 2 adjacent each other right and left, and bottom plate parts extending from the lower ends in the center in the front to back direction of one slanted wall 2b-3, and the other slanted wall 2b-4, of one and the other rectangular frusta 2 respectively facing towards both lateral ends of the bottom plate 2, to the lower ends of the frame parts on both sides of the rectangular outer frame rim 10, are made to bulge upward and deformed in the same shape as that from the top surfaces of the protrusions 4 and 4 to the inclined end faces on both sides thereof. The structural member 1 is thus configured so that these engaging recesses 5 and 5' fit over the protrusions 4 and 4 of the structural member 1 arranged below and engage therewith.

[0040] The lower end central portions 2b-3' and 2b-4' of the slanted walls on both sides 2b-3 and 2b-4 of the slanted peripheral wall plates 2 of each rectangular frustum 2 are not provided with a recess that is continuous with the engaging recess 5 or 5' but are protruded downward from the underside of the base end of the engaging recess 5 or 5' with a length corresponding to the height of the protrusions 4, as shown in FIG. 6, so that, when the structural members 1 and 1 are stacked upon one another, these portions engage with both ends of the top walls 2a, at the lower corners on the inner side of the protrusions 4 and 4, of the lower structural member 1, and are supported on both ends of the top walls 2a.

[0041] Further, the center engaging recess 5 provided in the center bottom plate part 3a is formed over the entire width of the center bottom plate part 3a, so that, when the structural members 1 and 1 are vertically stacked upon one another in alternating orthogonal directions, as shown in FIG. 13, the engaging recesses 5 are placed over and engage with the opposite protrusions 4 and 4 of the lower structural members 1 adjacent each other right and left such that these protrusions 4 and 4 are housed into the both sides of the engaging recesses 5. The engaging recesses on both sides 5' and 5' provided in the bottom plate parts on both sides 3a' and 3a', which are continuous with inner faces of both frame parts 10a and 10a of the outer frame rim 10 and forming both side edges of the structural member 1, are placed over the protrusions 4 on the outer side of the top walls 2a and 2a of adjacent rectangular frusta 2 and 2 of the lower structural member 1. Open recesses 10b are cut out in the same shape as the engaging recess 5' in the frame parts on both sides 10a and 10a of the outer frame rim 10 continuous with the bottom plate parts on both sides 3a' where the engaging recesses on both sides 5' and 5' are formed, so that the engaging recesses 5' communicate with the outside through these open recesses 10b.

[0042] One to several large and small water passage holes 6 that extend through in the up and down direction are drilled in each of the top walls 2a of the rectangular frusta 2, protrusions 4 and 4 protruded on the top walls 2a, and all of the bottom plate parts 3a, 3a', and 3b. Reinforcing ribs 7a that are continuous with the opposite surfaces at upper ends of the slanted walls on both sides 2b-3 and 2b-4 of the rectangular frustum 2 at both ends and extend long in the width direction of the top walls 2a are protruded downward, from the underside at both ends in the widthwise direction of the top walls 2a of the rectangular frusta 2. Two reinforcing ribs 7b and 7b having

a certain height are protruded in a lower portion of the outer walls of the slanted walls on both sides 2b-3 and 2b-4, with a certain distance from each other in the front to back direction, and with the lower ends being continuous with the front and back upper surfaces of the engaging recesses 5 in the bottom plate parts 3a.

[0043] The structural members 1 configured as described above can be neatly and compactly stacked upon one another during transportation or storage as shown in FIG. 10 and FIG. 11, with the rectangular frusta 3 and 3 deeply nested in each other. When in use, a multiplicity of structural members 1 are aligned in rows and columns, with opposing frame parts of frame rims 10 abutted and joined together inside the water storage tank 20 formed by digging down into the ground under a park, road, or the like, and upper layer structural members 1 are placed upon lower layer structural members 1 such that the lengthwise direction of the rectangular top walls 2a of the rectangular frusta 2 of the upper layer structural members 1 are oriented orthogonal to the lengthwise direction of the top walls 2a of the rectangular frusta 2 of the lower layer structural members 1, thereby to build the rainwater storage stack structure 21, as shown in FIG. 12.

[0044] When structural members 1 are stacked upon one another such that upper structural members 1 are oriented orthogonal to lower structural members 1, as shown in FIG. 13, the lower end central portions 2b-3' and 2b-4' of the slanted walls on both sides 2b-3 and 2b-4 of rectangular frusta 2 of the upper structural member 1 are supported on both ends of the top walls 2a of rectangular frusta 2 of the lower structural member 1 corresponding to the rectangular frusta 2 of the upper structural member 1, and the lower ends of the portions 2b-3' and 2b-4' engage with the lower ends on the inner side of the protrusions 4 and 4 protruded upward from both ends of these top walls 2a. The center engaging recesses 5 provided in the center bottom plate part 3a between the lower end central portions 2b-3' and 2b-4' of the opposite slanted walls 2b-3 and 2b-4 of adjacent rectangular frusta 2 of the upper structural member 1 bridge between the opposite protrusions 4 and 4 of adjacent rectangular frusta 2 and 2 of the lower structural member 1 and are fitted over these protrusions 4 and 4, so that the bottom faces of the center engaging recesses abut and are supported on the top surfaces of these protrusions 4 and 4.

[0045] At the same time, the engaging recesses on both sides 5' provided in the bottom plate parts on both sides 3a' and 3a', which form both side edges of the upper structural member 1, are placed over and supported by the protrusions 4 on the outer side of the top walls 2a and 2a of adjacent rectangular frusta 2 and 2 of the lower structural member 1.

[0046] In this manner, a plurality of structural members 1 are stacked upon one another to build a rainwater storage stack structure 21 such that upper structural members 1 are oriented with the lengthwise direction of the top walls 2a of their rectangular frusta 2 being oriented at right angles with that of the lower structural members 1, whereby the lower end central portions of the slanted walls on both sides 2b-3 and 2b-4 of the rectangular frusta 2 of the upper structural members 1 are fitted in between the protrusions 4 and 4 protruded at both ends in the lengthwise direction of the top walls 2a of the rectangular frusta 2 of the lower structural members 1 and are supported on both ends of the top walls 2a at the lower ends on the inner side of the protrusions 4 and 4, and whereby the engaging recesses 5 and 5' provided in the bottom plate parts 3a and 3a' of the upper structural members 1 are placed over the protrusions 4 and 4 of the lower structural members 1.

