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(71) **Demandeur/Applicant:**
SG SCHAUMGLAS GMBH & CO. KG, DE
(72) **Inventeur/Inventor:**
FRANK, WALTER, DE
(74) **Agent:** HEER LAW

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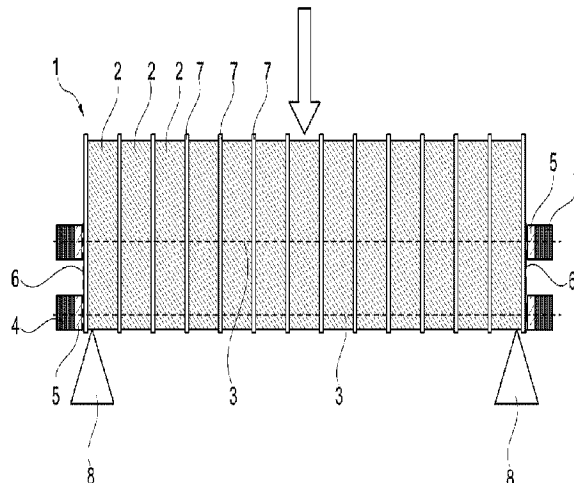


Fig. 1

(57) **Abrégé/Abstract:**

The present invention relates to a composite foam-glass element, and in particular to a composite foam-glass-panel element, having at least one, and preferably more than one, foam-glass body (2; 12; 22; 32; 42, 42a, 42b, 42c, 42d; 52, 52a, 52b, 52c; 62, 62a, 62b, 62c, 62d; 72; 82; 92; 102; 112; 122; 132; 142; 152; 162; 172; 192; 212; 222; 242; 252; 282; 282a; 292, 292a; 302, 302a), and at least one reinforcing element (3, 4, 5, 6, 9; 19; 23, 24, 25; 33, 34, 35, 36; 43, 44, 46, 50; 54, 56, 60; 66, 69, 70; 73, 74, 75, 76, 77, 78, 79; 83, 85, 86, 87, 88; 93, 94, 95, 96; 103, 106, 109; 113; 123; 133; 143, 145, 146, 148, 149; 153, 154, 155, 156, 157; 163, 164, 165, 166, 168, 169; 173, 174, 175, 176, 177, 178, 179, 180; 193, 194, 195, 196, 197; 203, 204, 205, 206, 207; 213, 214, 215, 216; 223, 224, 225, 226; 246, 249; 253), which is arranged such that the one or more foam-glass bodies is or are subjected to compressive stressing, at least along one direction, by the at least one reinforcing element and/or two or more foam-glass bodies are connected to one another by the at least one reinforcing element, and also relates to constructions produced from the composite foam-glass element and to methods for producing the same and the use thereof.



ABSTRACT

The present invention relates to a composite foam-glass element, and in particular to a composite foam-glass-panel element, having at least one, and preferably a plurality of

5 foam-glass bodies
 (2;12;22;32;42,42a,42b,42c,42d;52,52a,52b,52c;62,62a,62b,62c,62d;72;82;92;102;112;
 122;132;142;152;162;172;192;212;222;242;252;282282a;292,292a;302,302a), and at
 least one reinforcing element
 (3,4,5,6,9;19;23,24,25;33,34,35,36;43,44,46,50;54,56,60;66,69,70;73,74,75,76,77,78,7
 10 9;83,85,86,87,88;93,94,95,96;103,106,109;113;123;133;143,145,146,148,149;153,154,
 155,156,157;163,164,165,166,168,169;173,174,175,176,177,178,179,180;193,194,195,
 196,197;203,204,205,206,207;213,214,215,216;223,224,225,226;246,249;253), which
 is arranged such that the one or more foam-glass bodies is or are subjected to com-
 pressive stressing, at least along one direction, by the at least one reinforcing element
 15 and/or two or more foam-glass bodies are connected to one another by the at least one
 reinforcing element, and also relates to constructions made thereof and to methods for
 producing the same and the application thereof.

(Figure 1)

COMPOSITE FOAM-GLASS ELEMENTS AND THEIR APPLICATION

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

- 5 The present invention relates to a composite foam-glass element and, in particular, to a composite foam-glass-panel element having at least one, preferably a plurality of foam-glass bodies or foam-glass panels, as well as to constructions produced therefrom and methods for producing the same and the application thereof.

10 STATE OF THE ART

Foam-glass panels are already known from the state of the art and are mainly used as thermal insulation material. Due to the structure of foam-glass from a plurality of pores surrounded by a glass matrix, foam-glass has excellent properties, in particular thermal insulation properties. Foam-glass has a high compressive strength relative to its weight,
 15 is chemically resistant, can be configured to be water- or vapour-tight when the porosity is closed, is non-flammable and pest-proof, has low thermal conductivity and is extremely durable. Meanwhile, foam-glass panels can also be produced ecologically and sustainably, economically 100% from recycled glass. Panel sizes of 3 m x 1.5 m can already be produced on an industrial scale.

- 20 However, foam-glass has a relatively low tensile strength. In addition, foam-glass is relatively brittle. As a result, the areas of application or use are limited.

In addition, the production of foam-glass panels, i.e. foam-glass bodies with a defined shape and dimensions, which enable a defined arrangement of individual foam-glass bodies, is very complex, since very slow cooling must take place to avoid residual stress
 25 cracks during cooling. Accordingly, foam-glass is also often used as foam-glass ballast with a plurality of foam-glass grains of undefined shape, which is easier to produce for the appropriate reasons and can also be used as a thermal insulation material.

Due to the complex production and the brittle behaviour with low fracture toughness of foam-glass panels, the use of foam-glass panels is still limited despite the outstanding

properties with regard to thermal insulation properties, non-flammability, compressive strength and low specific weight.

DISCLOSURE OF THE INVENTION

5 OBJECT OF THE INVENTION

It is therefore the object of the present invention to improve or broaden the possible applications of foam-glass or foam-glass panels without compromising the existing advantageous properties. In particular, the disadvantageous properties with regard to low tensile strength, in particular in applications with bending stress, are to be overcome or at
10 least reduced.

TECHNICAL SOLUTION

This object is achieved by a composite foam-glass element having the features of claim 1 as well as a construction having the features of claim 19 and a method having the
15 features of claim 25. Advantageous embodiments are the subject matter of the dependent claims.

According to the invention, a composite foam-glass element and in particular a composite foam-glass panel element having at least one, preferably a plurality of foam-glass bodies and at least one reinforcing element is proposed, wherein the at least one reinforcing
20 element is arranged such that the at least one reinforcing element applies a compressive stress to the one or more foam-glass bodies at least along one direction. The application of compressive stresses counteracts possible tensile stresses that could lead to failure of the foam-glass body or bodies, and in the case of a plurality of foam-glass bodies that are pressed against one another in a composite foam-glass element by the reinforcing
25 element, a correspondingly high frictional force is established at the interfaces of the foam-glass bodies, so that the composite foam-glass element has a high overall strength and stiffness. Accordingly, the composite foam-glass element can be used under tensile loads and, in particular, also under bending loads. The composite foam-glass element can replace conventional building materials such as concrete or wood due to its improved
30 mechanical properties compared to simple foam-glass panels. In view of the fact that

cement production has a high energy requirement and releases considerable amounts of CO₂ (approx. 10% of global CO₂ emissions are generated during cement production), the composite foam-glass element according to the invention is very advantageous in terms of energy consumption and CO₂ emissions compared to conventional building materials because, during production, the glass material is not completely melted, but heated to only approx. 800°C in the presence of additives. Foam-glass is also an excellent insulating material and in addition it is not flammable and can be protected from weathering by cladding. It is also significantly lighter than conventional building materials and can therefore be transported and installed with less energy input. Finally, reinforcing elements/tensile elements that run through the foam-glass bodies forming a composite foam-glass element are better protected against thermal material fatigue in the event of a fire.

As a result, the invention offers a forward-looking building material for numerous applications, because the composite foam-glass element according to the invention combines the low energy consumption, low CO₂ generation, thermal insulation, fire resistance and reusability of foam-glass with the mechanical stability (compressive, tensile and flexural strength) required for the construction of buildings.

Foam-glass bodies received in the composite foam-glass element according to the invention can be understood as bodies that are integrally formed from foam-glass and/or have a homogeneous structure, wherein a plurality of enclosed pores are surrounded by a glass matrix. These may be open or closed pores, wherein, when the pores are closed, no fluid such as water, for example, can permeate into the pores from the outside.

The foam-glass bodies of a composite foam-glass element may be configured with varying properties of the foam-glass bodies. For example, the density of the foam-glass bodies may vary such that higher density foam-glass bodies are used in certain areas of the composite foam-glass element, while lower density foam-glass bodies may be used in other areas. Accordingly, the moduli of elasticity of the foam-glass bodies can also be different and adapted to the intended use. Accordingly, different foam-glass bodies can also be used in a composite foam-glass element, which differ in other properties, for example with regard to an open or closed porosity. Thus, in a composite foam-glass element, only the same foam-glass bodies or foam-glass bodies with different properties can be used.

The foam-glass bodies of a composite foam-glass element can all be configured identically in shape and/or size, but different foam-glass bodies, which differ from one another in shape and/or size, can also be received in a composite foam-glass element.

5 The foam-glass body may have a defined shape and dimensions that allow the corresponding foam-glass bodies to be arranged in a defined manner in the composite foam-glass element. In particular, the dimensions can be selected such that composite foam-glass elements can be formed, which are suitable for the design and constructive use for the production of constructions or parts of constructions and in particular of buildings or parts of buildings. Although a wide range of dimensions are possible both for the foam-glass bodies used and for the composite foam-glass elements formed from the foam-glass bodies, the minimum dimensions of a foam-glass body or a composite foam-glass element may be in the range of 1 cm, 5 cm or 10 cm and more, while the maximum dimensions of a foam-glass body or composite foam-glass element may be in the range of some 10 cm, for example 50 cm, 1 m, 2 m, 5 m, 10 m or more. The minimum dimension or minimal dimension of a foam-glass body or a composite foam-glass element represents the dimension of the foam-glass body or the composite foam-glass element that has the smallest extent and can be present, for example, in the thickness or width direction, while the maximum dimension of a foam-glass body or composite foam-glass element is the dimension of the foam-glass body or the composite foam-glass element that has the largest extent and can accordingly define the longitudinal direction.

25 The foam-glass body may be any shaped body, but it has a defined and predetermined shape. In particular, the foam-glass body of a composite foam-glass element according to the invention may have the shape of a cuboid, cuboid-shaped body, cuboid-like body, a cube, a prism, a pyramid, a parallelepiped, a tetrahedron, a polyhedron, a cylinder, a hollow cylinder, a rotational body, a circular body, a disk-shaped body and/or an annular body or the like.

30 The foam-glass body may have at least one planar surface and/or at least two surfaces aligned parallel to one another and/or any three-dimensionally shaped surfaces, of which the surfaces (contact surfaces) of adjacent foam-glass bodies that bear against one another are configured to be complementary to one another, so that they bear against one another in a planar manner, in order thus to be able to form stacks or, in general, bonds of foam-glass bodies for the production of a composite foam-glass element. Accordingly,

opposing surfaces of a foam-glass body may be configured complementary to one another, or the contact surface of a foam-glass body may be adapted to the contact surface of another, differently configured foam-glass body. Correspondingly, other foam-glass bodies can then be arranged on the at least one contact surface. In the case of two or more contact surfaces or planar or complementary surfaces, the foam-glass bodies can be arranged in rows and/or columns on top of one another and/or one behind the other and/or next to one another in order to form different shapes of composite foam-glass elements. Preferably, the surfaces of the foam-glass body can be configured as contact surfaces, which represent the largest surfaces, in order to maximise the mutual frictional force of the contacting foam-glass bodies.

In the case of contact surfaces of the foam-glass bodies that are configured to be complementary to one another, a foam-glass body may have a first contact surface on one side and a second contact surface that is configured to be complementary to the first contact surface on an opposite side, so that a plurality of these foam-glass bodies can be arranged in a bond or stack. The contact surfaces may have projections and/or depressions. If the contact surface is defined by a plane spanned in a Cartesian coordinate system in the x- and y-directions, the projections and/or depressions extend in the z-direction running perpendicular to the xy-plane. In addition to completely arbitrary arrangements of projections and/or depressions, the projections and/or depressions can periodically repeat in one or both directions of the xy-plane, i.e. in the x- or y-direction, so that the contact surfaces may have a undulating or sawtooth or nub-like surface shape.

The foam-glass bodies in a composite foam-glass element can be stacked one on top of the other and/or one behind the other and/or next to one another and/or arranged in the manner of a brickwork, without binders such as are provided, for example, with mortar in brickworks, being placed between the foam-glass bodies. In particular, the foam-glass bodies in the composite foam-glass element may at least partially have no cohesive connection with one another, but preferably no cohesive connection at all, so that a corresponding composite foam-glass element can also be recycled again in a simple manner, since foam-glass bodies and reinforcing elements and their components can easily be separated from one another again.

The type of arrangement of the foam-glass bodies in a composite foam-glass element can take place in different ways. In particular, known types of brickworks may be formed, such as load-bearing bond, stretcher bond, header bond, English bond, cross bond, or

the like. In addition, simple stacks in which the foam-glass bodies are provided in a single-layer or multilayer stack of individual foam-glass bodies arranged on top of one another or in rows are possible. The foam-glass bodies may be arranged in a stack, aligned from row to row, on top of one another and/or staggered relative to one another.

- 5 The foam-glass bodies can at least partially directly and/or directly contact one another in the composite foam-glass element, or at least partially separating elements, for example in the form of sheets or films, can be provided at least partially between adjacent foam-glass bodies. The sheets or foils may be formed from paper, cardboard, rubber or plastic, for example polyisobutylene, textiles such as woven fabrics, crocheted fabrics,
- 10 knitted fabrics, braided fabrics, sewn fabrics, nonwovens and felts or other suitable materials. The separating elements can be configured in such a way that they are elastically or plastically deformable, so that they can penetrate into the rough surface of the foam-glass bodies and, on the one hand, prevent mutually abutting foam-glass bodies from damaging one another and, on the other hand, cause the frictional force between the
- 15 foam-glass bodies to be increased, in order to strengthen the cohesion of the foam-glass bodies in the composite foam-glass element and thus the strength of the composite foam-glass element. The additional stabilisation that can result from the separating elements can be reinforced by the surface structure of the foam-glass bodies. The foam-glass bodies may be cut and preferably ground to obtain a planar surface. Cutting and/or grinding
- 20 results in microcavities (pores) close to the surface being broken up and the remnants of the walls that had enclosed these microcavities protruding sharply from the macroscopically planar surface. The penetration of these microscopic, protruding edges into a separating element arranged on the surface (or between two foam-glass bodies) can cause a hook-and-loop fastener-like static friction between the separating element and the re-
- 25 spective foam-glass body, which can contribute to the stabilisation of wall elements formed from foam-glass bodies stacked one on top of the other against transversely acting forces (arrow in Fig. 1), without the additional use of an adhesive or mortar, so that such wall elements can also be completely dismantled again and the foam-glass bodies can be reused accordingly. That is why the composite foam-glass element is not only
- 30 advantageous for energy reasons, but also a sustainable building material. It should also be noted that concrete slabs require reinforcement in order to be sufficiently resistant to transverse forces. However, a considerable part of the reinforcement is due to the high dead weight of the concrete. In contrast, the composite foam-glass element according to the invention has a very low dead weight or specific weight, so that for this reason alone

the reinforcing elements can be selected with regard to their number and dimensions with a low volume and weight proportion in the composite foam-glass element, wherein, however, the frictional force between the foam-glass bodies forming the composite foam-glass element and the separating elements can additionally bring about resistance to transverse forces due to the high static frictional force, and consequently the proportion of the reinforcing elements can be even lower.

The at least one reinforcing element, which together with one or more foam-glass bodies forms the composite foam-glass element, can also be configured in very diverse forms and, in particular, can be shaped in such a way that it can absorb tensile forces in one or more directions or exert compressive forces on the glass bodies arranged with the reinforcing element. In particular, the at least one reinforcing element of a composite foam-glass element according to the invention may be configured as a band, cable, strand, fibre, wire, strip, strap, bar, rod, profile rod, threaded rod, tube, cylinder, girder, sectional beam, T beam, double T beam, plate, plate with at least partially bent around edges, U profile, frame element, two- or three-dimensional frame element, in particular rectangular or cuboid frame element, yoke, two- or three-dimensional truss, bolt, tensioning element, clamping element, spring, plastically deformable holding elements or the like.

The reinforcing element may be configured as a single component or may be made up of a plurality of components, wherein the components may be formed in particular by the elements listed above. The components of a reinforcing element or a plurality of reinforcing elements can be combined and connected to one another in any suitable manner, wherein positive, non-positive and/or cohesive connections are possible. For example, screw connections, clamp connections, welded or adhesive connections may be established between the reinforcing elements and/or the components of the reinforcing element(s).