[0047] Accordingly, the structural members are stacked up, with the engaging recesses 5 and 5' provided in the bottom plate parts 3a and 3a' extending horizontally from the lower end central portions of the slanted walls on both sides 2b-3 and 2b-4 of the rectangular frusta 2 of the upper structural members 1 placed over the protrusions 4 and 4 protruded at both ends in the lengthwise direction of the top walls 2a of the rectangular frusta 2 of the lower structural members 1. Therefore, in this stack structure, the upper structural members 1 are stacked upon the top walls 2a of the rectangular frusta 2 of the lower structural members 1 such that the entire rectangular frusta 2 of the upper structural members 1 from the lower end to the top surface thereof is placed above the top walls 2a, so that the internal space of the rectangular frusta 2 can entirely be used as the space for storing rainwater, and thus the capacity for rainwater can be increased. Also, the number of structural members 1 used to build a rainwater storage stack structure 21 of a predetermined height inside the water storage tank 20 can be reduced, so that the assembling operation of the rainwater storage stack structure 21 can be carried out efficiently.

[0048] Further, the engaging recesses 5 and 5' provided in the bottom plate parts 3a and 3a' of the upper structural members 1 are placed over and engage with the protrusions 4 and 4 protruded on the top walls 2a of the rectangular frusta 2 of the lower structural members 1 and, accordingly, can prevent unwanted displacement of the structural members 1 in the lengthwise direction of the top walls 2a. Also, the lower end central portions 2b-3' and 2b-4' of the slanted walls on both sides 2b-3 and 2b-4 of the upper structural members 1 engage with the lower ends on the inner side of the protrusions 4 and 4 protruded on the top walls 2a of the rectangular frusta 2 of the lower structural members 1 and can prevent unwanted displacement of the structural members 1 in the widthwise direction of the top walls 2a.

[0049] The slanted walls on both sides 2b-3 and 2b-4 of the upper structural members 1 try to stretch and deform outwards on the top walls 2a of the rectangular frusta 2 of the lower structural members 1 by the load applied vertically on the structural members 1 of the uppermost layer. However, as mentioned above, the lower end central portions of the slanted walls on both sides 2b-3 and

2b-4 engage with the lower ends on the inner side of the protrusions 4 and 4 protruded on the top walls 2a of the rectangular frusta 2 of the lower structural members 1 and prevent unwanted outward displacement, and therefore a stable stack condition can be maintained without any displacement of the structural members 1.

[0050] The slanted walls on both sides 2b-3 and 2b-4 of the rectangular frusta 2 of the structural members 1 may have two reinforcing grooves 7 each with a constant width and recessed into the rectangular frusta 3 such as to have a U-shaped cross section as shown in FIG. 14, the reinforcing grooves extending from the top walls 2a to the lower ends of the slanted walls on both sides 2b-3 and 2b-4 over their entire height, respectively. With such reinforcing grooves 7 extending over the entire height of the slanted walls on both sides 2b-3 and 2b-4 of the rectangular frusta 2, the structural member 1 can exhibit a high pressure resistance relative to the load applied from above, and can prevent buckling deformation of the slanted walls 2b of the rectangular frusta 2. Also, as compared with the structure in which reinforcing ribs are protruded over the entire height of the slanted walls on both sides 2b-3 and 2b-4, stacking operation wherein the structural members are fitted to one another for storage or the like can be performed with little restrictions. Moreover, reinforcing ribs may be provided on the recessed surface of the reinforcing grooves 7.

[0051] Other than the reinforcing grooves 7 formed to the slanted walls on both sides 2b-3 and 2b-4 of the rectangular frusta 2 to give pressure resistance to the rectangular frusta 2, as shown in FIG. 15, reinforcing groove part 71 with a U-shaped cross section recessed downward may be formed at the center in the lengthwise direction of the top walls 2a, also to give pressure resistance to the rectangular frusta 2. More specifically, this reinforcing groove part 71 is formed by bending the upper end of the top wall 2a downward. Lower ends of the front and rear groove walls 71a and 71b reach an approximately middle height of the rectangular frusta 2, and are joined together by a groove bottom 71c. Both ends of these front and rear groove walls 71a and 71b and the groove bottom 71c are continuous with the opposite walls of the slanted walls on both sides 2b-3 and 2b-4 of the rectangular frustum 2. The upper ends are entirely open upwards from the center in the lengthwise direction of the top walls 2a. Both ends are entirely open outwards from the center in the width direction of the front to back direction of the slanted walls on both sides 2b-3 and 2b-4. Furthermore, ribs 72 and 72 are protruded downward from both ends of the underside of the groove bottom 71c of the reinforcing groove part 71, both ends of which are continuous with the opposite walls of the slanted walls on both sides 2b-3 and 2b-4. Other structural features are the same as those of the embodiment described above, and same parts are given the same reference numerals and will not be described in detail again.

[0052] With the structural member 1 configured as described above to include reinforcing groove parts 71, when structural members 1 are successively stacked upon one another such that upper structural members 1 are oriented orthogonal to lower structural members 1 to build a rainwater storage stack structure 21 of a predetermined height, and when load is applied vertically from above, the slanted walls on both sides 2b-3 and 2b-4 of upper structural members 1 try to bulge and deform inward and outward in an arcuate shape at the lower end central portions engaging with the lower ends on the inner side of the protrusions 4 and 4 protruded on the top walls 2a of the lower structural members 1 as a fulcrum, but the reinforcing groove part 71 with a U-shaped cross section and ribs 72 and 72 that integrally connect the opposite walls of the slanted walls on both sides 2b-3 and 2b-4 firmly resist such a deformation, and can reliably prevent buckling deformation of the slanted walls on both sides 2b-3 and 2b-4.

[0053] The structural member 1 described above is of a small size with four rectangular frusta 2 and 2 arranged front and back and right and left with a predetermined distance. The structural member 1 according to the present invention is not limited to this and may be, for example, as shown in FIG. 16, of a medium size 1A with two rows of rectangular frusta 2 arranged side by side on right and left, each row consisting of four rectangular frusta 2 in front to back series arrangement on a floor board, or a medium size 1B with four rows of rectangular frusta 2 arranged side by side on right and left, each row consisting of two rectangular frusta 2 and 2 in front to back series arrangement on a floor board, or a large size 1C with four rows of rectangular frusta 2 arranged side by side on right and left, each row consisting of four rectangular frusta 2 in front to back series arrangement on a floor board.

[0054] These large and small structural members 1, 1A to 1C are aligned in rows and columns in various combinations on the bottom of the water storage tank 20 such that their top walls 2a are all oriented in the same lengthwise direction, and on top of this group of structural members, another group of structural members 1, 1A to 1B are stacked as the upper layer such that the lengthwise direction of their top plates 3a is oriented orthogonal to the lengthwise direction of the top walls 2a of the lower layer structural members, whereby the rainwater storage stack structure 21 is constructed.

Industrial Applicability

[0055] A rainwater storage stack structure is formed by aligning a large number of structural members in rows and columns and stacking them upon one another inside a water storage tank formed by digging down into the ground of a park, road, or a car park beside the road. Rainwater storage facilities having a rainwater storage tank may be configured underground by providing pavement above this rainwater storage stack structure to allow people to walk or cars to drive.