The reinforcing elements may be formed from any suitable material and in particular from metallic materials, such as steel, in particular stainless steel, non-rusting steels or other conventional metal alloys. In addition, carbon materials or plastics, such as nylon or polyester, or fibre materials, such as carbon fibres or carbon fibre-reinforced plastics, may be used for the reinforcing elements. Natural materials, such as hemp fibres or the like, as well as other natural materials, such as basalt, stone slabs or the like, are also conceivable. In addition, glass, ceramics or ceramic composites may also be used, for example, to form plate elements or the like.

The at least one reinforcing element may be elastically deformable in order to be able to apply the compressive stresses to the at least one foam-glass body of the composite foam-glass element accordingly. If a plurality of reinforcing elements or and/or reinforcing elements having a plurality of components are used, at least one reinforcing element or
 5 at least one component, preferably a plurality of reinforcing elements or a plurality of components, can be elastically deformable. Accordingly, the at least one reinforcing element or a component thereof may be under tensile stress in the composite foam-glass element.

The at least one reinforcing element may be arranged in the composite foam-glass element in such a way that it runs at least partially through the at least one foam-glass body.
 10 If a plurality of foam-glass bodies are joined to form a composite foam-glass element, the at least one reinforcing element and in particular a plurality of reinforcing elements may likewise run at least partially through the foam-glass bodies, which may have corresponding passages or openings for this purpose. The reinforcing element(s) may also extend
 15 almost completely through the foam-glass body or bodies, with, for example, only small sections protruding from the corresponding foam-glass body in order to be connected to further reinforcing elements, such as, for example, plates. In addition, the at least one reinforcing element may also be arranged along the surface of the at least one foam-glass body.

In particular, a plurality of reinforcing elements of a composite foam-glass element can interact, so that, for example, plates, bands or frame elements arranged on the surface of the foam-glass bodies or the composite foam-glass element are connected to one another by cables, rods, bars, bands, wires or the like running through the foam-glass bodies, and the foam-glass bodies arranged therebetween, through which the reinforcing elements run, are pressed against one another.
 20
 25

To arrange the at least one reinforcing element on the at least one foam-glass body, corresponding receiving areas, such as recesses or the like, may also be provided on the surface of the foam-glass body or bodies. For example, a band provided on the surface as reinforcing element may run in a corresponding groove, so that they can form a smooth
 30 or planar surface of the composite foam-glass element.

The at least one reinforcing element may, in particular, extend annularly around the foam-glass bodies of the composite foam-glass element, wherein the annular reinforcing ele-

ment can compress the foam-glass bodies from all sides. By arranging a plurality of annular reinforcing elements, which may run parallel to one another and/or crosswise to one another, compressive stresses may be built up on the foam-glass bodies from a plurality of, in particular all, sides of the composite foam-glass element, thus creating a compact bond.

The composite foam-glass elements may be designed in a wide variety of shapes similar to the foam-glass bodies that form the composite foam-glass elements, wherein in particular cuboid or cuboid-like designs may be provided. Correspondingly, such composite foam-glass elements have a width, a length and a height, the main surfaces of such a cuboid or cuboid-like composite foam-glass element being spanned by the directions that have the largest dimensions, that is to say, for example, by the height and length or width and length. The other surfaces form corresponding end faces. With such a design of the composite foam-glass elements, the reinforcing elements can preferably be arranged in such a way that the foam-glass bodies are pressed against one another at least in the direction of the largest extent or largest dimensions of the composite foam-glass element, i.e. in the longitudinal direction, i.e., for example, the reinforcing elements in the form of rods, bars, wires, cables or bands extend in the longitudinal direction, and the reinforcing elements in the form of plates or bands, with which the compressive stresses are transmitted to the foam-glass bodies, are correspondingly arranged on the end faces.

The composite foam-glass element may at least partially have a coating and/or a cover on its surface in order to be able to adapt the surface to different areas of application.

In addition, the composite foam-glass element or the foam-glass bodies present on the surface of the composite foam-glass element may have a structured surface, a variety of structures being conceivable. For example, convex and/or concave bulges and/or blind holes and/or steps and/or undercuts and/or sawtooth steps and the like may be provided on the surface of the composite foam-glass element.

A corresponding composite foam-glass element can be used in a variety of applications, for example as a wall and/or ceiling and/or floor element of a construction or a building, as a floating body, as a cladding element, as a tunnel lining element or as a sound insulation element. Further applications are conceivable. A construction is understood to mean any construction that can also be movable.

Accordingly, protection is also claimed for a construction which comprises at least one, preferably a plurality of composite foam-glass elements, in particular of the type described above.

5 For connecting a plurality of composite foam-glass elements in a construction, the construction may comprise at least one, preferably a plurality of connecting elements to which the composite foam-glass elements are connected. The connecting elements may be structured similarly to the reinforcing elements that connect the foam-glass bodies to one another within the composite foam-glass element. In addition, however, further connecting elements, including cohesive connections, are also conceivable. Quite generally, the
10 composite foam-glass elements can be connected to one another in any suitable manner by a non-positive and/or positive and/or cohesive connection.

In particular, the connecting elements may comprise bands, cables, wires, strips, rods, profile rods, threaded rods, plates, plates with at least partially bent around edges, U-profiles, frame elements, two- or three-dimensional, in particular rectangular or cuboid
15 frame elements, yokes, two- and three-dimensional trusses, bolts, tensioning elements, clamping elements, plastically deformable holding elements, and the like.

The connecting elements may be made up of a plurality of components, wherein the components may be formed by components that may also be used as individual connecting elements, as has already been described for the reinforcing elements.

20 Similar to the reinforcing elements of the composite foam-glass elements, the connecting elements can also be elastically deformable and, in particular, can be at least partially under tensile stress in the construction, so that the composite foam-glass elements are in turn connected to one another under compressive stress.

The composite foam-glass elements of the present invention can be used to form a variety
25 of structures or buildings, such as walls, floors and/or ceilings of buildings, noise barriers, pontoons, floating houses, tunnel linings, and the like.

BRIEF DESCRIPTION OF THE FIGURES

The attached drawings show, in a purely schematic way, in

- Figure 1 a first embodiment of a composite foam-glass element according to the invention,
- Figure 2 a perspective view of the embodiment of Figure 1,
- Figure 3 a perspective view of a second embodiment of a composite foam-glass element according to the invention,
- 5 Figure 4 a side view of a third embodiment of a composite foam-glass element according to the invention,
- Figure 5 a side view of a fourth embodiment of a composite foam-glass element according to the invention,
- 10 Figure 6 a partially broken-away illustration of a fifth embodiment of a composite foam-glass element according to the invention,
- Figure 7 a first embodiment of a construction according to the invention in the form of a noise barrier with a plurality of composite foam-glass elements of Figure 6,
- 15 Figure 8 a sixth embodiment of a composite foam-glass element according to the invention similar to the illustration in Figure 6,
- Figure 9 a detailed view of a part of the composite foam-glass element of Figure 8,
- Figure 10 a second embodiment of a noise barrier with a plurality of composite foam-glass elements of Figure 8,
- 20 Figure 11 a seventh embodiment of a composite foam-glass element according to the invention similar to the embodiments of Figures 6 and 8,
- Figure 12 a third embodiment of a noise barrier with a plurality of composite foam-glass elements of Figure 11,
- Figure 13 a perspective illustration of a part of a further composite foam-glass element according to the invention,
- 25 Figure 14 a detailed illustration of the composite foam-glass element of Figure 13,

- Figure 15 a further perspective partial illustration of a composite foam-glass element according to the invention,
- Figure 16 a further perspective partial illustration of a composite foam-glass element according to the invention,
- 5 Figure 17 a further perspective illustration of a composite foam-glass element according to the invention,
- Figure 18 a further perspective illustration of a composite foam-glass element according to the invention,
- 10 Figure 19 a further perspective illustration of a composite foam-glass element according to the invention,
- Figure 20 a further perspective illustration of a composite foam-glass element according to the invention,
- Figure 21 a further perspective, partially broken-away illustration of a composite foam-glass element according to the invention,
- 15 Figure 22 a perspective, partially broken-away illustration of a further composite foam-glass element according to the invention, in which some foam-glass bodies are not shown for clarification,
- Figure 23 a perspective detailed illustration of a part of the composite foam-glass element of Figure 22,
- 20 Figure 24 a perspective, partially broken-away illustration of a further composite foam-glass element according to the invention, in which some foam-glass bodies are not shown for clarification,
- Figure 25 a further perspective illustration of a composite foam-glass element according to the invention, in which some foam-glass bodies are not shown for clarification,
- 25 Figure 26 yet another perspective illustration of a composite foam-glass element according to the invention, in which some foam-glass bodies are not shown for clarification,

- Figure 27 an illustration of the composite foam-glass element of Figure 26 from a different perspective,
- Figure 28 a partial, perspective detailed illustration of the composite foam-glass element according to the invention of Figures 26 and 27,
- 5 Figure 29 a partial, perspective detailed illustration of the composite foam-glass element according to the invention of Figure 28 from a different perspective,
- Figure 30 a perspective illustration of a reinforcing element in the form of a band with a tensioning element,
- Figure 31 a partial, perspective illustration of a composite foam-glass element according to the invention with reinforcing elements according to the embodiment of Figure 30,
- 10 Figure 32 an illustration of a further reinforcing element in the form of an elastically tensionable band with clamping elements for fixing the band,
- Figure 33 an illustration of a further composite foam-glass element according to the invention,
- 15 Figure 34 an illustration of a part of a tunnel lining made of composite foam-glass elements according to the invention,
- Figure 35 a perspective illustration of a composite foam-glass element used as part of the tunnel lining of Figure 34,
- 20 Figure 36 a partial perspective illustration of the composite foam-glass element of Figure 36,
- Figure 37 an illustration of the arrangement of the composite foam-glass elements of Figures 36 and 37 as tunnel lining,
- Figure 38 a further perspective illustration of a composite foam-glass element which can be used as part of a tunnel lining according to Figures 34 and 38,
- 25 Figure 39 a detailed perspective view of the arrangement of composite foam-glass elements of Figures 36, 37 and 39 in a tunnel,

- Figure 40 a further embodiment of a tunnel lining with composite foam-glass elements according to the invention,
- Figure 41 another embodiment of a tunnel lining with further composite foam-glass elements according to the invention,
- 5 Figure 42 an illustration of a composite foam-glass element of the tunnel lining of Figure 42,
- Figure 43 an illustration of a building made of composite foam-glass elements according to the invention
- Figure 44 an illustration of a high-rise building in which the façade is made with the composite foam-glass element according to the invention,
- 10 Figure 45 an illustration of a bond of two different foam-glass bodies with contact surfaces configured to be complementary to one another,
- Figure 46 a further illustration of a bond of two different foam-glass bodies with contact surfaces configured to be complementary to one another,
- 15 Figure 47 another illustration of a bond of two different foam-glass bodies with contact surfaces configured to be complementary to one another, and in
- Figure 48 an illustration of a building on a pontoon, wherein both the building or parts thereof and the pontoon are made of composite foam-glass elements according to the invention.

20

EXEMPLARY EMBODIMENTS

Further advantages, characteristics and features of the present invention will be apparent from the following detailed description of the exemplary embodiments. However, the invention is not limited to these exemplary embodiments.

- 25 Figure 1 shows a first exemplary embodiment of a composite foam-glass element 1 according to the invention, which can be used, for example, as a ceiling or roof element of a building or in any other form as a girder or beam. The composite foam-glass element 1 is mounted at its two ends on two supports 8, and the arrow, which is shown in Figure 1

illustrates that the composite foam-glass element 1 can withstand bending stress due to a load application in the middle between the two supports 8 due to the structure of the composite foam-glass element according to the invention. The composite foam-glass element 1 is made up of a plurality of cuboid foam-glass bodies 2, which are arranged
 5 adjacent to one another, wherein separating elements 7 are provided between the individual foam-glass bodies 2, which can be formed from a compressible, in particular elastically compressible, material, such as a rubber material or rubber-like plastic.

The foam-glass bodies 2 are connected to one another via threaded rods 3, which are inserted through the foam-glass bodies 2 and the separating elements 7. At their ends,
 10 the reinforcing elements or tensile elements in the form of threaded rods 3 have threads, so that a fixing in the form of a nut 4 can be screwed onto the respective thread. By screwing on and tightening the nuts 4, the space between the nuts 4 on the threaded rod 3 can be reduced and the foam-glass bodies 2 and the separating elements 7 are pressed against one another, so that a compressive stress acts on the foam-glass bodies 2 and
 15 the separating elements 7 and the elastically deformable threaded rod 3 is subjected to tensile stress. As already described above, the separating elements cause a considerable static friction to act between the foam-glass bodies without the need for an adhesive or mortar, which is why the composite foam-glass element 1 can be completely disassembled into its components again after the nuts 4 have been loosened, and the foam-glass
 20 bodies and reinforcing elements can then be used again. Accordingly, the composite foam-glass element 1 according to the invention is particularly advantageous from the point of view of sustainability.

In the exemplary embodiment shown in Figure 1, spring elements 5 are also arranged in each case between the nuts 4 and the respective last foam-glass body 2 of the composite
 25 foam-glass element 1, which are likewise tensioned by screwing the nuts 4 to the threaded rods 3 and correspondingly exert a compressive stress on the foam-glass bodies 2 and separating elements 7.

In order not to introduce any stress peaks into the foam-glass bodies 2 or separating elements 7 arranged at the ends of the composite foam-glass element 1 by means of the
 30 nuts 4 and/or the spring elements 5, a pressure distribution plate 6 is arranged in each case on the surfaces of the composite foam-glass element 1 in order to distribute the compressive stress applied to the foam-glass bodies 2 or the separating elements 7 by the nuts 4 by screwing to the thread of the threaded rods 3 and/or by the spring elements

5 over a larger area on the surface of the foam-glass bodies 2 or separating elements 7 attached to the ends of the composite foam-glass element 1.

The threaded rods 3 can be guided directly through openings in the foam-glass bodies 2 and separating elements 7, or guide elements, such as tubes, may be provided, in which
5 the threaded rods 3 can be received. Accordingly, other reinforcing elements, such as cables or the like, may also be used instead of threaded rods 3.

As can be seen from Figure 1, in the exemplary embodiment shown, the reinforcing elements in the form of the threaded rods 3 in conjunction with the nuts 4, the spring elements 5 and the pressure distribution plates 6 are arranged in the lower region of the
10 composite foam-glass element 1 shown as a cantilever, so that in the region in which the greatest tensile stresses occur in the event of bending according to the load illustrated by the arrow, there is a counter-tension in the form of a compressive stress due to the prestress via the reinforcing elements 3, 4, 5 and 6. This compressive prestress compensates for the tensile stress applied by the bending in this area. Accordingly, despite the
15 brittle foam-glass material, there is no failure of the component.

Figure 2 shows the composite foam-glass element 1 with a plurality of foam-glass bodies 2 and the reinforcing elements/tensile elements 9 in the form of threaded rods 3, nuts 4, spring elements 5 (not shown separately in Fig. 2) without the arrangement of the pressure distribution plates 6 in a further perspective illustration in the arrangement on the
20 supports 8. It can be seen here that the number of reinforcing elements 9 may be higher in the lower region of the composite foam-glass element 1 than in a central region.

Figure 3 shows a further embodiment of a composite foam-glass element 11 according to the invention having a plurality of foam-glass bodies 12 which are arranged next to one another and one behind the other, the arrangement of the foam-glass bodies 12 in the
25 respective rows being staggered relative to one another, so that a so-called brickwork is provided, but without a cohesive connection of the foam-glass bodies 12 being provided by any binder. In addition, in the composite foam-glass element 11, reinforcing elements/tensile elements 19 are arranged in both the longitudinal direction L and the width direction B, so that the foam-glass bodies 12 are arranged under compressive stress in
30 both the longitudinal direction L and the width direction B, and pressure distribution plates 16 are provided on both the broad sides and the long sides.

Figure 4 shows a further embodiment of a composite foam-glass element 21 according to the invention, similar to the illustration in Figure 1. Here, too, a plurality of cuboid foam-glass bodies 22 are arranged next to one another and are separated from one another by separating elements 27 arranged between the foam-glass bodies. Instead of the threaded rods 3 running through the foam-glass bodies 2, as used in the composite foam-glass element 1 of Figure 1, however, the foam-glass bodies 22 of the composite foam-glass element 21 and the separating elements 27 are connected by a reinforcing element provided on the outside of the composite foam-glass element 21, which reinforcing element has a band 23 in the form of a tensile band/tensioning band with a fixing in the form of a tensioning element 24, by means of which the band 23 can be tensioned tightly and under tensile stress around the foam-glass bodies 22 and the separating elements 27, so that these in turn bear against one another under compressive stress. In order to distribute the pressure that acts on the foam-glass bodies 22 and the separating elements 27 through the band 23 and the tensioning element 24, pressure distribution profiles 25 in the form of L-shaped profiles are provided at the corners, which extend along an edge of the composite foam-glass element 1. Alternatively, individual pressure distribution plates can also be used. Also, in such a design as shown in Fig. 4, the composite foam-glass element 21 can withstand bending stress as represented by the support of the composite foam-glass element 21 on the supports 28 and the load application by the arrow in Fig. 4.

Figure 5 shows a further composite foam-glass element 31 in the form of a wall element. Here, too, a plurality of foam-glass bodies 32 are arranged on top of one another, separated from one another by separating elements 37, and are connected via reinforcing elements/tensile elements in the form of threaded rods 33, which are screwed at their ends to fixings in the form of nuts 34 (only one threaded rod 33 is shown, but a plurality of threaded rods 33 are arranged one behind the other in the direction perpendicular to the plane of the drawing). Spring elements 35 and pressure distribution plates 36 in turn apply compressive stress to the foam glass bodies 32 and separating elements 37. Such a wall element 31 can also withstand shear stresses, as indicated by the arrow in the lower region of the composite foam-glass element 31, since the foam-glass bodies 32 and the separating element 33 are firmly connected to one another by the compressive stress applied via the reinforcing elements 33, 34, 35, 36. Accordingly, such a foam-glass composite element can also be used for earthquake-proof buildings in which, in particular, shear forces have to be absorbed. However, since the composite foam-glass element 31

in the form of a wall element has to transfer lateral forces, such as shear forces, from both sides, the reinforcing elements in the form of threaded rods 33, nuts 34, tensioning elements 35 and pressure distribution plates 36 are arranged in the centre of the composite foam-glass element 1 in order to achieve a symmetrical arrangement.

- 5 Figure 6 shows a fifth exemplary embodiment of a composite foam-glass element 41 according to the invention, which is configured as part of a noise barrier. The composite foam-glass element 41 has a plurality of foam-glass bodies 42, 42a, 42b, 42c, 42d, which have a cuboid basic shape and are stacked on top of one another. The composite foam-glass element 41 of the embodiment shown in Figure 1 has various foam-glass bodies
10 42, 42a, 42b, 42c, 42d, which differ in shape.

The foam-glass body 42, which is the uppermost foam-glass body in the illustration of Fig. 1, has sloping surfaces at the upper longitudinal edges, so that the foam-glass body 42 forms a roof structure.

- Below the foam-glass body 42 that is arranged as the uppermost foam-glass body of the
15 composite foam-glass element 41, there is a foam-glass body 42a, which has a concave recess 47 on a longitudinal side. A foam-glass body 42b having a convex bulge 48 is arranged below the foam-glass body 42a having the concave recess 47, resulting in an S-shaped surface in combination with the foam-glass bodies 42a and 42b. Furthermore, a plurality of foam-glass bodies 42a and 42b are alternately arranged on top of one an-
20 other, so that the composite foam-glass element 41 has a surface with a wave shape. This, together with blind holes, which can be made in the surface, provides for reflection and absorption of sound waves and thus for sound insulation. Sound insulation can also be improved if the foam-glass bodies 42, 42a, 42b, 42c, 42d are configured with an open porosity.

- 25 Further foam-glass bodies 42c, 42d with different shapes are arranged in the lower region of the composite foam-glass element 41. The foam-glass body 42c has a groove 49 along its longitudinal side, while the foam-glass body 42d is configured as a cuboid-shaped foam-glass body. In the composite foam-glass element 41 shown in Figure 6, two foam-glass bodies 5 and 6 are arranged alternately in each case.

- 30 All foam-glass bodies 42, 42a, 42b, 42c, 42d are arranged on a base plate 50, which can be made, for example, of a metal plate.

Opposite the base plate 50, a cover plate or pressure distribution plate 46 is arranged on the uppermost foam-glass body 42, which is connected to the base plate 50 via reinforcing elements/tensile elements in the form of threaded rods 43. For clarification, in the illustration of Figure 6, the lowermost foam-glass body and two foam-glass bodies are shown spaced apart in the upper region, in order to show the threaded rods 43, even if this is of course not the case in the real composite foam-glass element 41. The threaded rods 43 each have a thread at their ends, and the base plate 50 may have corresponding threaded holes into which the rods 43 are screwed. The foam-glass bodies 42, 42a, 42b, 42c, 42d have corresponding openings through which the rods 43 are guided, wherein the cover plate 46 also has openings so that the rods 43 protrude with their respective threads at their ends through the openings of the cover plate 46. The ends of the rods 43 are screwed to fixations in the form of nuts 44, so that the cover plate 46 is pressed against the foam-glass bodies 42, 42a, 42b, 42c, 42d and the entire stack of foam-glass bodies 42, 42a, 42b, 42c, 42d is tensioned via the rods 43 and the base plate 50 as well as the cover plate 46 and the screw connections with the nuts 44, so that the foam-glass bodies 42, 42a, 42b, 42c, 42d are placed under compressive stresses, while a tensile stress acts on the rods 43.

The composite foam-glass element 41, which is shown in Figure 6, has in each case one foam-glass body 42, 42a, 42b, 42c, 42d above the other, but instead of a single foam-glass body 42, 42a, 42b, 42c, 42d, a plurality of foam-glass bodies of the same type can also be provided next to one another in a row.

Figure 7 shows a plurality of composite foam-glass elements 41 of Figure 6 in a wall arrangement next to one another, so that a complete noise barrier 45 is formed, wherein the individual composite foam-glass elements 41 of Figure 1 are placed in line next to one another. In this case, the composite foam-glass elements 41 may simply be placed next to one another or may be mutually connected to one another, for example by horizontally extending connecting elements which penetrate the composite foam-glass elements 41 similarly to the rods 43 or extend along the surfaces of the composite foam-glass elements 41.

Figure 8 shows a further exemplary embodiment of a composite foam-glass element 51, which substantially corresponds to the composite foam-glass element 41 of the exemplary embodiment of Figure 6. Instead of the foam-glass bodies 42a and 42b of the composite foam-glass element 41 of Figure 6, in the composite foam-glass element 51 of

Figure 8, a plurality of identical foam-glass bodies 52a are arranged on top of one another, which in turn have a cuboid basic shape, but on one of their longitudinal sides have an slopping surface 58, which results in the base area of the foam-glass body 52a being smaller than the upper side, so that a sawtooth-like surface of the composite foam-glass element 51 results in the foam-glass bodies 52a stacked on top of one another. Such a surface, in turn, together with possible further surface structures such as blind holes or the like, is used to reflect and/or absorb sound waves in order to form a noise protection element. As in the case of the composite foam-glass element 41, the individual foam-glass bodies 52, 52a, 52b, 52c are screwed together and tensioned via the cover plate 56 and the base plate 60 as well as the rods (not shown).

The detailed view of a part of the composite foam-glass element 51 in Figure 9 shows the fixings in the form of nuts 54 to which the threaded rods (not shown), which run through the foam-glass bodies 52, 52a, and the cover plate or pressure distribution plate 56 and the foam-glass bodies 52, 52a are screwed. In addition, Figure 9 shows the blind holes 59, which are made in the foam-glass bodies 52a to improve the reflection and/or absorption of sound waves.

Figure 10 shows a noise barrier 55 similar to the noise barrier 45 of Fig. 7, which is formed from a plurality of composite foam-glass elements 51.

Figure 11 shows a further exemplary embodiment of a composite foam-glass element 61, which is formed by a plurality of foam-glass bodies 62, 62a, 62b, 62c, 62d stacked one on top of the other. The exemplary embodiment of Figure 11 differs from the exemplary embodiments of Figures 6 and 8 in that instead of the foam-glass bodies 42a and 62b of the exemplary embodiment of Figure 6 and the foam-glass bodies 52a of the exemplary embodiment of Figure 3, foam-glass bodies 62a and 62b having different widths and base areas, respectively, the foam-glass bodies 62a and 62b are alternately stacked on top of one another, so that when one of the longitudinal sides of the foam-glass bodies 62a and 62b is aligned, recesses 67 and projections 68 result on the opposite side on the surface of the composite foam-glass element 61, the recesses 67 and projections 68 each being of cuboidal configuration. Correspondingly, a structured surface of the composite foam-glass element 61 is also configured here, which in turn provides for sound reduction by reflection and/or absorption of sound waves.

Figure 12 shows a corresponding noise barrier 65 similar to the noise barriers 45, 55 from the exemplary embodiments of Figures 7 and 10, with a plurality of foam-glass composite elements 61 arranged next to one another.

Figure 13 shows a perspective partial illustration of a further embodiment of a composite foam-glass element 71 according to the invention, in which a plurality of cuboid-shaped foam-glass bodies 72 are held together via different reinforcing elements, which act in different directions. Firstly, on the main surfaces of the composite foam-glass element 71, which are spanned by the width and length of the composite foam-glass element 71, truss elements 73 are provided, which are connected to one another via tensile elements in the form of tension wires 74 running through the foam-glass bodies 72, so that the foam-glass bodies 72 are tensioned together in the height direction H. In addition, two U-profiles 75, 76, which are connected to one another via cross braces 77, are arranged along the longitudinal direction L of the composite foam-glass element 71. The U-profiles 75, 76 provided on both longitudinal sides of the composite foam-glass element 71 are connected via reinforcing elements /tie rods in the form of threaded rods 79, which are screwed to nuts 78 on the U-profiles, so that the foam-glass bodies 72 are likewise tensioned together in the width direction.

Figure 14 shows the reinforcing elements in the form of the U-profiles 75, 76 and the cross braces 77 as well as the threaded rod 79 and nuts 78 in greater detail.

A corresponding composite foam-glass element 71 can be used as a wall element, floor or ceiling element in a plurality of applications and, in particular, in the erection of a plurality of constructions or buildings. For example, composite foam-glass elements 71 of this type can be used to form floating bodies, so-called pontoons, or to erect buildings.

Figure 15 shows a further exemplary embodiment of a composite foam-glass element 81 according to the invention, in which U-profiles 85, 86 are in turn arranged on the longitudinal sides, which are connected via reinforcing elements/ tensile elements in the form of threaded rods 87, which are screwed to nuts 88. As the exemplary embodiment of Figure 15 shows, U-profiles of any shape may be used, such as the U-profiles 85, 86 shown in Figure 15, with a base dimensioned large compared to the strips, so that the U-profiles 85, 86 are configured to be plate-like.

It can also be seen from Figure 15 that in the composite foam-glass element 81, in which the foam-glass bodies 82 are already tensioned over the longitudinal sides with reinforcing elements in the form of U-profiles 85, 86 and threaded rods 87 and nuts 88, the broad sides of the composite foam-glass element 81 are additionally also connected and tensioned via reinforcing elements, i.e. a connection and bracing of the foam-glass bodies 82 is present in a direction transverse to the direction of the longitudinal axis of the threaded rods 87. In the exemplary embodiment of Figure 15, trusses 83 are provided on the broad sides for this purpose, which are in turn connected to one another via tensioning wires (not shown).

A further embodiment of a composite foam-glass element 91 according to the invention is shown in a partial perspective view in Figure 16. The composite foam-glass element 91 comprises a plurality of foam-glass bodies 92, which in turn are arranged on top of one another and next to one another in a cuboid structure. As already in the preceding exemplary embodiments, the foam-glass bodies 92 of the composite foam-glass element 91 are tensioned against one another via reinforcing elements in the form of trusses 93, 94 on the main surfaces and broad sides of the composite foam-glass element 91 and tension wires (not shown) arranged between the respective trusses 93, 94, while double-T beams 95, 96 are arranged on the longitudinal sides of the composite foam-glass element 91, which in turn are connected via threaded rods and nuts (not shown in more detail) and press and brace the foam-glass bodies 92 arranged therebetween against one another. In addition to the reinforcing elements already known from the preceding embodiments, such as trusses, threaded rods, tensioning cables and the like, this embodiment thus has double T-beams 95, 96 on one end face, which in turn are tensioned via threaded rods or tensioning cables or the like with opposite reinforcing elements, such as, for example, also double T-beams, in order to apply a compressive stress to the foam-glass bodies 92 located therebetween.

Figure 17 shows a composite foam-glass element 101, in which a plurality of cuboid-shaped foam-glass bodies 102, which are arranged next to one another and on top of one another, on the one hand, have double T beams 106 peripherally on the side surfaces by means of trusses 103 on the top and bottom and on the side surfaces and corresponding reinforcing elements for connecting the mutually opposite trusses 103, which in turn are tensioned via reinforcing elements 109 to the opposite double T beams 106, so that the foam-glass bodies 102 are held under compressive stress on all sides.

Figures 18, 19 and 20 show various composite foam-glass elements 111, 121 and 131 with different dimensions, but which otherwise have an identical structure with a plurality of cuboid-shaped foam-glass bodies 112, 122, 132 and trusses 113, 123 and 133 arranged opposite one another on the surface sides, the trusses 113, 123 and 133 arranged on opposite surface sides in turn being connected to one another via bars, rods, cables or the like, which run through the foam-glass bodies 112, 122, 132, in such a way that the foam-glass bodies 112, 122 and 132 located therebetween are each held under compressive stress.

A further composite foam-glass element 141 is shown in Figure 21, wherein, in the perspective view of the composite foam-glass element 141, a part of a cover 147 is cut open on a main surface of the composite foam-glass element 141, and a part of the foam-glass bodies 142 is not illustrated, in order to make visible the reinforcing elements/tensile elements in the form of threaded rods 143 running through the composite foam-glass element 141, which run through the composite foam-glass element 141 in both the longitudinal (L) and width (B) directions. As already illustrated in the preceding embodiments of the composite foam-glass elements, the composite foam-glass element 141 comprises a plurality of cuboid-shaped foam-glass bodies 142, which are stacked next to one another and on top of one another to form a wall element. At the end faces of the composite foam-glass element 141, pressure distribution plates 145, 146 are provided peripherally, and are connected and tensioned via reinforcing elements/tensile elements 148, 149 to the respectively opposite pressure distribution plates 145, 146, so that compressive stresses are exerted on the foam-glass bodies 142. The threaded rods 143 running inside the composite foam-glass element 141 are part of the reinforcing elements/tensile elements 148, 149.

The exemplary embodiment of Figure 21 further shows that a cover 147 is provided on a surface of the composite foam-glass element 141, namely one of the main surfaces of the composite foam-glass element 141, which is spanned by the length (L) and width (B) direction, so that the composite foam-glass element 141 may have any surface. All suitable materials, such as steel, plastic, plasterboard and the like, can be used as materials for such covers, which can also be designed as coatings. Of course, such covers can be provided on all or only on individual surfaces of a composite foam-glass element and on all embodiments of composite foam-glass elements.

Figure 22 shows a further example of a composite foam-glass element 151 according to the invention which is formed from a plurality of foam-glass bodies 152 which are clamped to one another via reinforcing elements/tensile elements in the form of side plates 155, 156 and bars 153, 154. The composite foam-glass element 151 of the embodiment shown in Figure 22 further has a cover (or cladding or façade) 158 that covers a major surface of the composite foam-glass element 151. In order to illustrate the foam-glass bodies 152 and the bars 153, 154 that connect the side plates 155, 156 of the composite foam-glass element 151 on opposite sides, the cover 158 is omitted in a central region and, in addition, some foam-glass bodies 152 are also not illustrated.

The bars 153 connect the side plates 156 arranged on opposite sides of the cuboid composite foam-glass element 151, while the bars 154 extending horizontally in the illustration of Figure 22 connect the side plates 155 arranged on opposite sides of the composite foam-glass element 151. The bars 153, 154 are connected to the side plates 155, 156 via fixations in the form of screw connections 157, wherein a wide variety of designs of the screw connections are conceivable, such as, for example, an arrangement of nuts, which are screwed to the bars 153, 154 inserted through openings in the side plates 155, 156, or threaded holes in the side plates 155, 156, into which the bars 153, 154 are screwed with threads at their ends.

Figure 23 shows a portion of the composite foam-glass element 151 of Figure 22 from a different perspective, illustrating how the cover 158 may be arranged on one of the major surfaces. In the illustration of Figure 23, the cover 158 is raised from the main surface, so that the bars 153, 154 lying behind it, which connect the opposite side plates 155, 156 and thus press the foam-glass bodies 152 located therebetween against one another, can be seen.

The cover 158 can be formed from any suitable material, such as plastic or metal, and can be connected to the composite foam-glass element 151 or the foam-glass bodies 152 and the reinforcing elements in the form of the side plates 155, 156 and bars 153, 154 by suitable joining techniques. For example, the cover 158 may be arranged by a cohesive connection, in particular by gluing or welding.

The bars 153, 154 have screw connections 157, wherein, in the exemplary embodiment shown, the bars 153, 154 have threads at their ends, wherein the bars 153, 154 passed through openings in the side plates 155, 156 are screwed to a nut.

The side plates 155 and 156 as well as the bars 153, 154 may be formed from any suitable material, in particular metallic materials and in particular steel materials or the like being suitable here.