Reference Signs List

[0056]

1	Structural member
2	Rectangular frustum
2a	Top wall
2b	Slanted peripheral wall plate
3a, 3b	Bottom plate part
4, 4	Protrusion
5, 5'	Engaging recess
6	Water passage hole
10	Outer frame rim
20	Water storage tank
21	Rainwater storage stack structure

Claims

1. A structural member used for a rainwater storage stack structure, the structural member being arranged in rows and columns and vertically stacked upon one another in alternating orthogonal directions inside a water storage tank formed by digging down into the ground for constructing the rainwater storage stack structure, the structural member comprising hollow rectangular frusta having a certain height arranged front and back and right and left on a flat rectangular bottom plate, each rectangular frustum having a bottom completely open through the bottom plate downward, and including a rectangular top wall that is long in a front to back direction, downwardly divergent slanted peripheral wall plates extending from four side edges of the top wall, protrusions having a certain height at both ends in a lengthwise direction of the top wall, distanced from each other such that between the protrusions fittable are lower end parts of slanted walls on both sides of the slanted peripheral wall plate of a rectangular frustum of a structural member stacked up above, the lower ends of the slanted peripheral wall plates of adjacent rectangular frusta being coupled together with the floor board, and a downwardly open engaging recess formed in part of the bottom plate continuous with the lower ends of the slanted wall plates on both sides of the rectangular frusta to be placed over the protrusions protruded on the top walls of the rectangular frusta of a structural member arranged below.

2. The structural member used for a rainwater storage stack structure according to claim 1, wherein the engaging recess formed in part of the bottom plate continuous with the lower ends of the slanted walls on both sides of the rectangular frusta is formed by making part of the bottom plate bulge upward in the same shape as that from the top surface of the protrusion to the slanted wall surfaces on both sides of the protrusion protruded on the top wall of the rectangular frusta, and the lower ends of the slanted walls on both sides are protruded downward from both ends of the engaging recess with a length corresponding to a height of the protrusions.

3. The structural member used for a rainwater storage stack structure according to claim 1, wherein the slanted walls on both sides that extend downward from longer sides of the top walls of the rectangular frusta are formed with reinforcing grooves extending between upper and lower ends.

4. The structural member used for a rainwater storage stack structure according to claim 1, wherein a reinforcing groove part having a U-shaped cross section is formed in a central portion in the lengthwise direction of the top walls of the rectangular frusta so as to be recessed downward, both ends of the reinforcing groove part being continuous with opposite walls of the slanted walls on both sides.

5. The structural member used for a rainwater storage stack structure according to claim 1 or 2, wherein vertically extending water passage holes are formed in the top walls, in the protrusions protruded at both ends in the lengthwise direction of the top walls, and in the bottom plate parts and the engagement recesses in the rectangular frusta.

6. The structural member used for a rainwater storage stack structure according to claim 1, wherein the structural member is configured to be square or rectangular in plain view, with at least two rectangular frusta arranged in the lengthwise direction and in the width direction of the bottom plate, respectively, the lower ends of the slanted peripheral wall plates of adjacent rectangular frusta being connected by parts of the top plate, and an outer frame rim having a certain height integrally formed along four peripheral edges of the bottom plate.