5 A combination of the composite foam-glass elements 141 and 151 is made in the composite foam-glass element 161, which is shown in a perspective view in Figure 24, in turn a part of the cover 167 being cut open and a part of the foam-glass bodies 162 being omitted in order to illustrate the arrangement of the reinforcing elements/tensile elements in the form of the inner and outer threaded rods 163, 164. As has already been shown in the preceding exemplary embodiments, at least parts of the reinforcing elements, such as threaded rods, tensioning cables or the like, can run inside the composite foam-glass element and in particular through the foam-glass bodies. However, it is also possible for reinforcing elements to be arranged entirely or predominantly on the surfaces of the composite foam-glass element or the foam-glass bodies. However, it is also possible to combine the inner and outer arrangement of the reinforcing elements with one another, as shown in Figure 24 by way of example for the composite foam-glass element 161. In order to connect the pressure distribution plates 165, 166, which are located peripherally on the end faces or side faces, to the respectively opposite pressure distribution plate 165, 166, both reinforcing elements/tensile elements 168, 169 are provided, which run predominantly through the foam-glass bodies 162 and along the surface of the foam-glass bodies 162. As can be seen in Figure 24, internal threaded rods 163 are located inside the composite foam-glass element 161, while external threaded rods 164 running along the surface of the foam-glass bodies 162 are arranged on the surface of the foam-glass bodies 162, wherein both internal and external threaded rods 163, 164 are in turn screwed to the pressure distribution plates 165, 166 in order to exert compressive stresses on the foam-glass bodies 162. The external threaded rods 164 may be covered by the cover 167.

Figure 25 shows a further embodiment of a composite foam-glass element 171 according to the invention, which is constructed in principle similar to the preceding composite foam-glass element 151. The composite foam-glass element 171 differs from the composite foam-glass element 151 only in that the side plates 175, 176 are not configured as planar side plates, such as the side plates 155, 156, but have rounded and angled regions at their longitudinal edges, which engage around the main surfaces of the composite foam-glass element 171. Accordingly, the reinforcing elements in the form of reinforcing elements/tensile elements 173, 174 may be arranged on these angled regions, for example

by being hooked in or extending through corresponding openings. The reinforcing elements/tensile elements 173, 174, which in turn connect the respective opposite side plates 175, 176, are correspondingly elastically tensioned, so that the side plates 175, 176 press the foam-glass bodies 82 located therebetween against one another.

5 A further composite foam-glass element 191 similar to the previous exemplary embodiments of Figures 21 to 25 is shown in Figure 26. The composite foam-glass element 191 also has side plates 193, 194, which have rounded and angled regions at their longitudinal edges, which are angled transversely to the base surface of the corresponding side plates 193, 194 and embrace the main surfaces. However, wires (or round steel or the like) 195,
10 196 are provided as reinforcing elements, which extend annularly peripherally around the composite foam-glass element 191, extending over the two main surfaces and the opposite side surfaces of the composite foam-glass element 191, on which the side plates 193, 194 are arranged. For ring closure, a tensioning screw connection or tensile element 197 is provided at the two ends of each wire 195, 196, by means of which the threaded ends
15 of the respective wire 195, 196 can be pulled toward one another and thus tensioned. The tensioned wires 195, 196 press the opposite side plates 193, 194 against the foam-glass bodies 192 located therebetween and tension them to form the composite foam-glass element 191 according to the invention.

Figures 27 to 29 show the composite foam-glass element 191 from different perspectives
20 in greater detail, so that the principle and structure of the tensioning screw connection 197 and the rounded and angled longitudinal edges of the side plates 193, 194 are clearly recognisable.

Figure 30 shows a further exemplary embodiment of a tensioning screw connection 177, which can also be used in the composite foam-glass element 191 from Figures 26 to 29
25 for the screw connection and tensioning of the wires 195, 196. Figure 30 clearly shows the annular arrangement of a band 173, which has an insert receptacle 178 and a threaded receptacle 179 at its ends, which interact with a bolt 180. The bolt 180 is inserted through the insert receptacle 178 and engages in a thread of the threaded receptacle 179, so that the ends of the band 173 connected to the insert receptacle 178 and the
30 threaded receptacle 179 are moved toward one another when the bolt is screwed into the threaded receptacle 179, and thus the band 173 can be tensioned about a composite foam-glass element (not shown).

Figure 31 shows a further exemplary embodiment of a composite foam-glass element 201, which, similar to the preceding exemplary embodiments, has side plates 203, 204 on the end faces of the composite foam-glass element 201, which have angled and rounded regions on their longitudinal edges, which are angled in the direction of the main surfaces of the composite foam-glass element 201 and engage around them. Similar to the wires 195, 196 of the composite foam-glass element 191, a plurality of parallel bands 205, 206 extend around the composite foam-glass element 201, which press the side plates 203, 204 located on opposite end faces against the foam-glass bodies arranged therebetween. For the ring closure of the bands 205, 206, a clamping element is provided in each case, which is shown in Figure 32 with a corresponding band 206. The ends of the band 206 are passed through a laterally slotted sleeve so as to overlap, subsequently compressing the sleeve so as to press the ends of the band 206 together. The resulting frictional engagement between the ends of the band 206, which is maintained by the clamping element 207 due to the plastic deformation of the clamping element 207, allows a secure ring closure of the band 206 to be achieved. In order to exert an elastic tension of the corresponding bands 205, 206 on the side plates 203, 204, the bands 205, 206 can be elastically deformed by tension before being clamped to the clamping element 207, so that after the ends of the band 206 have been fastened to one another by the clamping element 207, the foam-glass bodies arranged between the side plates 203 and 204 are pressed against one another.

Figure 33 shows a further composite foam-glass element 211, which in turn is made up of a plurality of foam-glass bodies 212. The cuboid-shaped foam-glass bodies 212 are stacked to form a cuboid-shaped composite foam-glass element 211, wherein an edge frame 213 is provided on each of the end faces, which are spanned by the width direction and the height direction, which extends along the edge of the end face and is made up of corner profiles, so that the edge frame bears on the one hand against the corresponding end face and on the other hand against the neighbouring main faces and longitudinal sides, which are defined by the height and length of the composite foam-glass element 211. The two edge frames 213 arranged on the opposite end faces are tensioned with respect to one another via a plurality of parallel, elastically deformed bands 216, so that the foam-glass bodies 212 lying therebetween are pressed against one another. In addition, corner profiles 214 are arranged on the longitudinal edges of the composite foam-glass element 211, which are likewise pressed against the foam-glass bodies 212 via a plurality of bands 215 running parallel to one another, which are elastically tensioned, so

that the foam-glass bodies 212 are tensioned against one another both in the width direction and in the height direction and longitudinal direction of the composite foam-glass element 211.

One of many possible applications of the composite foam-glass elements according to the invention is the formation of a tunnel 228, in which a tunnel lining 229 is arranged, which defines a tunnel tube, so that a tunnel intermediate space 230 is formed between the tunnel lining 229 and the tunnel wall of the tunnel 228. The tunnel lining 229 is formed by a plurality of composite foam-glass elements 221 attached to the tunnel wall of the tunnel 228 via brackets 227.

Figure 34 shows the arched arrangement of composite foam-glass elements 221 for forming a tunnel lining 229. Due to the mechanical properties of the composite foam-glass elements 221, an arrangement in a tunnel lining is possible even in tunnels for high-speed trains, since the compressive loads are transferred by the composite foam-glass elements when trains pass at high speeds. The individual composite foam-glass elements 221 are themselves configured to be arched, wherein the individual foam-glass bodies 222 have a slight wedge shape, so that the opposite contact surfaces of a foam-glass body 222, against which the adjacent foam-glass bodies 222 bear, are not aligned parallel to one another, but rather assume a small angle with respect to one another, so that when a plurality of foam-glass bodies 222 are arranged with their contact surfaces against one another, an arched structure of the composite foam-glass element 221 results. The corresponding reinforcing elements for connecting and mutually pressing the foam-glass bodies 222 against one another can be guided through the foam-glass bodies 222 and/or along the surface of the foam-glass bodies 222 according to the previously shown exemplary embodiments.

One of the composite foam-glass elements 221 that form the tunnel lining 229 is illustrated in Figure 35. The composite foam-glass element 221 is in turn made up of a plurality of foam-glass bodies 222, which are supported between end plates 223 and 224 (base plate not visible in Fig. 23, see Fig. 36) and are clamped to one another via a rod 226 extending through the foam-glass bodies 222 and strips 225 running on the surface. The exemplary embodiment of Figure 35 shows that curved or arched composite foam-glass elements can also be formed. In the exemplary embodiment shown in Figure 35, the individual foam-glass bodies 222 are configured as ring segments or truncated wedges, so that the two opposite surfaces, which are joined with adjacent foam-glass

bodies 222 or which serve to stack the foam-glass bodies 122 on top of one another, are configured obliquely with respect to one another. As a result, a curved or arched development of the composite foam-glass element 221 can be achieved, wherein a plurality of curved composite foam-glass elements 221 together result in a curved tunnel lining 229, which is annular in cross section.

The rod 226, by which the end plates 223, 224 are pressed against the foam-glass bodies 222 arranged therebetween, extends through the foam-glass bodies 222 and the composite foam-glass element 221, respectively. In addition, strips 225 are provided on the outer surface of the composite foam-glass element 221, which also connect the end plates 223, 224 of the composite foam-glass element 221 to one another.

Brackets 227 are provided on at least one of the end plates 223, which make it possible to fasten the composite foam-glass element 221 in the tunnel 228 at a distance from the tunnel wall.

Figures 36 to 39 show the tunnel lining 229 or the associated composite foam-glass elements 221 in various views, wherein both the arrangement of the composite foam-glass elements 221 on the tunnel wall of the tunnel 228 via the brackets 227 and the development of the individual composite foam-glass elements 221 with the end plates 223, 224 and the U-shaped strips 225 can be seen.

Figure 37 also shows how improved accident protection can be made in combination with the tunnel lining 229. In addition, an energy-absorbing material, such as foam-glass ballast 220, can be filled into the tunnel intermediate space 230 between the tunnel lining 229 and the tunnel 228, which can absorb and dissipate a large part of the impact energy in the event of a vehicle impacting the tunnel lining 229, so that the consequences of an accident with a collision on the tunnel wall or the tunnel lining 229 can be mitigated.

Further embodiments of tunnel linings 229 can be seen in Figures 40-42. In the tunnel lining 229 of Figure 40, instead of arched composite foam-glass elements 221, straight or planar composite foam-glass elements 231 are used, which are lined up in the form of a polygonal line in order to also achieve an arched tunnel lining 229. Wedge elements 232 made of foam-glass are inserted between the individual, planar or straight composite foam-glass elements 231 in order to fill in the gaps that arise between the straight or planar composite foam-glass elements 231 at the joints.

Alternatively, composite foam-glass elements 241 may be used, which themselves have wedge-shaped foam-glass end bodies 243 at the connection ends to the adjacent composite foam-glass elements 241, while the remaining foam-glass bodies 242 of the composite foam-glass element 241 may in turn be configured as cuboid foam-glass bodies.

- 5 The composite foam-glass element 241 is illustrated in detail in Figure 42. As can be seen from Figure 42, the parallelepiped-shaped foam-glass bodies 242 are stacked on top of one another and wedge-shaped foam-glass end bodies 243 are arranged at the two ends of the stack. Pressure distribution plates 246 with brackets 247 are arranged on the respective surfaces of the wedge-shaped foam-glass end bodies 243, which brackets are
10 used to fasten the composite foam-glass element 241 to a tunnel wall. Compressive stresses are exerted on the foam-glass bodies 242, 243 via the pressure distribution plates 246 by means of a reinforcing element 249, which extends through the wedge-shaped foam-glass end bodies 243 and the cuboid-shaped foam-glass bodies 242, so that these are in turn under compressive stress.
- 15 Two further applications of the present invention are shown in Figures 43 and 44.

Figure 43 shows a building 260 formed entirely of composite foam-glass elements 251 and 261. The composite foam-glass elements 261 form the walls, while the composite foam-glass element 251 is configured as a ceiling or roof.

- The foam-glass bodies 252 of the composite foam-glass element 251 are reinforced by
20 metal plates 253 arranged peripherally on the end faces of the composite foam-glass element 251, which together with metal bars inserted through the foam-glass bodies 252, the metal plates 253 with the metal bars pressing the foam-glass bodies 252 against one another and thus increasing the strength. Due to foam-glass bodies 252 with closed porosity, such a composite foam-glass element 251 has impermeability to water, and due
25 to the mechanical strength, a roof made of a corresponding composite foam-glass element 251 can easily transfer required snow loads or the like. Furthermore, the mechanical properties can be influenced by a change in the density of the foam-glass during the production process of the foam-glass bodies. Thus, a higher modulus of elasticity and thus a higher mechanical strength can be set by a higher density of the foam-glass bod-
30 ies.

In addition, the composite foam-glass elements 251, 261 meet high standards in terms of thermal conductivity and building safety, such as non-flammability, so that corresponding buildings, such as passive houses, can be built with them.

As in all the preceding exemplary embodiments, the composite foam-glass elements 251, 261 are easily recyclable, since they usually have no or only slight cohesive connections, but only have mechanical connections through the reinforcing elements, which are detachable, so that the individual materials, such as the foam-glass and the materials of the reinforcing elements, can easily be separated for reusability.

A further case of application of the composite foam-glass elements according to the invention is shown in Figure 44. Figure 44 shows a high-rise building 270 that has been built, for example, in a skeleton structure. The composite foam-glass elements 271 are inserted as façade elements into the skeleton of the high-rise building 270. Due to the good mechanical properties of the composite foam-glass elements 271, they are able to withstand wind loads as occur in corresponding high-rise buildings. In addition, they have the advantages of good thermal insulation and easy recyclability.

The composite foam-glass elements that form the walls may be formed, for example, by the previously described cuboid composite foam-glass elements.

In order to additionally avoid cold bridges between the individual foam-glass bodies of a composite foam-glass element and/or to improve the connection of the adjacent foam-glass bodies, the shape of the foam-glass bodies can be adapted in such a way that a positive fit is additionally provided between adjacent foam-glass bodies at least in one direction. This is made possible by a special configuration of the surface profile or the surface shape of the contact surfaces of the foam-glass bodies. This applies quite generally to all composite foam-glass elements of the present invention and in particular also to all embodiments already described.

Figures 45 to 47 show various configurations of foam-glass bodies 282, 282a, 292, 292a, 302 and 302a.

Figure 45 shows two different foam-glass bodies 282 and 282a, which have different contact surfaces for connection to adjacent foam-glass bodies 282, 282a. Thus, the foam-glass body 282 has a wave-shaped first end face 283, while at the opposite end of the foam-glass body 282, a second end face 284 with two planar surfaces arranged at an

angle to one another is provided. The foam-glass body 282a has a third end face 285 that is complementary to the second end face 284 of the foam-glass body 282, while the fourth end face 286 of the foam-glass body 282a is in turn wave-shaped and is correspondingly complementary to the first end face 283 of the foam-glass body 282, so that foam-glass
 5 bodies 282 and 282a can be arranged alternately one behind the other.

Figure 46 similarly shows two foam-glass bodies 292 and 292a, which in turn have corresponding end faces 293, 294, 295 and 296. The first end face 293 of the foam-glass body 292 is complementary to the fourth end face 296 of the foam-glass body 292a and in turn has a wave shape. The mutually complementary end faces 294, 295, namely the
 10 second end face 294 of the foam-glass body 292 and the third end face 295 of the foam-glass body 292, have three planar partial surfaces, two of which are arranged at an angle to a third partial surface.

In the further exemplary embodiment of Figure 47, the first end face 303 of the foam-glass body 302 and the fourth end face 306 of the foam-glass body 302a correspond to
 15 the first and fourth end faces of the preceding exemplary embodiments, while the second end face 304 of the foam-glass body 302 and the third end face of the foam-glass body 302a have a sawtooth-like surface structure, but the second end face 304 and the third end face 305 are in turn configured to be complementary to one another.

In the exemplary embodiments of Figures 45 to 47, in each case two different foam-glass
 20 bodies have been combined with one another in a bond. However, it is also conceivable that the corresponding configurations of the contact surfaces or end face can also be realised in the case of composites with all the same foam-glass bodies or a plurality of different foam-glass bodies.

Figure 48 shows an application of the composite foam-glass elements for a floating house
 25 310, wherein the composite foam-glass elements are not only used for the walls and the ceiling or the roof of the house, as in the embodiment of Figure 43, but are used in particular to form a pontoon 311 on which the floating house is supported. Due to the high proportion of pores and the resulting low density of the foam-glass as well as the high mechanical strength of the composite foam-glass elements due to the high compressive
 30 strength of the glass and the mechanical reinforcing by the reinforcing elements, the composite foam-glass elements of the present invention are advantageous to use as a pontoon for a floating house, since the dead weight is low and the buoyancy is high.