Fig. 1

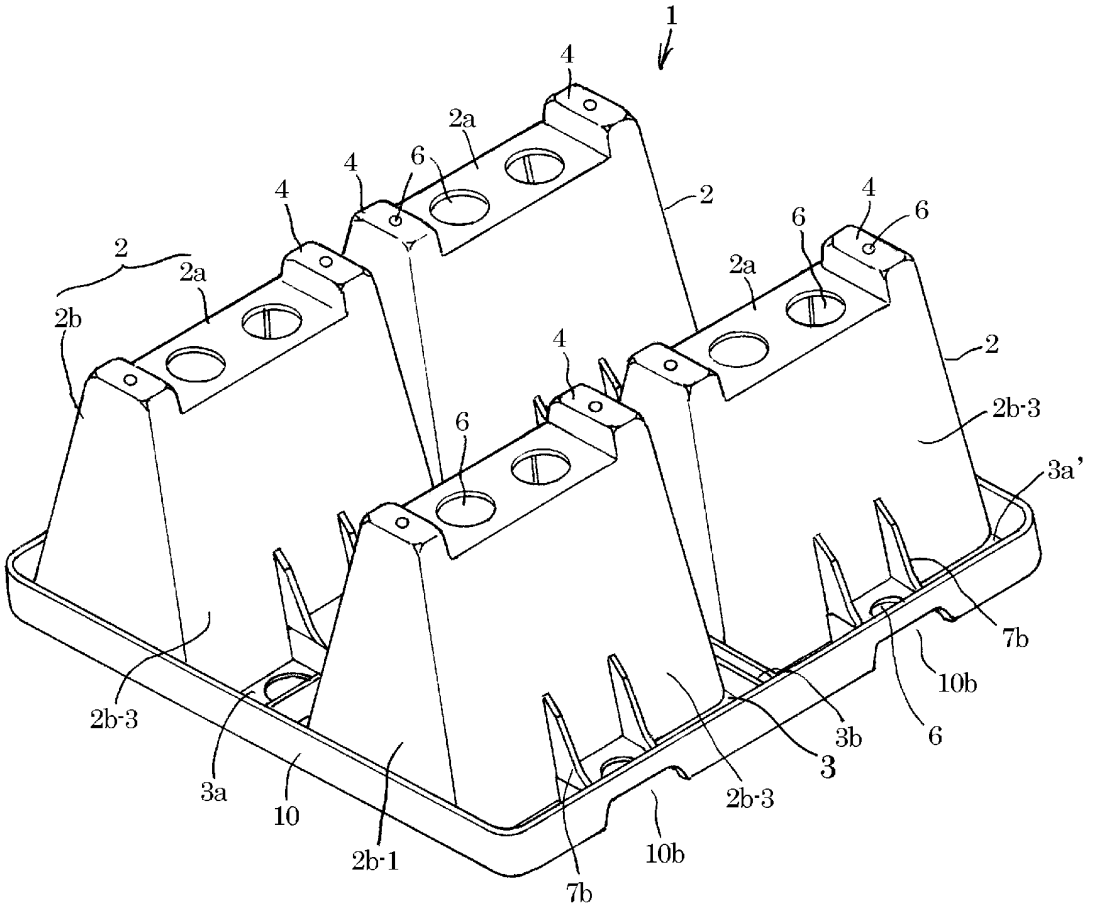


Fig. 2

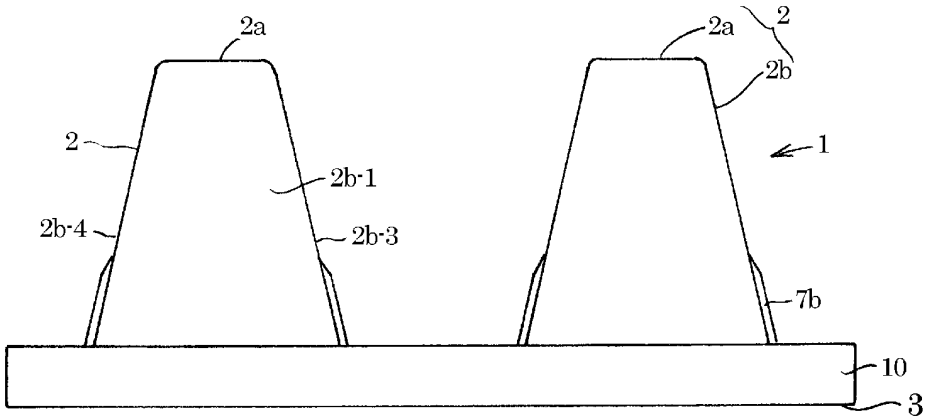


Fig. 3

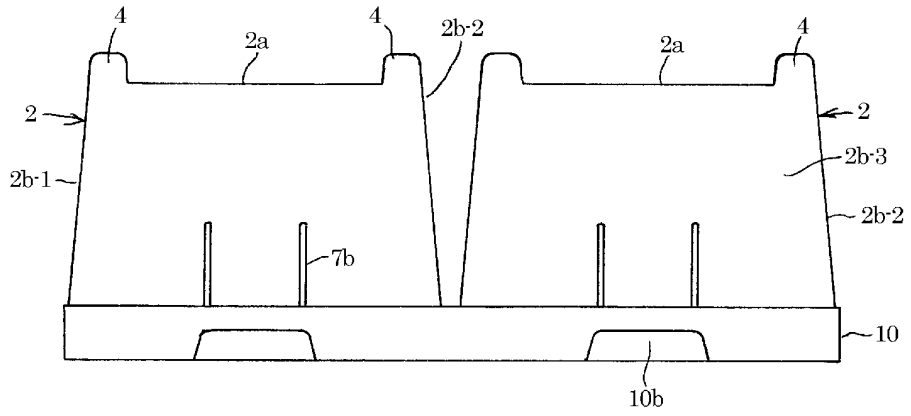

4
2a
4
2b-2
2a
4
2
2
2b-1
2b-3
2b-2
7b
10
10b

Fig. 4

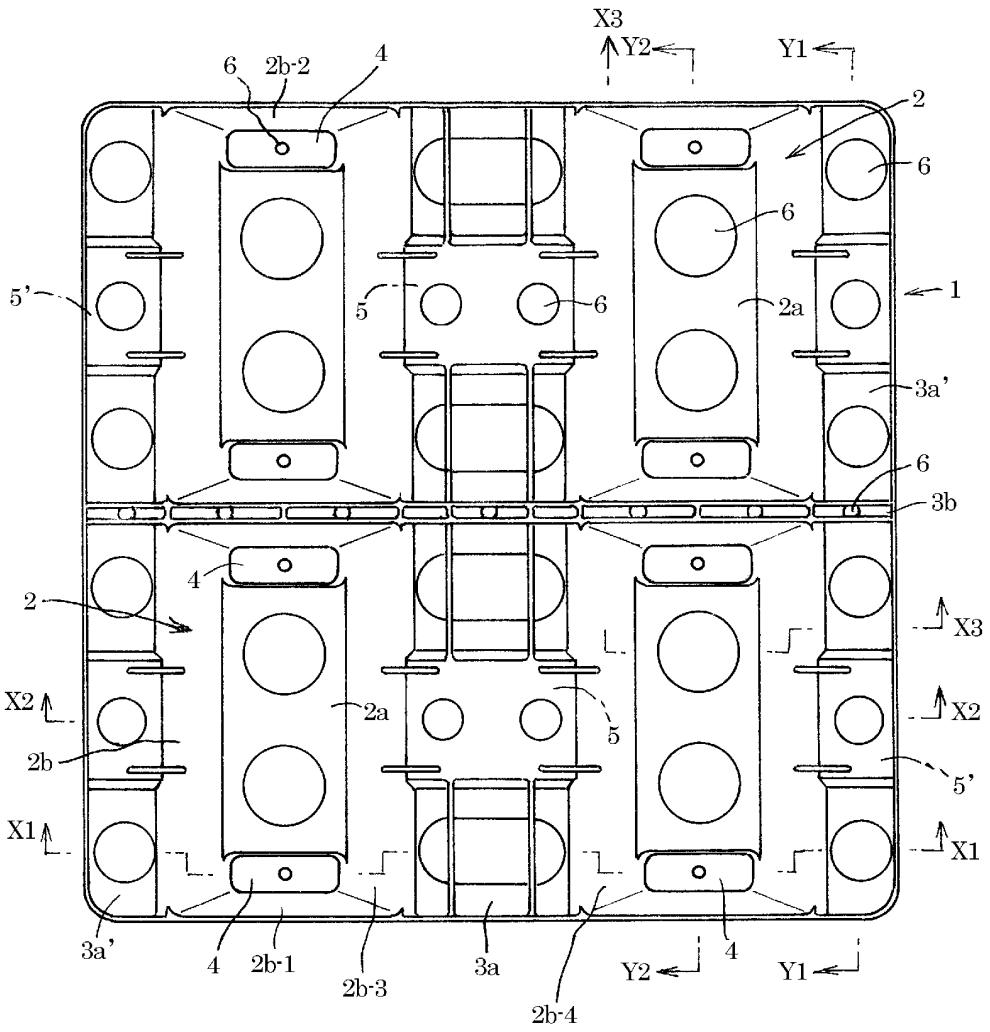

X3
Y2
Y1
6
2b-2
4
2
6
6
5'
5
6
2a
1
3a'
6
3b
4
2
X3
X2
2a
5
X2
2b
5'
X1
X1
3a'
4
2b-1
2b-3
3a
Y2
4
Y1
2b-4