Although the present invention has been described in detail on the basis of the exemplary embodiments, it is self-evident to the person skilled in the art that the invention is not limited to these exemplary embodiments, but rather that a variety of applications and modifications in the configuration are possible in such a way that, in particular, individual
5 features of the exemplary embodiments shown can be omitted or other combinations of features can be realised without departing from the scope of the appended claims. In particular, the present disclosure includes all combinations of the individual features shown in the various exemplary embodiments, so that individual features that are described only in connection with one exemplary embodiment can also be used in other
10 exemplary embodiments or combinations of individual features that are not explicitly illustrated.

LIST OF REFERENCE NUMBERS

	1	composite foam-glass element
	2	foam-glass bodies
5	3	reinforcing element/tensile element (threaded rod)
	4	fixation (nut)
	5	spring element
	6	pressure distribution plate
	7	separating element
10	8	support
	9	reinforcing element/tensile element
	11	composite foam-glass element
	12	foam-glass body
	16	pressure distribution plate
15	19	reinforcing element/tensile element
	21	composite foam-glass element
	22	foam-glass body
	23	band (tensioning band/tensile band)
	24	tensioning element (fixation)
20	25	pressure distribution profile
	27	separating elements
	28	supports
	31	composite foam-glass element
	32	foam-glass body
25	33	reinforcing element/tensile element (threaded rod)
	34	fixation (nut)
	35	tensioning element
	36	pressure distribution plate
	41	composite foam-glass element
30	42, 42a, 42b, 42c, 42d	foam-glass body
	43	reinforcing element/tensile element (threaded rod)
	44	fixation (nut)
	45	noise barrier
	46	pressure distribution plate

	47	concave recess
	48	convex bulge
	49	groove
	50	base plate
5	51	composite foam-glass element
	52, 52a, 52b, 52c	foam-glass body
	54	fixation (nut)
	55	noise barrier
	56	pressure distribution plate
10	58	sloping surface
	59	bore
	60	bottom plate
	61	composite foam-glass element
	62, 62a, 62b, 62c, 62d	foam-glass body
15	65	noise barrier
	66	pressure distribution plate
	67	recess
	68	protrusion
	69	reinforcing element/tensile element
20	70	base plate
	71	composite foam-glass element
	72	foam-glass body
	73	truss
	74	tensile element (tension wire)
25	75	U – profile
	76	U – profile
	77	cross brace
	78	nut
	79	reinforcing element / tensile element (threaded rod)
30	81	composite foam-glass element
	82	foam-glass body
	83	truss
	85	U – profile
	86	U – profile
35	87	reinforcing element / tensile element (threaded rod)

	88	nut
	91	composite foam-glass element
	92	foam-glass body
	93	truss
5	94	truss
	95	double – T – beam
	96	double – T – beam
	101	composite foam-glass element
	102	foam-glass body
10	103	truss
	106	double – T – beam
	111	composite foam-glass element
	112	foam-glass body
	113	truss
15	121	composite foam-glass element
	122	foam-glass body
	123	truss
	131	composite foam-glass element
	132	foam-glass body
20	133	truss
	141	composite foam-glass element
	142	foam-glass body
	143	reinforcing element/tensile element (threaded rods)
	145	pressure distribution plate
25	146	pressure distribution plate
	147	cover
	148	reinforcing element/tensile element
	149	reinforcing element/tensile element
	151	composite foam-glass element
30	152	foam-glass body
	153	bar
	154	bar
	155	side plate
	156	side plate
35	157	fixation (screw connection)

	158	cover/cladding/façade
	161	composite foam-glass element
	162	foam-glass body
	163	reinforcing element/tensile element (internal threaded rods)
5	164	reinforcing element/tensile element (external threaded rods)
	165	pressure distribution plate
	166	pressure distribution plate
	167	cover
	168	horizontal reinforcing elements/tensile elements
10	169	vertical reinforcing elements/tensile elements
	171	composite foam-glass element
	172	foam-glass body
	173	reinforcing element/tensile element
	174	reinforcing element/tensile element
15	175	side plate
	176	side plate
	177	tightening screw connection
	178	insert receptacle
	179	threaded receptacle
20	180	bolt
	191	composite foam-glass element
	192	foam-glass body
	193	side plate
	194	side plate
25	195	wire/round steel bar
	196	wire/round steel bar
	197	tightening screw connection/tensile element
	201	composite foam-glass element
	203	side plate
30	204	side plate
	205	band
	206	band
	207	clamping element
	211	composite foam-glass element
35	212	foam-glass body

	213	edge frame
	214	corner profile
	215	band
	216	band
5	220	foam-glass ballast
	221	composite foam-glass element
	222	foam-glass body
	223	end plate
	224	end plate
10	225	strip
	226	rod
	227	bracket
	228	tunnel
	229	tunnel lining
15	230	tunnel intermediate space
	231	composite foam-glass element
	232	wedge element
	241	composite foam-glass element
	242	foam-glass body
20	243	wedge-shaped foam-glass end body
	246	end plate
	247	bracket
	249	reinforcing element
	251	composite foam-glass element
25	252	foam-glass body
	253	metal plates
	260	building
	261	composite foam-glass element
	270	high-rise building
30	271	composite foam-glass element
	282, 282a	foam-glass body
	283	first end face
	284	second end face
	285	third end face
35	286	fourth end face

	292, 292a	foam-glass body
	293	first end face
	294	second end face
	295	third end face
5	296	fourth end face
	302, 302a	foam-glass body
	303	first end face
	304	second end face
	305	third end face
10	306	fourth end face
	310	floating house
	311	pontoon
	H	height
	W	width
15	L	length

CLAIMS

1. Composite foam-glass element having at least one, preferably a plurality of foam-glass bodies
 5 (2;12;22;32;42,42a,42b,42c,42d;52,52a,52b,52c;62,62a,62b,62c,62d;72;82;92;102;112;122;132;142;152;162;172;192;212;222;242;252;282282a;292,292a;302,302a) and at least one reinforcing element
 (3,4,5,6,9;19;23,24,25;33,34,35,36;43,44,46,50;54,56,60;66,69,70;73,74,75,76,77,78,79;83,85,86,87,88;93,94,95,96;103,106,109;113;123;133;143,145,146,148,
 10 149;153,154,155,156,157;163,164,165,166,168,169;173,174,175,176,177,178,179,180;193,194,195,196,197;203,204,205,206,207;213,214,215,216;223,224,225,226;246,249;253), which is arranged in such a way that a compressive stress acts on the one or more foam-glass bodies at least along one direction through the at least one reinforcing element and/or two or more foam-glass bodies are
 15 connected to one another by the at least one reinforcing element.
2. The composite foam-glass element according to claim 1,
characterised in that
 said foam-glass body
 (2;12;22;32;42,42a,42b,42c,42d;52,52a,52b,52c;62,62a,62b,62c,62d;72;82;92;1
 20 02;112;122;132;142;152;162;172;192;212;222;242;252;282282a;292,292a;302,302a) is a one-piece body made of foam-glass homogeneously formed of glass with a plurality of enclosed pores, wherein said pores are open or closed.
3. The composite foam-glass element according to any one of the preceding claims,
characterised in that
 25 several, in particular all, foam-glass bodies of the composite foam-glass element are of identical design, or the composite foam-glass element comprises a plurality of different foam-glass bodies, which differ in particular in their shape and/or size and/or their density and/or porosity and/or their chemical composition.
4. The composite foam-glass element according to any one of the preceding claims,
 30 **characterised in that**
 the foam-glass body
 (2;12;22;32;42,42a,42b,42c,42d;52,52a,52b,52c;62,62a,62b,62c,62d;72;82;92;1

- 02;112;122;132;142;152;162;172;192;212;222;242;252;282282a;292,292a;302,302a) is a body which has at least one planar surface and/or at least two surfaces aligned parallel to one another and/or contact surfaces complementary to one another, wherein, in particular in the case of a composite foam-glass element having a plurality of, in particular different, foam-glass bodies, a contact surface of the one foam-glass body is adapted to a contact surface of another foam-glass body.
- 5
5. The composite foam-glass element according to any one of the preceding claims, **characterised in that**
- 10 said foam-glass body
(2;12;22;32;42,42a,42b,42c,42d;52,52a,52b,52c;62,62a,62b,62c,62d;72;82;92;102;112;122;132;142;152;162;172;192;212;222;242;252;282282a;292,292a;302,302a) is formed by at least one element selected from the group comprising cuboids, cuboid-shaped bodies, cuboid-like bodies, cubes, prisms, pyramids, parallelepipeds, tetrahedrons, polyhedrons, cylinders, hollow cylinders, rotational bodies, circular bodies, disc-shaped bodies and annular bodies.
- 15
6. The composite foam-glass element according to any one of the preceding claims, **characterised in that**
the reinforcing element
- 20 (3,4,5,6,9;19;23,24,25;33,34,35,36;43,44,46,50;54,56,60;66,69,70;73,74,75,76,77,78,79;83,85,86,87,88;93,94,95,96;103,106,109;113;123;133;143,145,146,148,149;153,154,155,156,157;163,164,165,166,168,169;173,174,175,176,177,178,179,180;193,194,195,196,197;203,204,205,206,207;213,214,215,216;223,224,225,226;246,249;253) comprises at least one element selected from the group comprising bands, cables, strands, fibres, wires, strips, straps, bars, tubes, cylinders, girders, T-beams, double-T beams, rods, profile rods, threaded rods, plates, plates with at least partially bent around edges, U-profiles, frame elements, two or three-dimensional, in particular rectangular or cuboid-shaped frame elements, yokes, two or three-dimensional trusses, bolts, tensioning elements, springs, clamping elements, plastically deformable holding elements and the like.
- 25
- 30
7. The composite foam-glass element according to any one of the preceding claims, **characterised in that**

the reinforcing element is made up of several components and/or the reinforcing element

(3,4,5,6,9;19;23,24,25;33,34,35,36;43,44,46,50;54,56,60;66,69,70;73,74,75,76,77,78,79;83,85,86,87,88;93,94,95,96;103,106,109;113;123;133;143,145,146,148,149;153,154,155,156,157;163,164,165,166,168,169;173,174,175,176,177,178,179,180;193,194,195,196,197;203,204,205,206,207;213,214,215,216;223,224,225,226;246,249;253) is formed or comprises a material from the group comprising metal, plastics, glass, ceramics, plastic, natural materials, and combinations thereof.

10 8. The composite foam-glass element according to any one of the preceding claims, **characterised in that** at least one, preferably several, reinforcing elements are elastically deformed and are under tensile stress.

15 9. The composite foam-glass element according to any one of the preceding claims, **characterised in that** the at least one reinforcing element extends at least partially through the at least one foam-glass body and/or along the surface of the at least one foam-glass body and/or in a recess of the at least one foam-glass body.

20 10. The composite foam-glass element according to any one of the preceding claims, **characterised in that** the composite foam-glass element has at least two reinforcing elements in the form of plates or bands or frames, between which there are arranged a plurality of foam-glass bodies and at least one, preferably a plurality of reinforcing elements in the form of cables, strips, bands or the like, in order to press the plates or bands or plates against the foam-glass bodies and to press the foam-glass bodies against each other.

25 11. The composite foam-glass element according to any one of the preceding claims, **characterised in that** the at least one reinforcing element surrounds the at least one foam-glass body in a completely annularly manner.

30

12. The composite foam-glass element according to any one of the preceding claims, **characterised in that**

the foam-glass bodies

(2;12;22;32;42,42a,42b,42c,42d;52,52a,52b,52c;62,62a,62b,62c,62d;72;82;92;102;112;122;132;142;152;162;172;192;212;222;242;252;282282a;292,292a;302,302a)

5 the foam-glass bodies, in particular in a type of bond of the known type, preferably in a type from the group comprising simple stacks, load-bearing bond, stretcher bond, header bond, English bond, cross bond, and the like.

13. The composite foam-glass element according to any one of the preceding claims, **characterised in that**

10 the foam-glass bodies

(2;12;22;32;42,42a,42b,42c,42d;52,52a,52b,52c;62,62a,62b,62c,62d;72;82;92;102;112;122;132;142;152;162;172;192;212;222;242;252;282282a;292,292a;302,302a) at least partially have no cohesive connection with one another.

14. The composite foam-glass element according to any one of the preceding claims, **characterised in that**

15

the composite foam-glass element is formed from a single-layer or multilayer stack of foam-glass bodies arranged in rows, which are arranged on top of one another and/or staggered relative to one another from row to row.

15. The composite foam-glass element according to any one of the preceding claims, **characterised in that**

20

the foam-glass bodies

(2;12;22;32;42,42a,42b,42c,42d;52,52a,52b,52c;62,62a,62b,62c,62d;72;82;92;102;112;122;132;142;152;162;172;192;212;222;242;252;282282a;292,292a;302,302a)

25 02a) lie at least partially directly against one another or at least partially separating elements, in particular in the form of sheets or foils, preferably deformable sheets or foils, preferably made of paper, cardboard, rubber or plastic, polyisobutene, textiles, woven fabrics, crocheted fabrics, knitted fabrics, braided fabrics, sewn fabrics, nonwovens and felts, are arranged between adjacent foam-glass bodies.

30 16. The composite foam-glass element according to any one of the preceding claims, **characterised in that**

the composite foam-glass element and in particular the foam-glass body is

coated on the surface and/or the composite foam-glass element has a cover (158), in particular on at least one of its main surfaces.

17. The composite foam-glass element according to any one of the preceding claims,
characterised in that
 5 said composite foam-glass element or said foam-glass body has a structured surface, wherein said structured surface comprises at least one element selected from the group having convex bulges (48), concave bulges (47), blind holes, steps, undercuts, sawtooth steps, and the like.
18. The composite foam-glass element according to any one of the preceding claims,
 10 **characterised in that**
 the composite foam-glass element is selected from the group comprising a wall element, a ceiling element, a floor element, a floating body, a cladding element, a tunnel lining element, a sound insulation element, or the like.
19. A construction comprising at least one, preferably a plurality of composite foam-
 15 glass elements according to any one of the preceding claims.
20. The construction according to claim 19,
 characterised in that
 the construction comprises at least one connecting element to which at least two composite foam-glass elements are connected.
- 20 21. The construction according to claim 20,
 characterised in that
 the connecting element comprises at least one element selected from the group comprising bands, cables, wires, strips, rods, profile rods, threaded rods, plates, plates with at least partially bent around edges, U-profiles, frame elements, two-
 25 or three-dimensional, in particular rectangular or cuboid frame elements, yokes, two- and three-dimensional trusses, bolts, tensioning elements, clamping elements, plastically deformable holding elements, and the like.
22. The construction according to any one of claims 20 or 21,
 characterised in that
 30 the connecting element is made up of a plurality of components.

23. The construction according to any one of claims 20 to 22,
characterised in that
at least one, preferably several, connecting elements are elastically deformed
and are under tensile stress.
- 5 24. The construction according to any one of claims 19 to 23,
characterised in that
the construction is selected from the group comprising a wall, a noise barrier
(45,55,65), a building (260), a cladding, and a tunnel lining (229).
- 10 25. A method for producing a construction, preferably a construction according to
any one of claims 19 to 24, in which composite foam-glass elements according to
any one of claims 1 to 18 are used.