Fig. 5

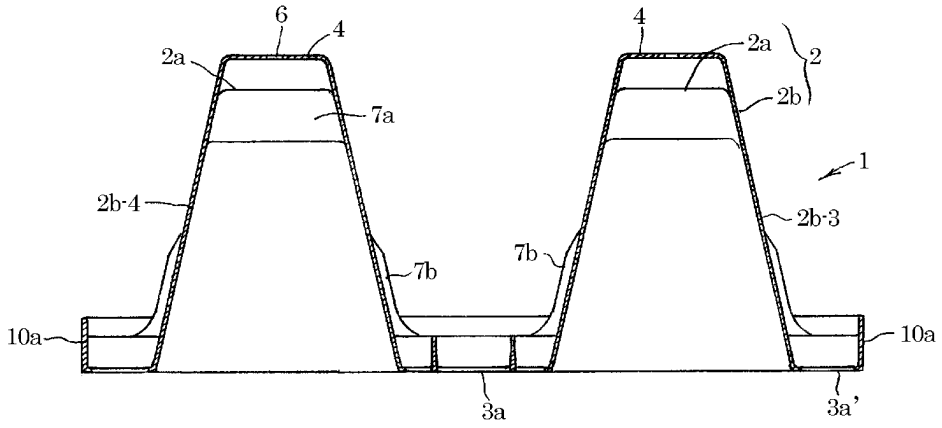


Fig. 6

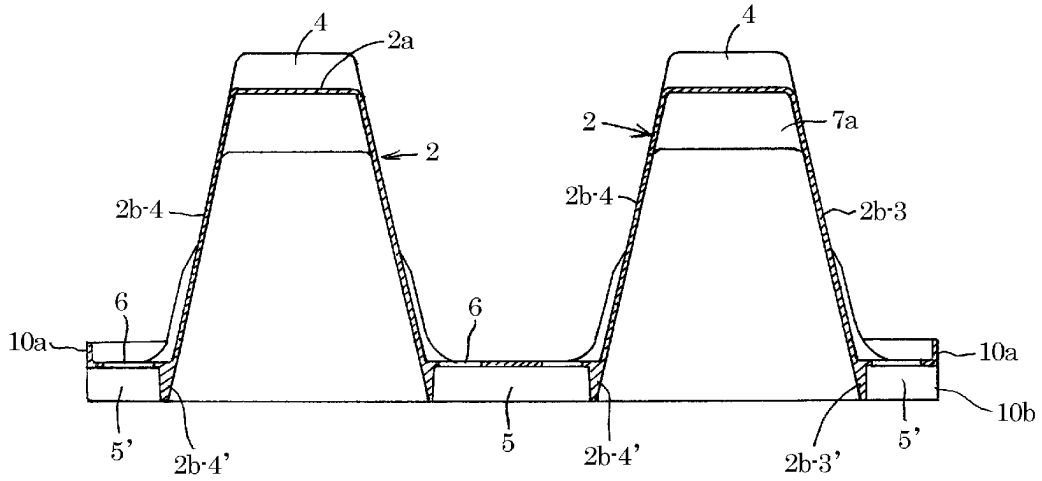


Fig. 7

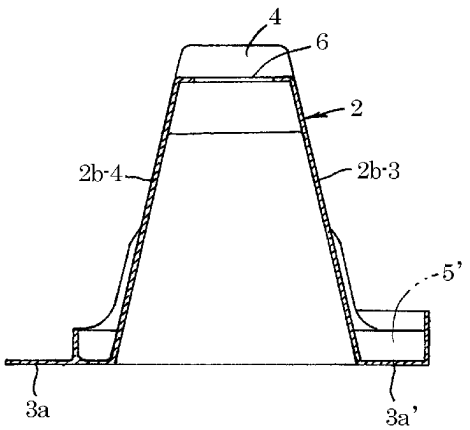


Fig. 8

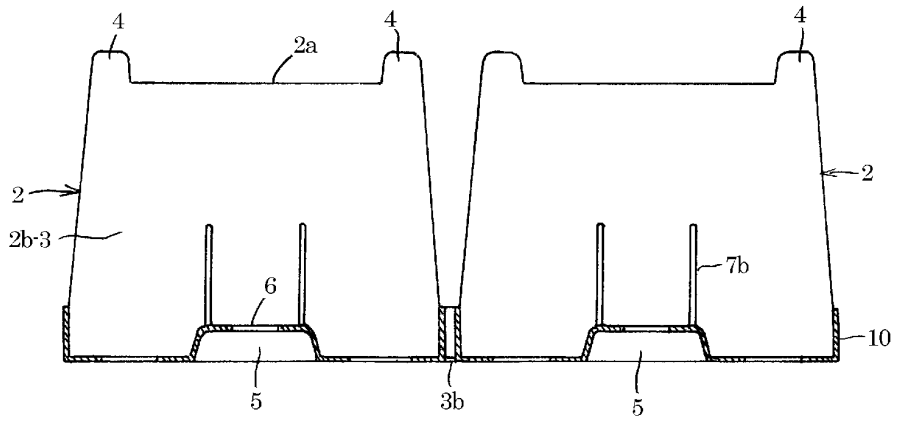


Fig. 9

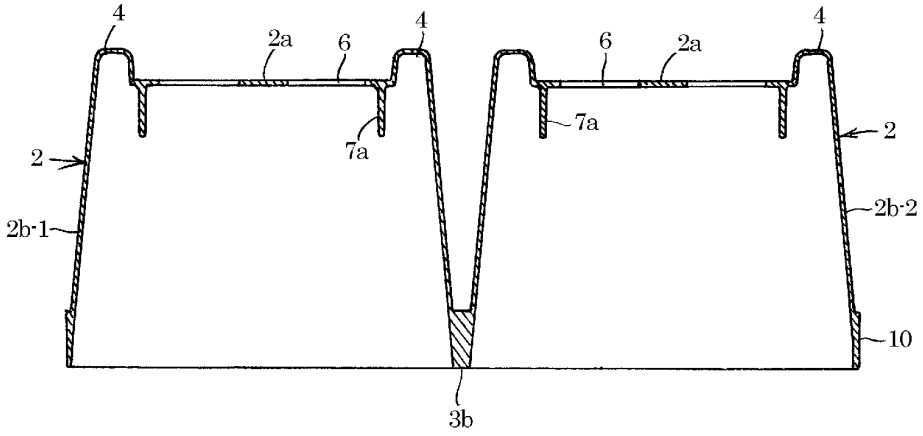


Fig. 10

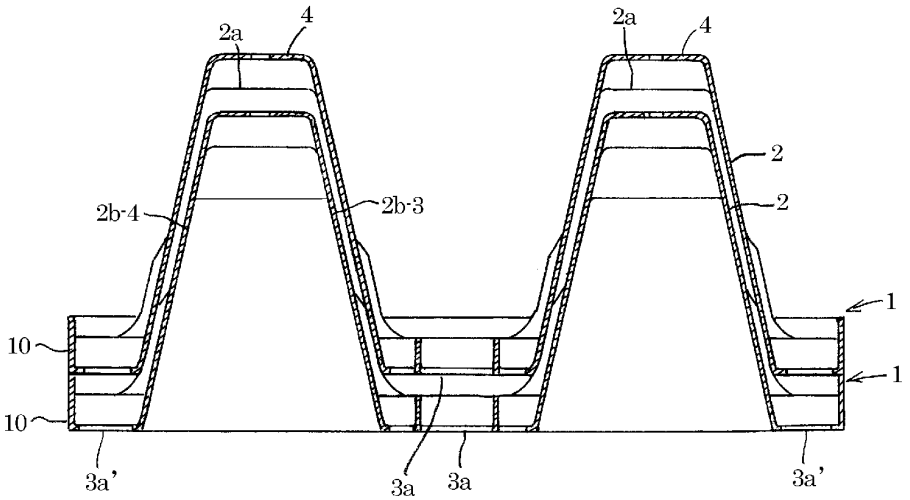


Fig. 11

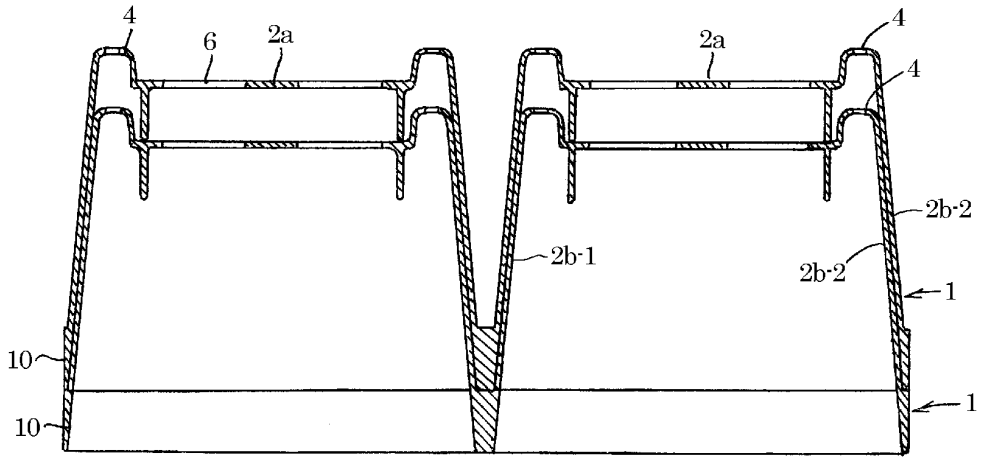


Fig. 12

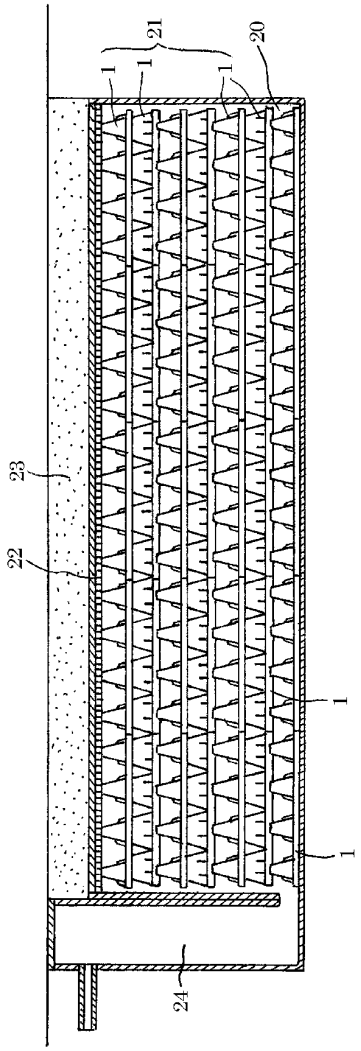


Fig. 13

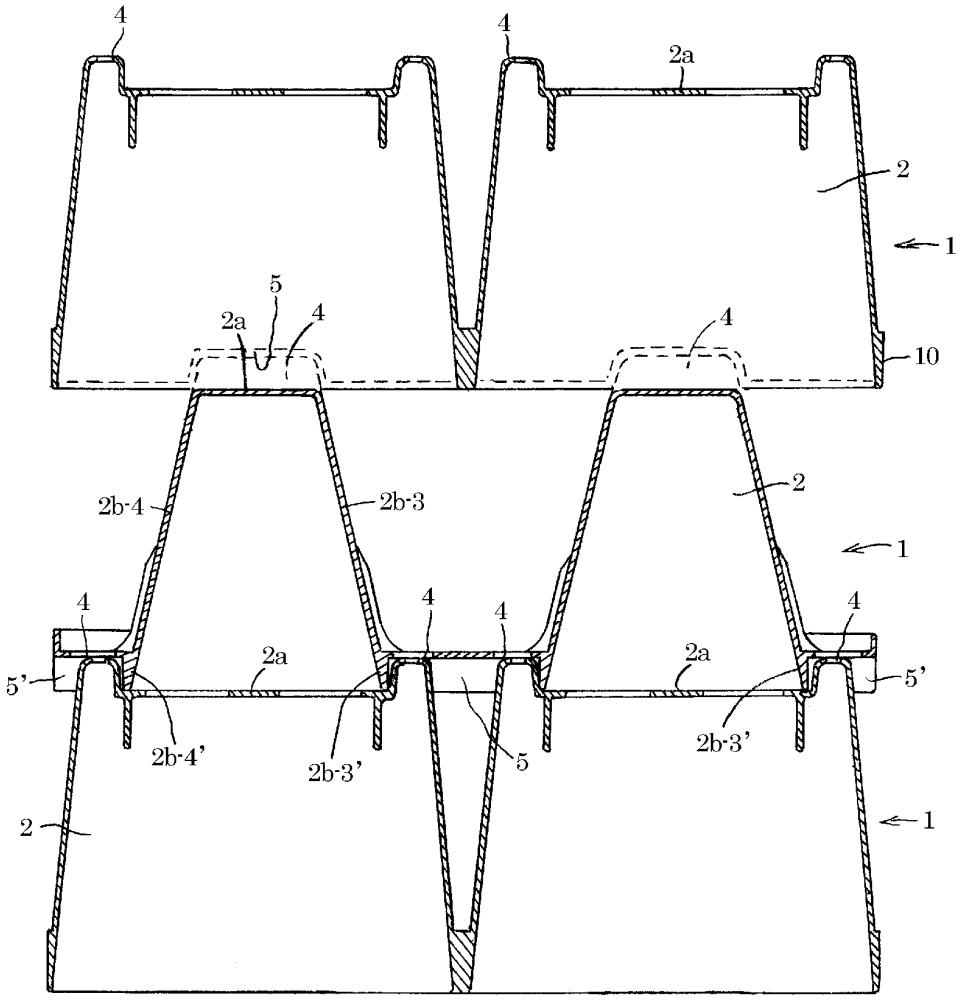