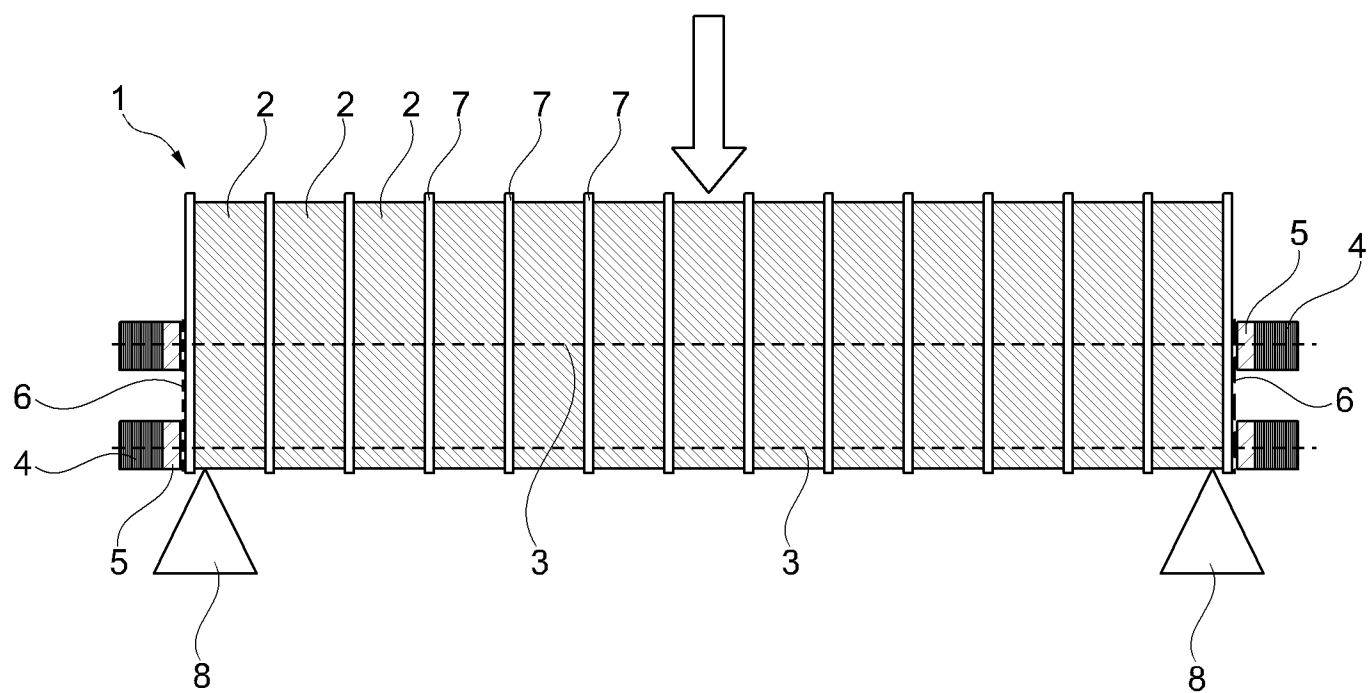


Fig. 1

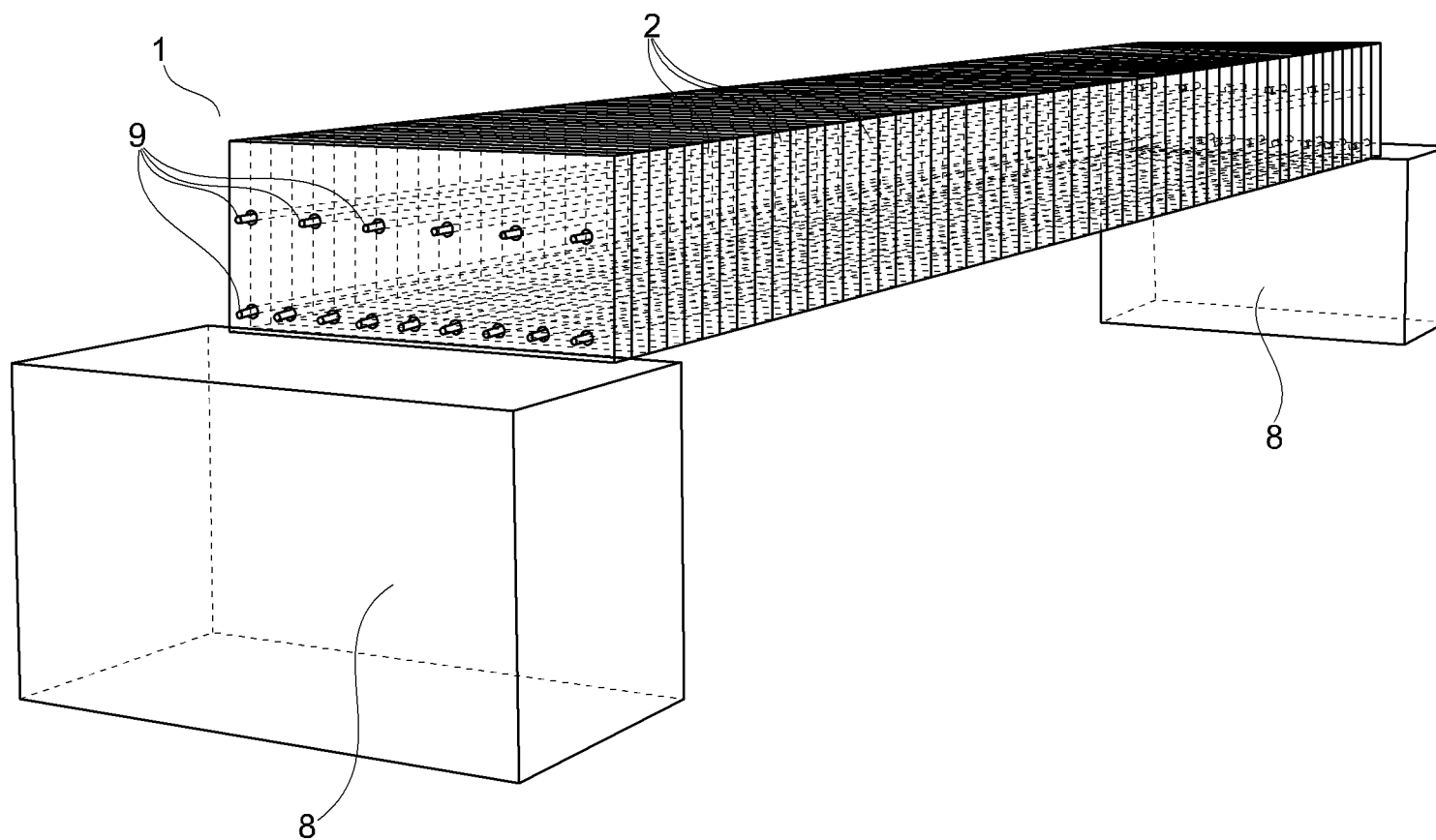
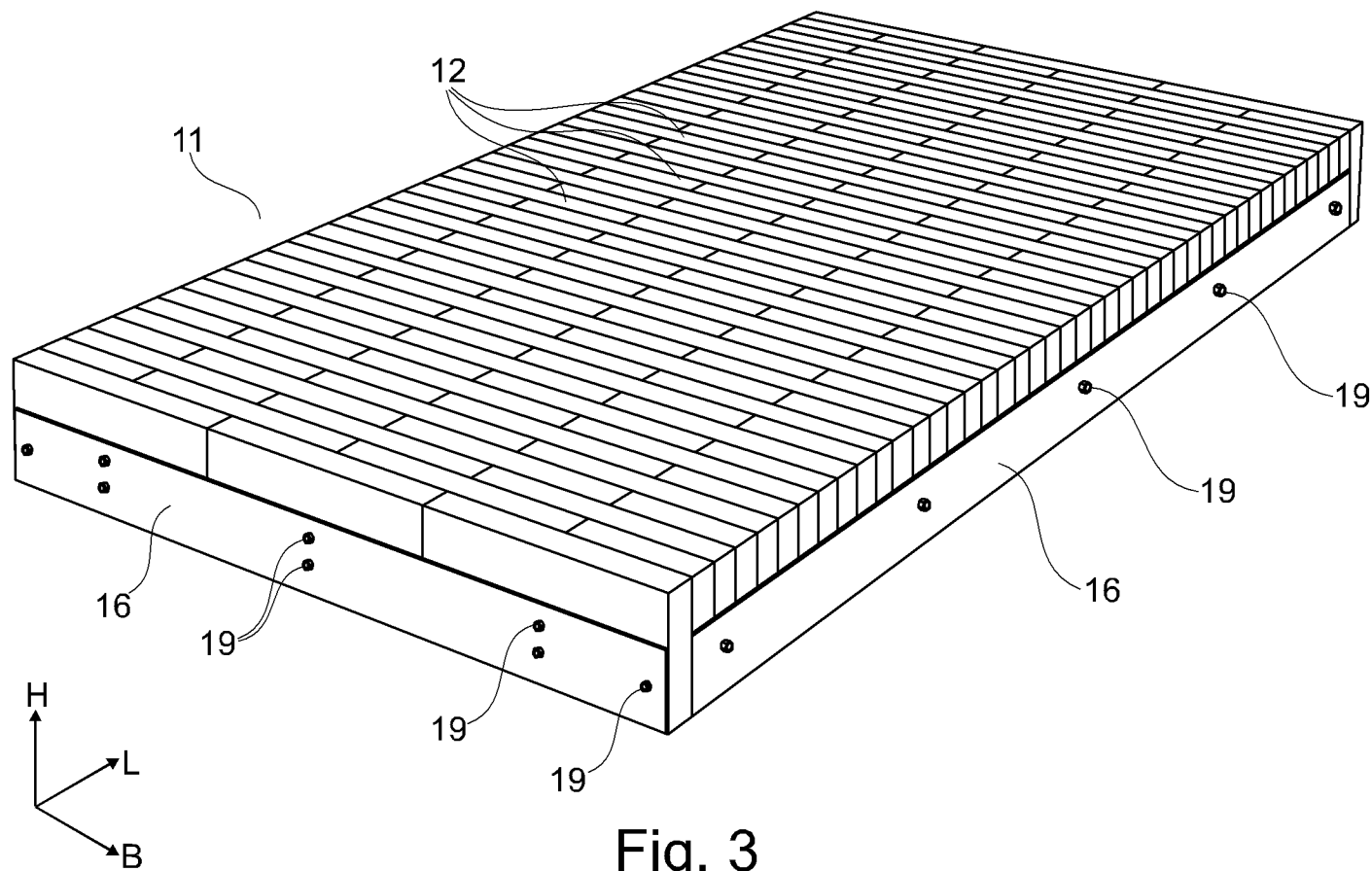