Fig. 14

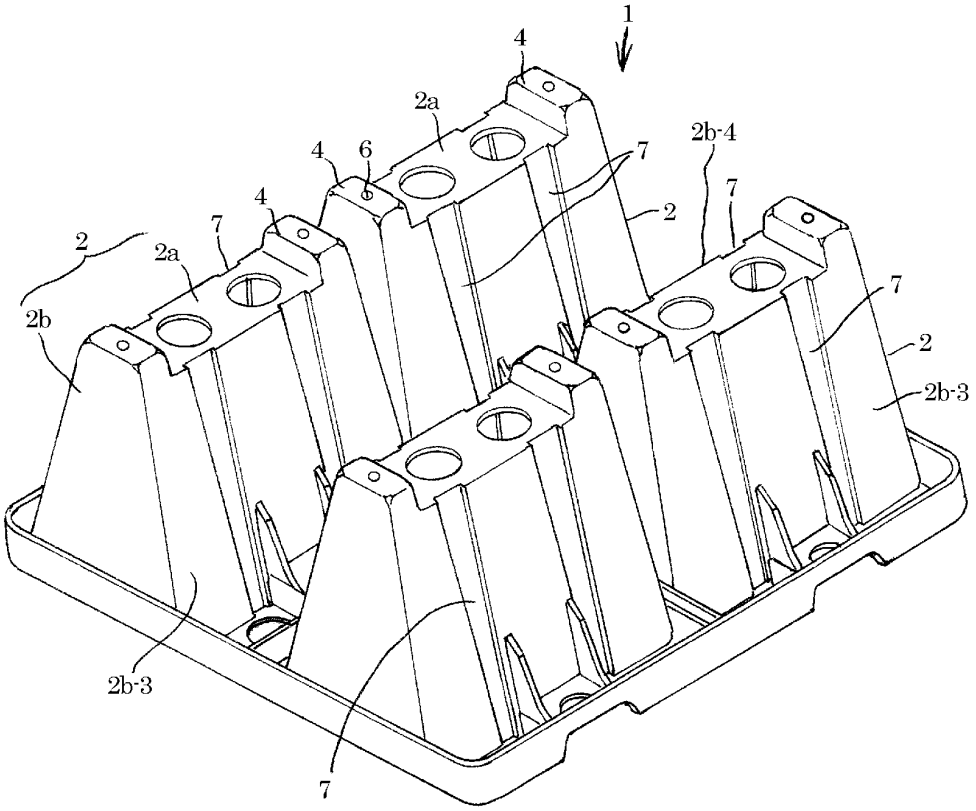


Fig. 15

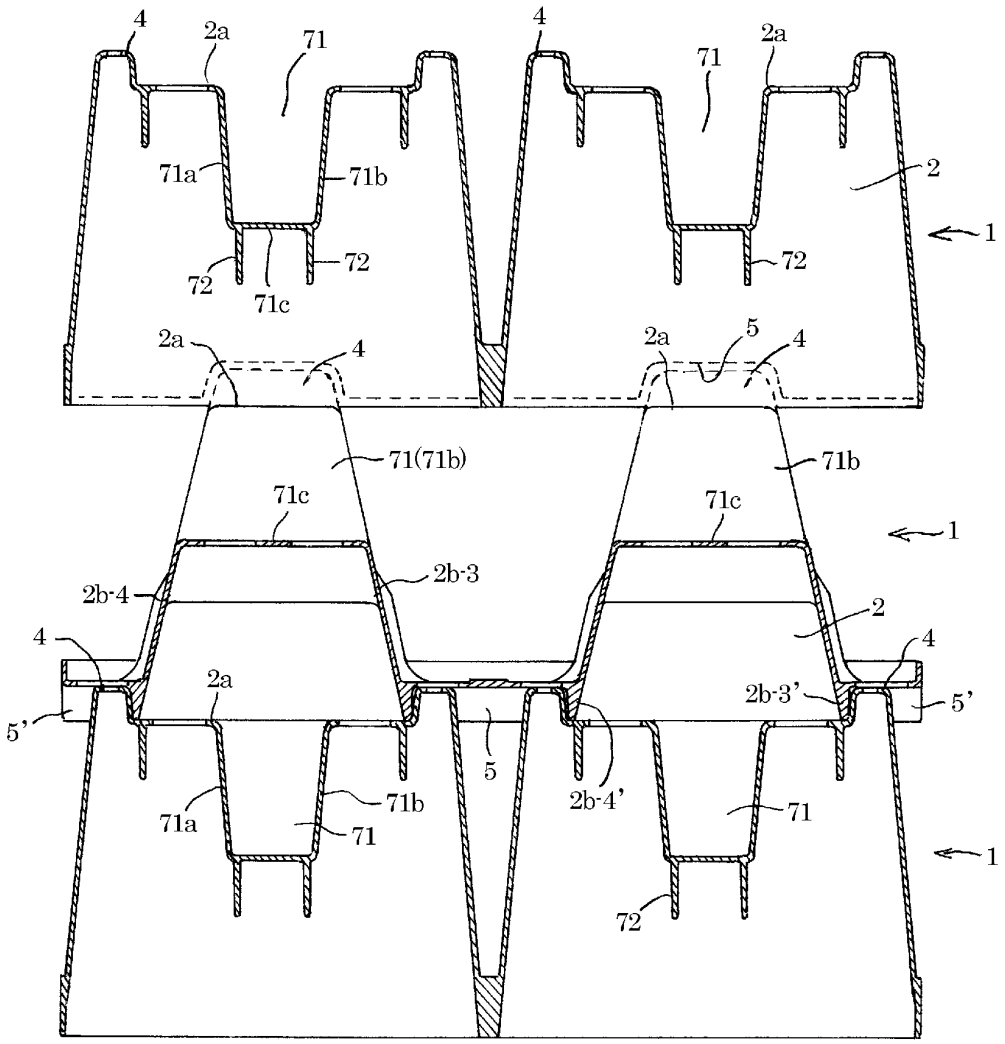


Fig. 16

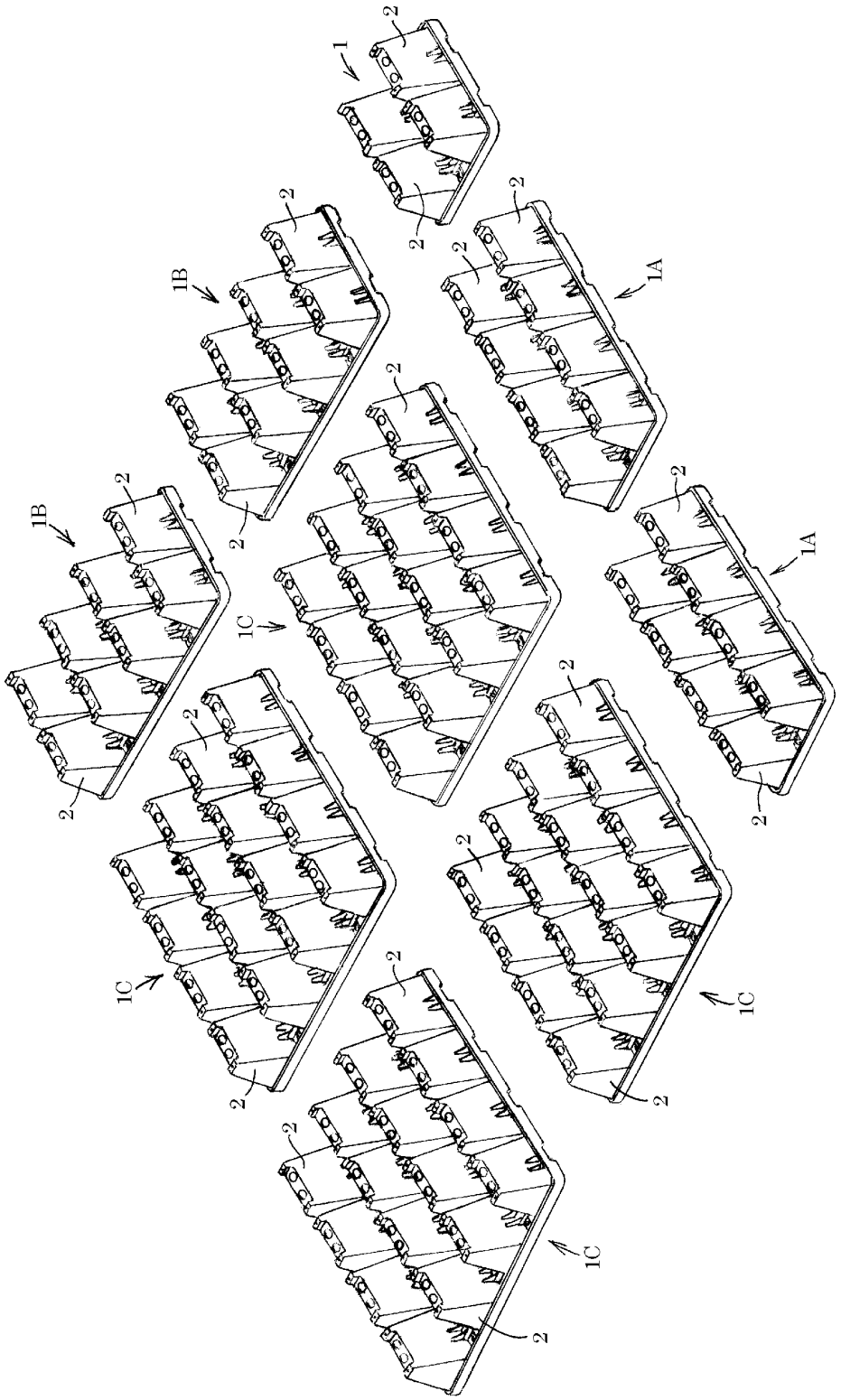
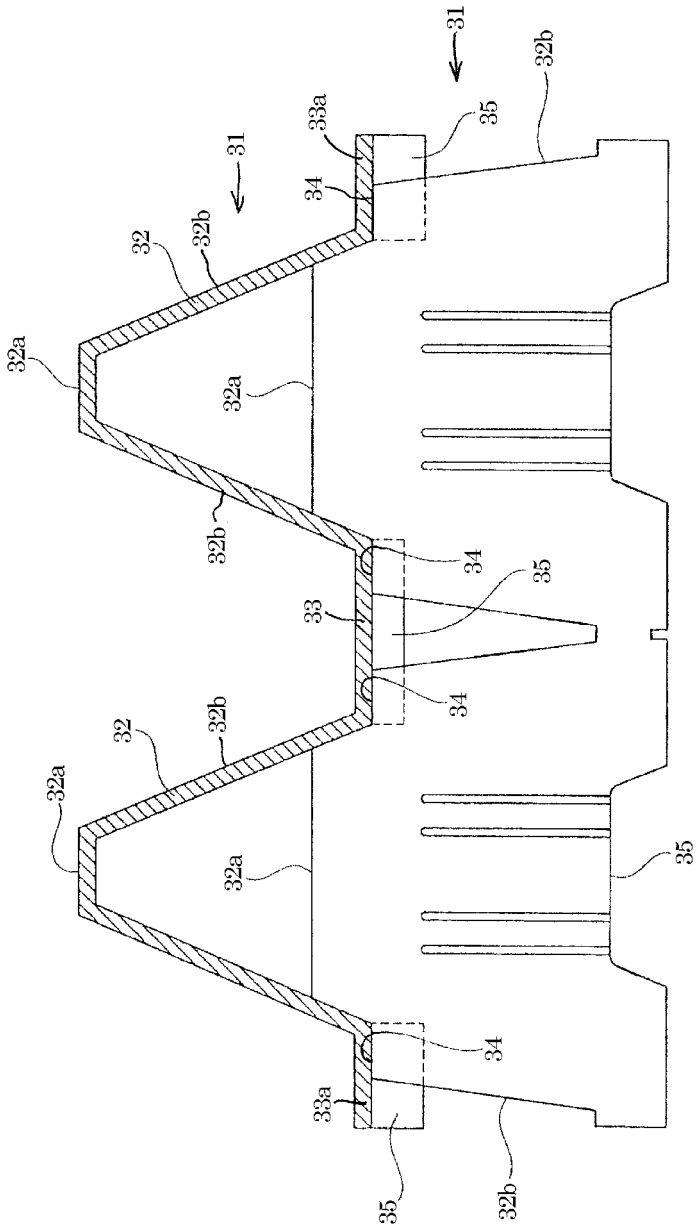


Fig. 17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32b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/059991

A. CLASSIFICATION OF SUBJECT MATTER
E03B3/03(2006.01)i, *E03B11/14*(2006.01)i, *E03F1/00*(2006.01)i

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)
E03B3/02-3/03, E03B11/14, E03F1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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.
A	JP 2009-235784 A (Sekisui Plastics Co., Ltd.), 15 October 2009 (15.10.2009), entire text; all drawings (Family: none)	1-6
A	JP 2008-31645 A (Bridgestone Corp.), 14 February 2008 (14.02.2008), entire text; all drawings (Family: none)	1-6
A	JP 2011-196064 A (Sekisui Techno Molding Co., Ltd.), 06 October 2011 (06.10.2011), entire text; all drawings (Family: none)	1-6

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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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
11 June, 2013 (11.06.13)	18 June, 2013 (18.06.13)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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- JP 2006342520 A **[0010]**
- JP 2009024447 A **[0010]**