Fig. 2



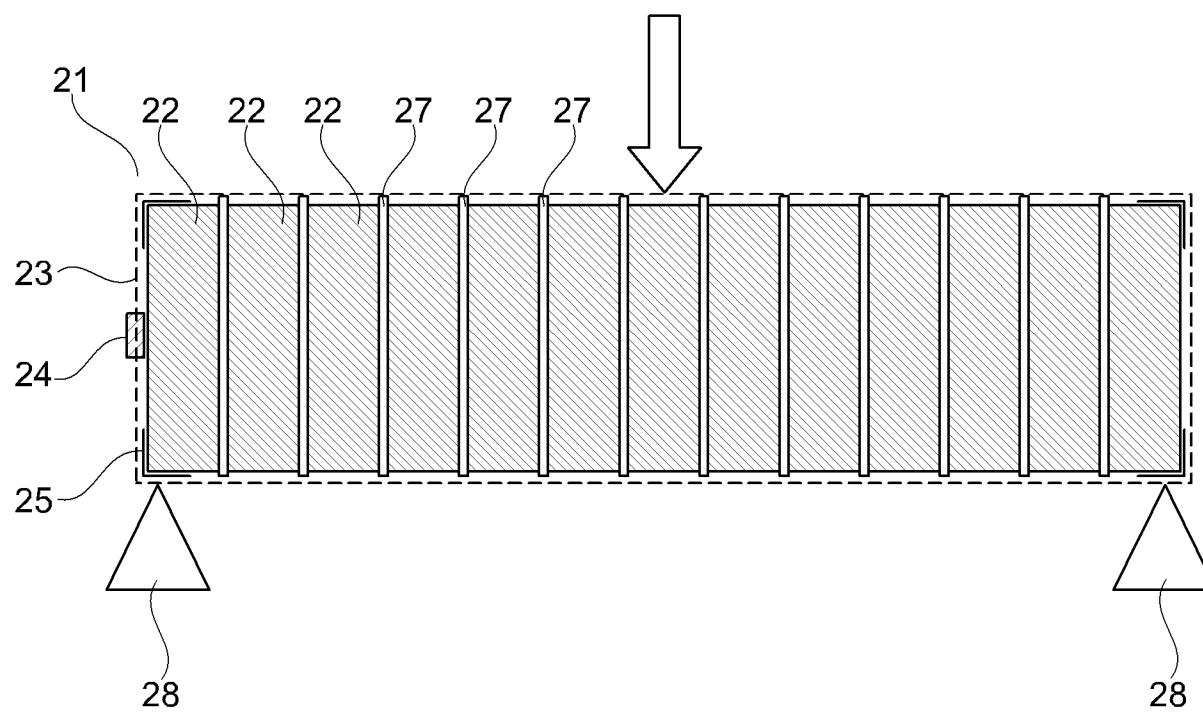


Fig. 4

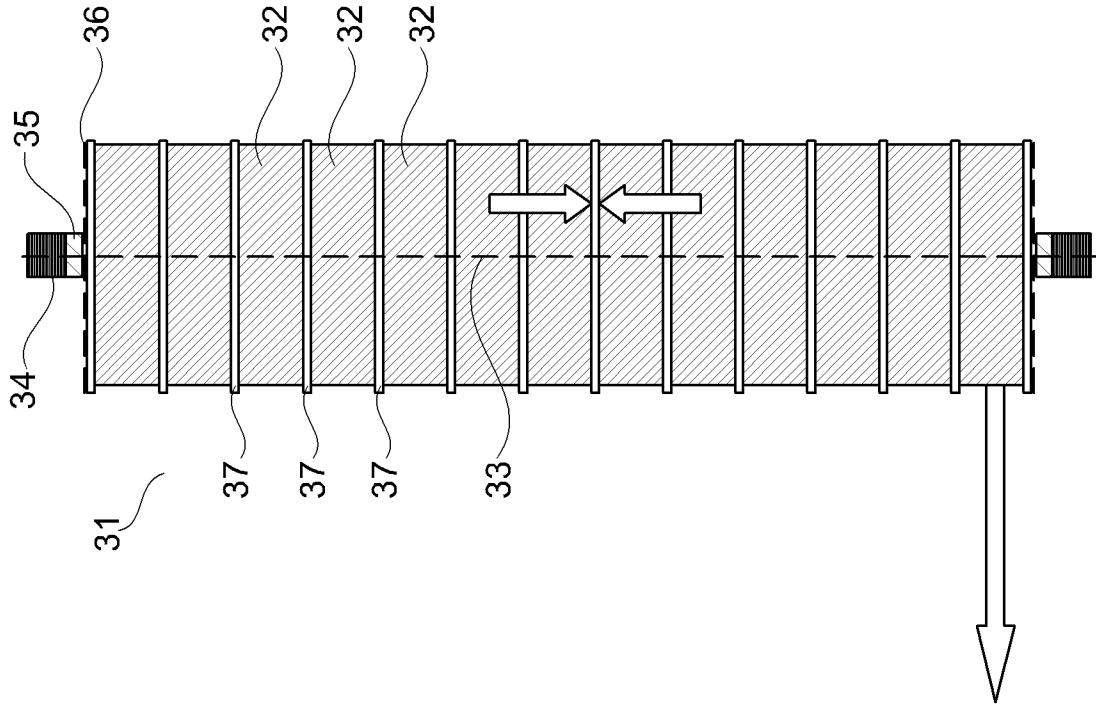


Fig. 5

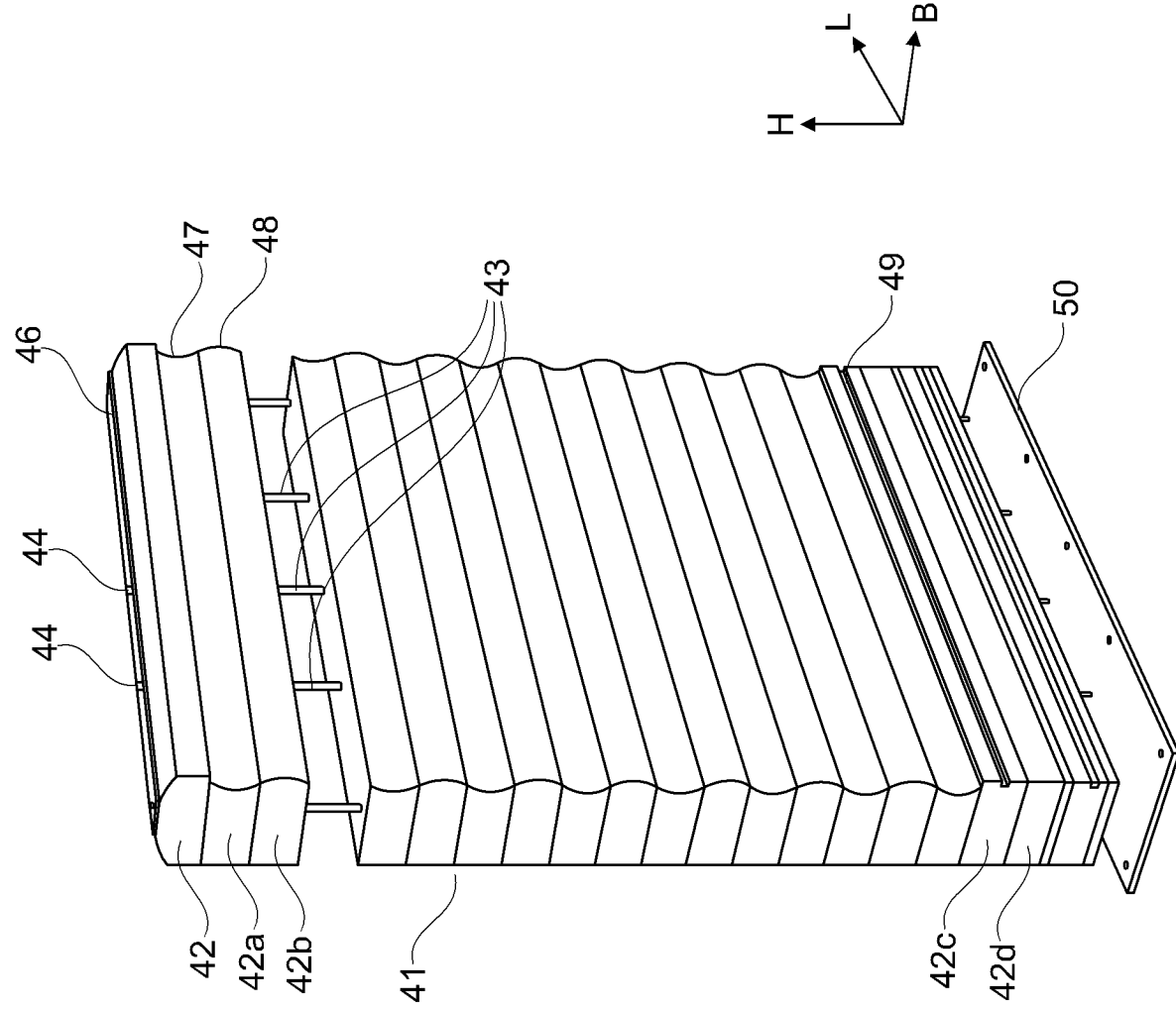


Fig. 6

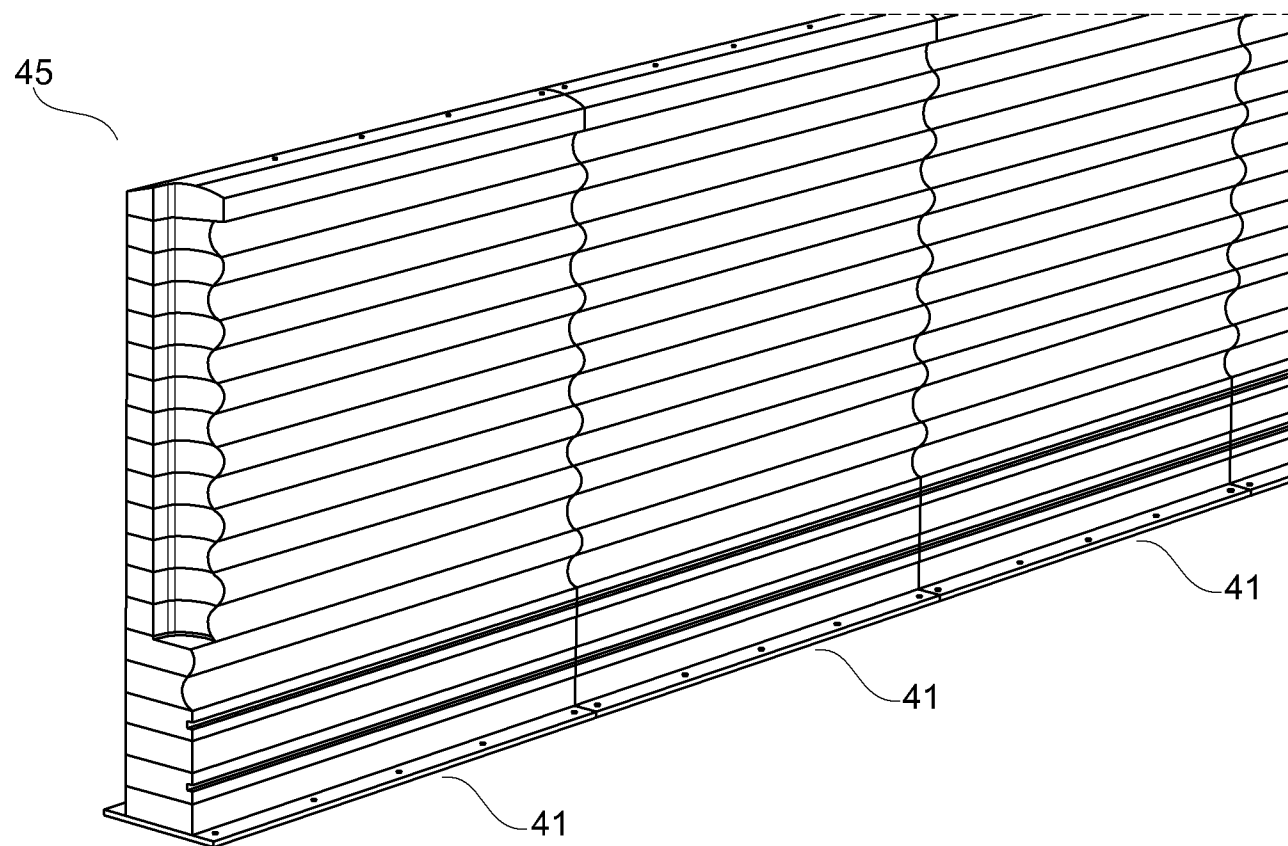


Fig. 7

7/45

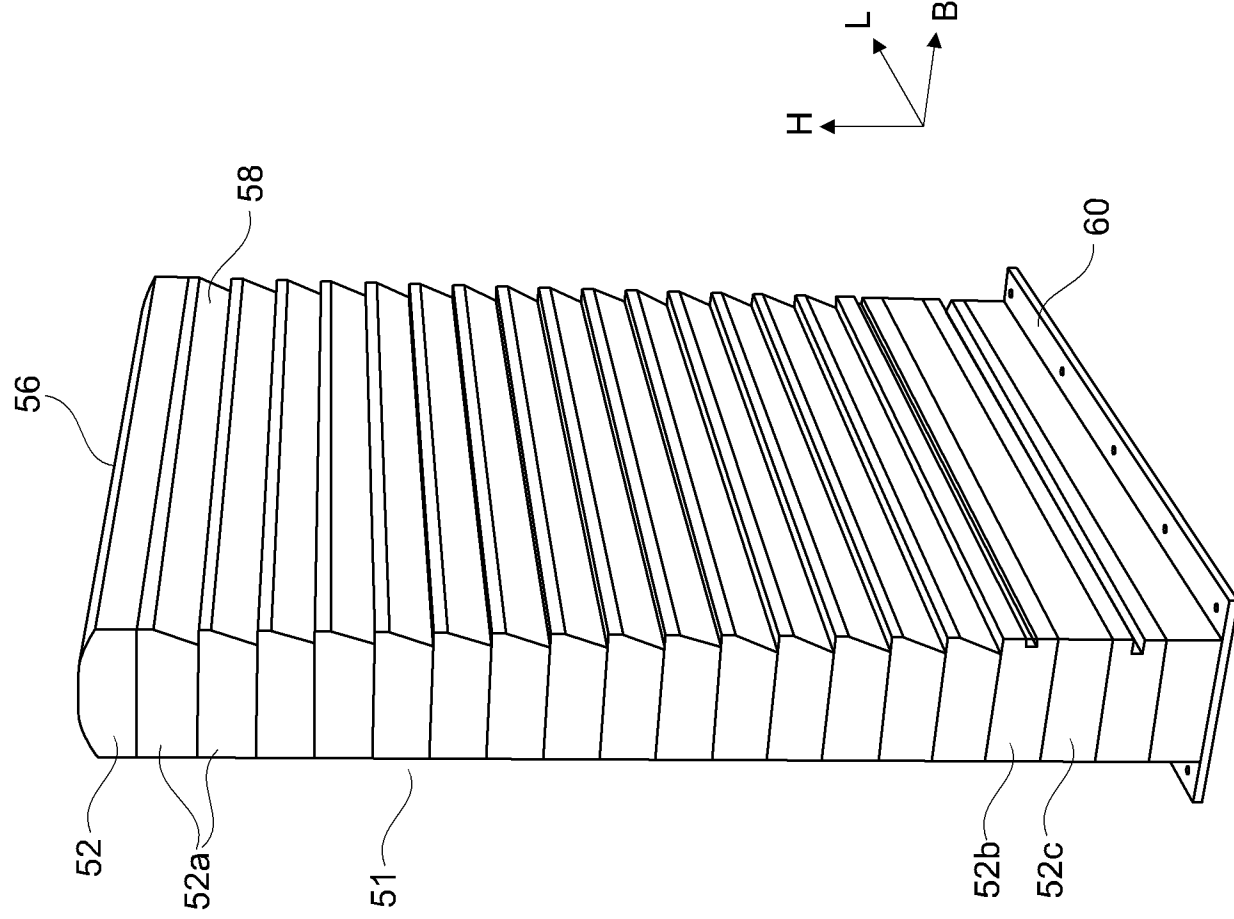


Fig. 8

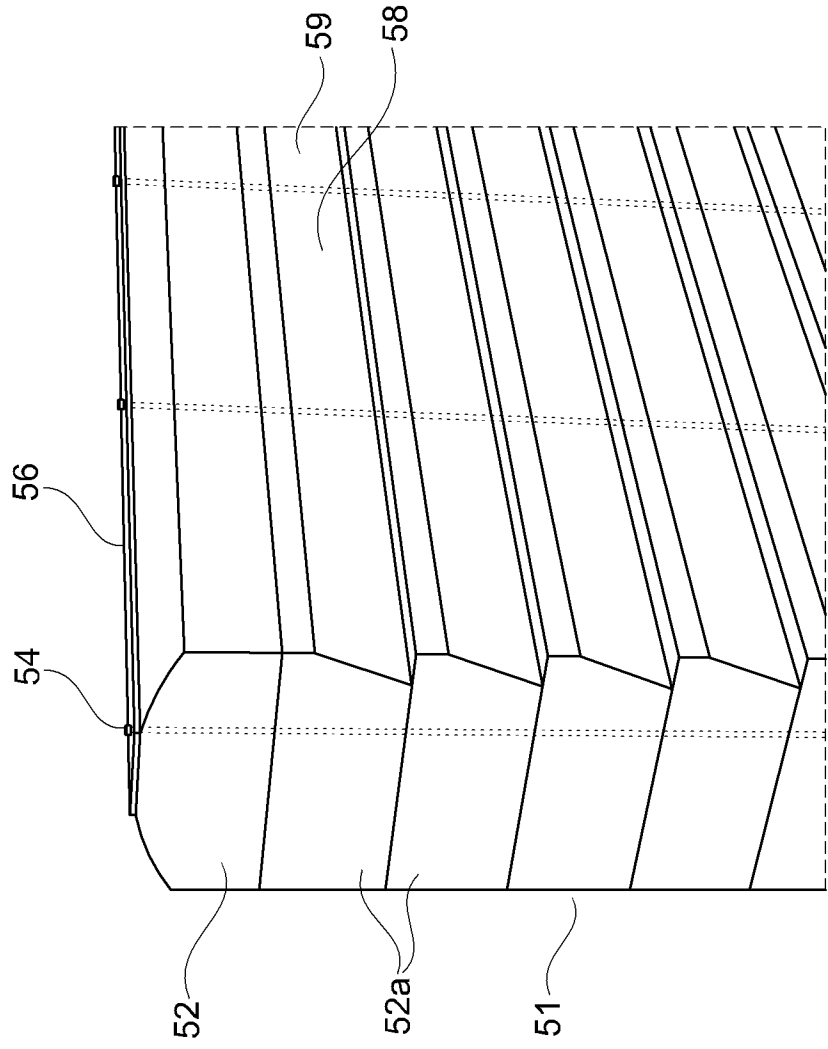


Fig. 9

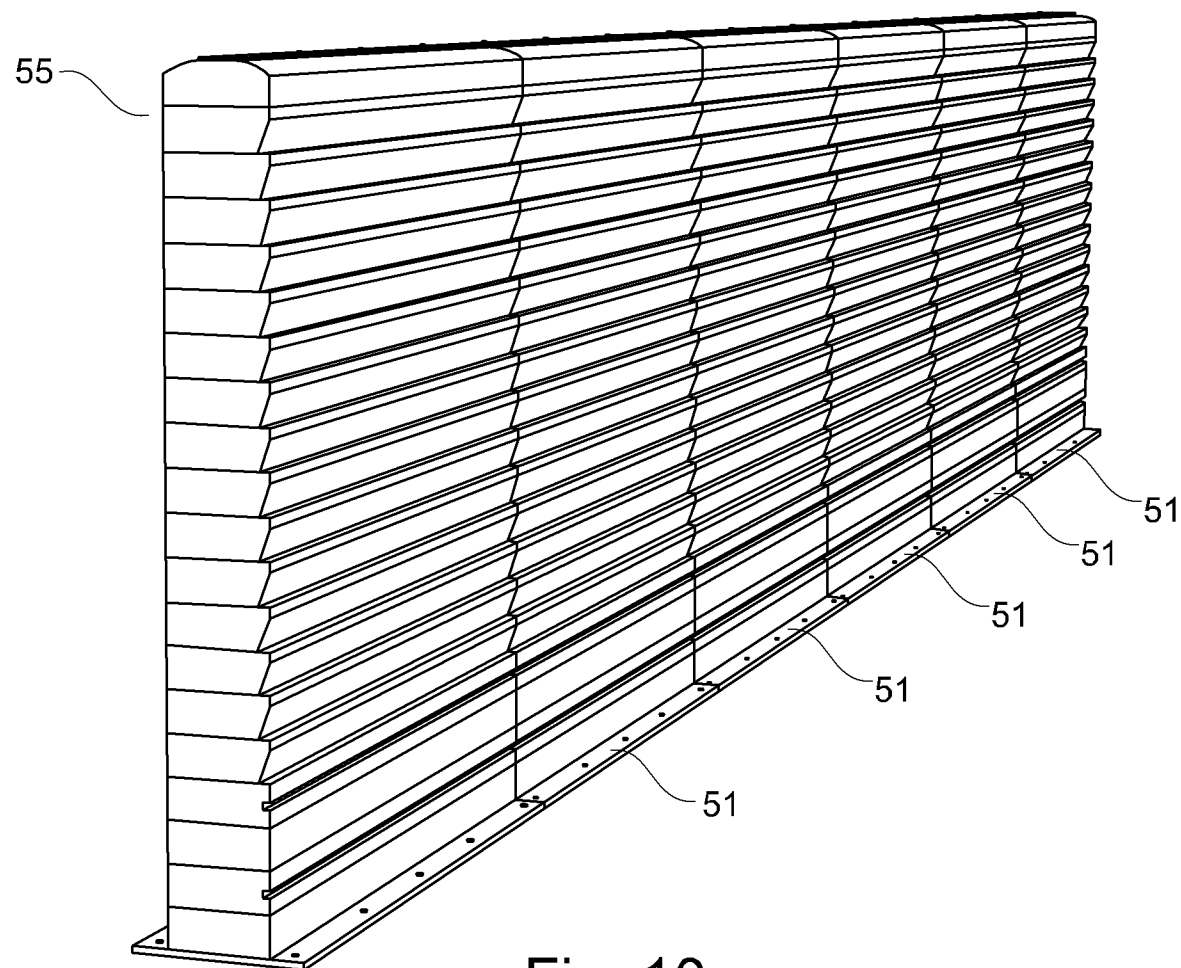


Fig. 10

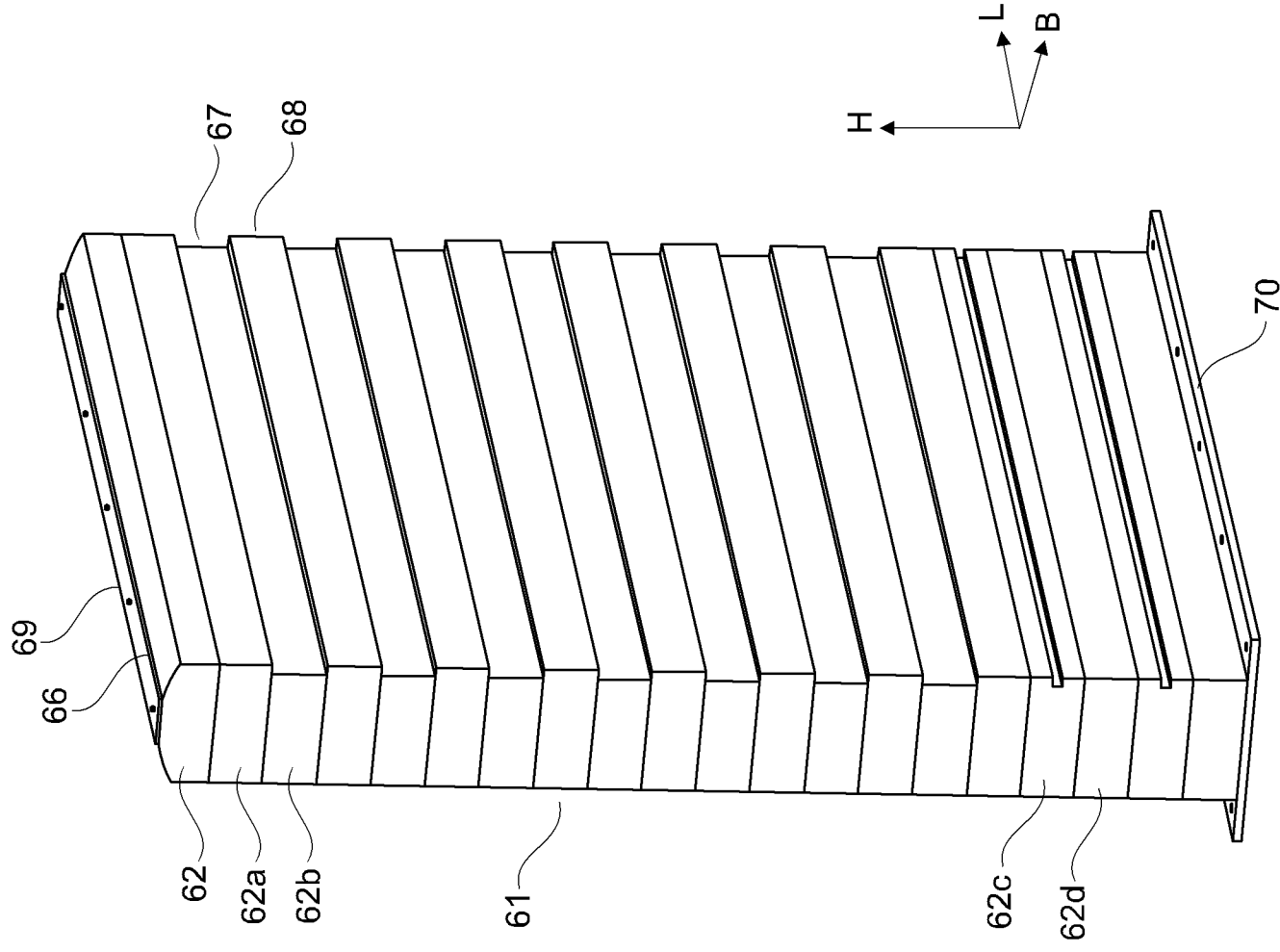


Fig. 11

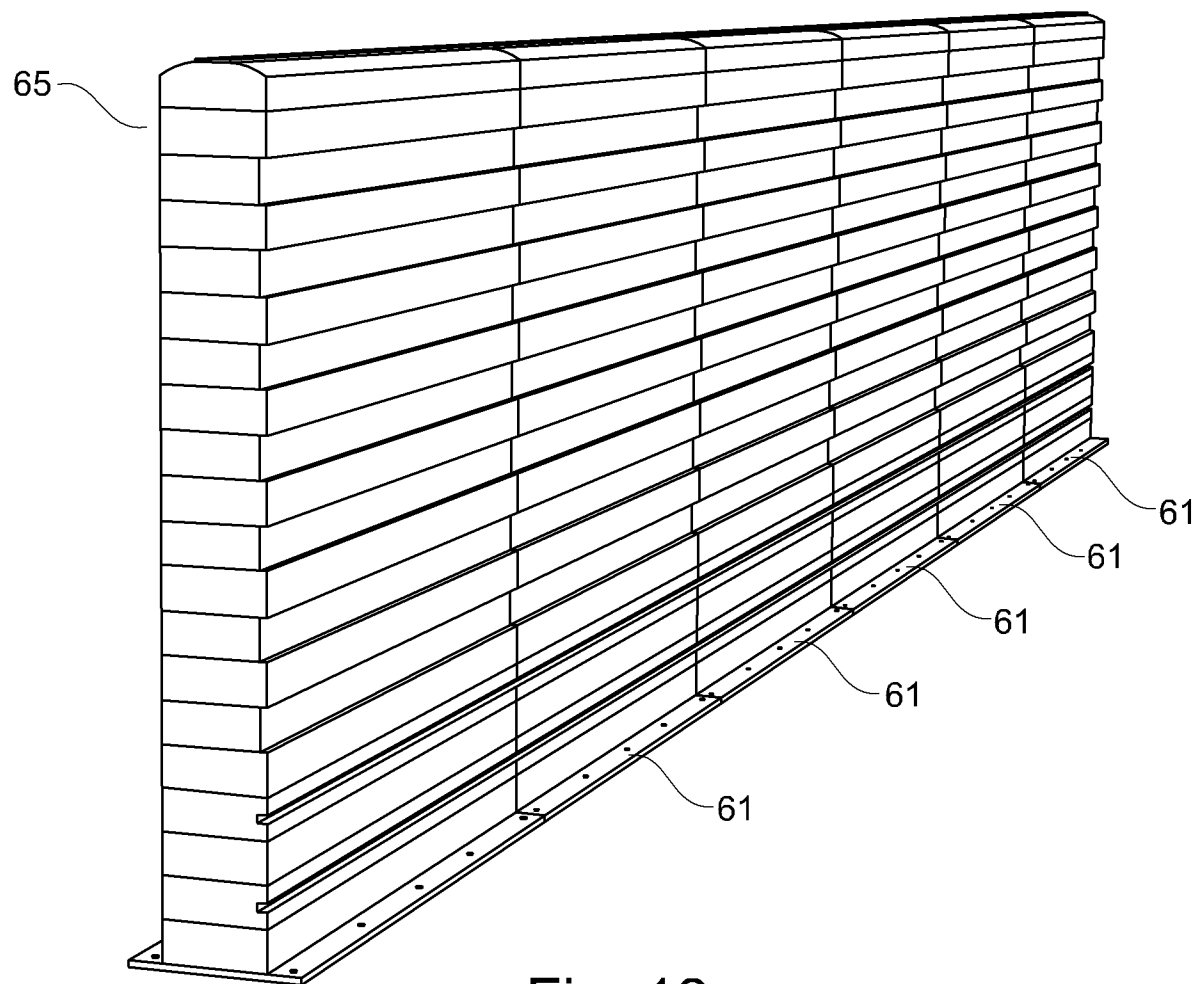


Fig. 12

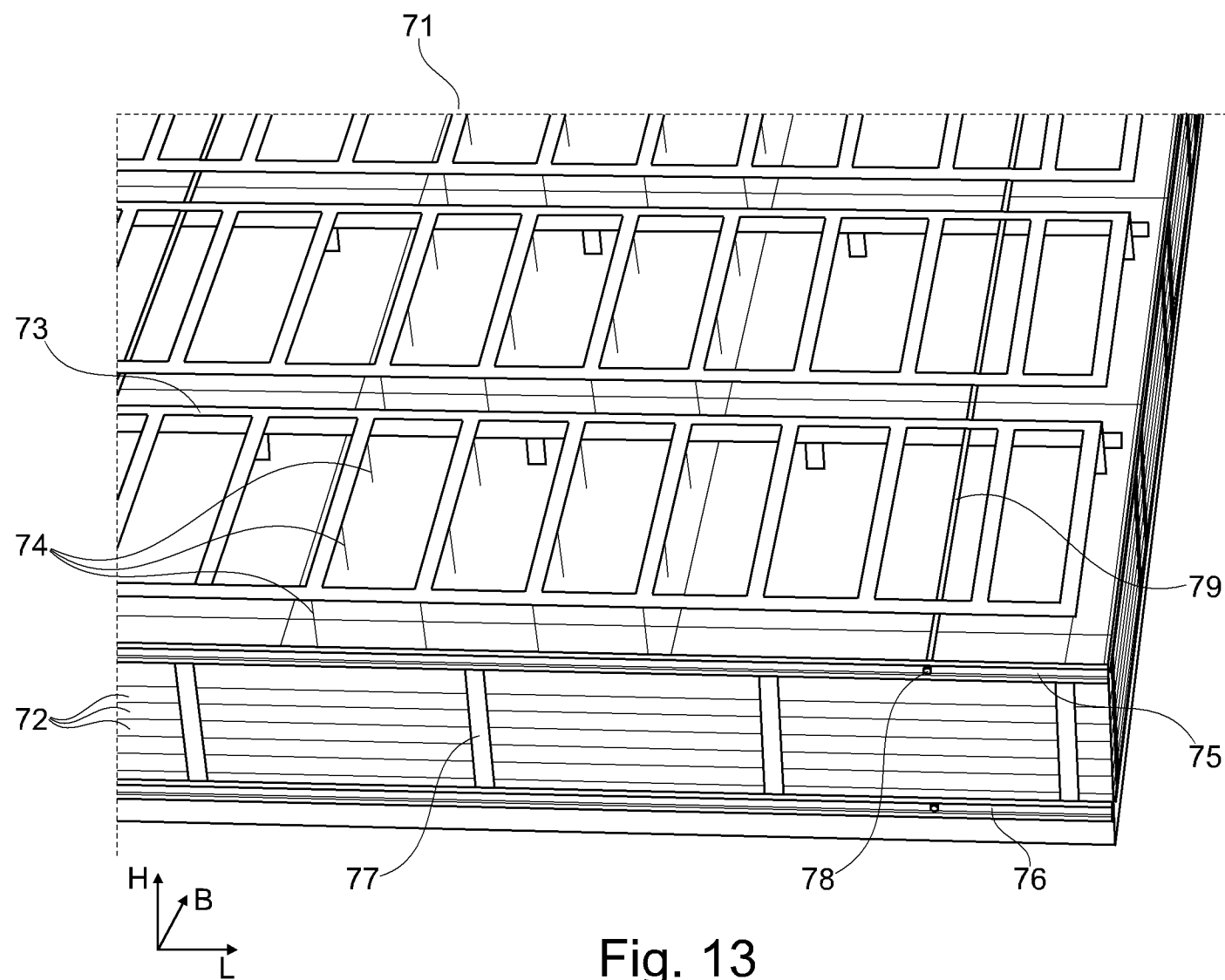


Fig. 13

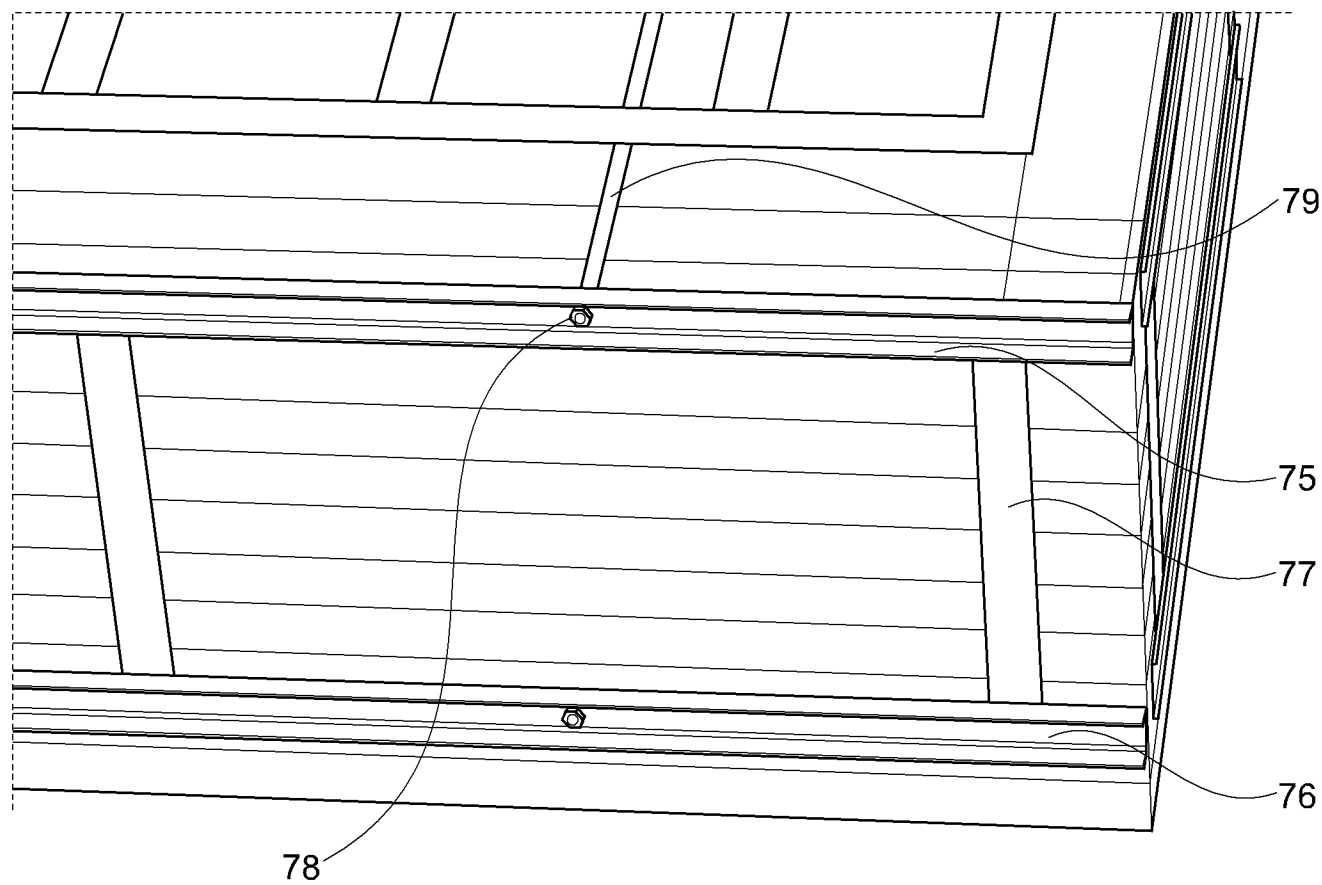


Fig. 14

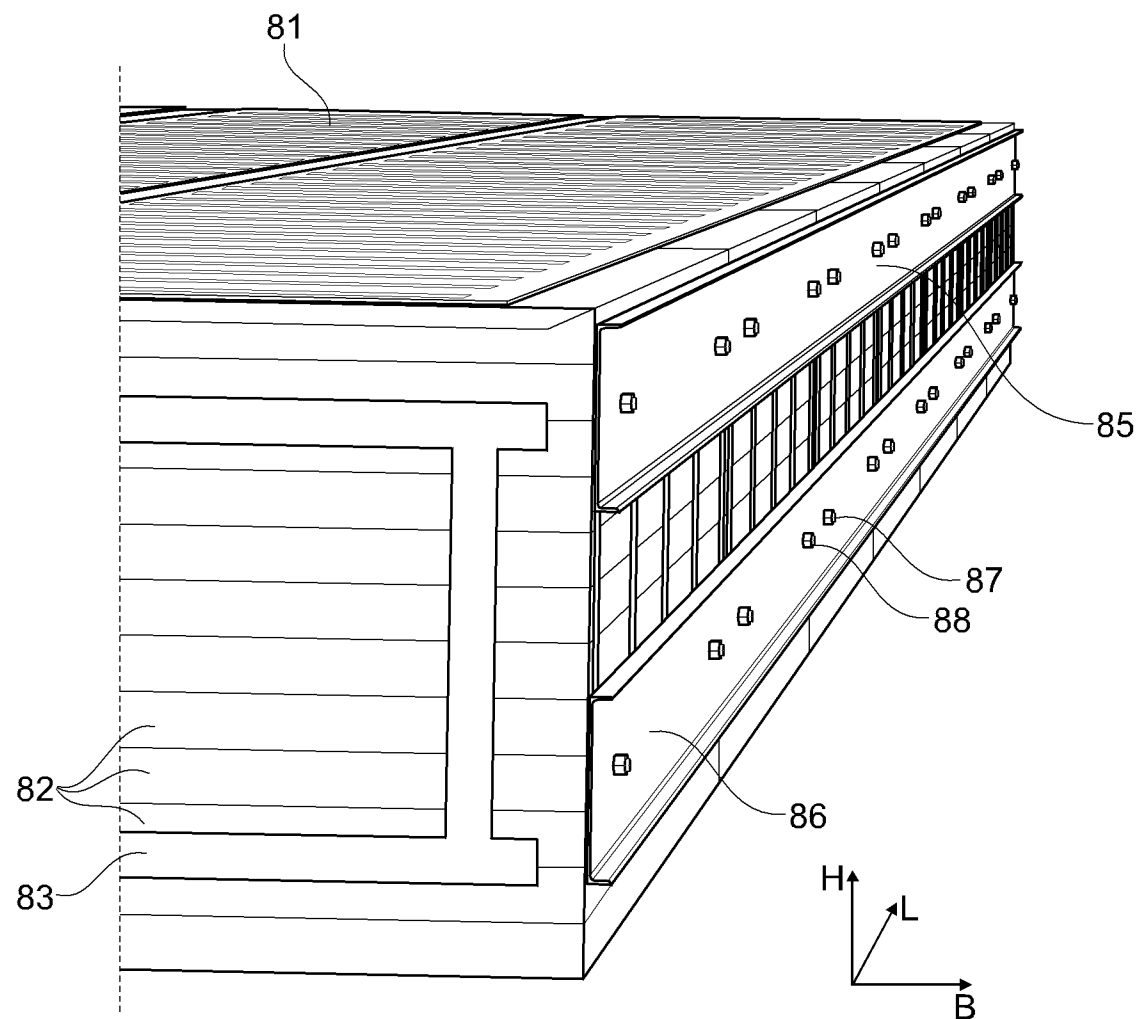


Fig. 15

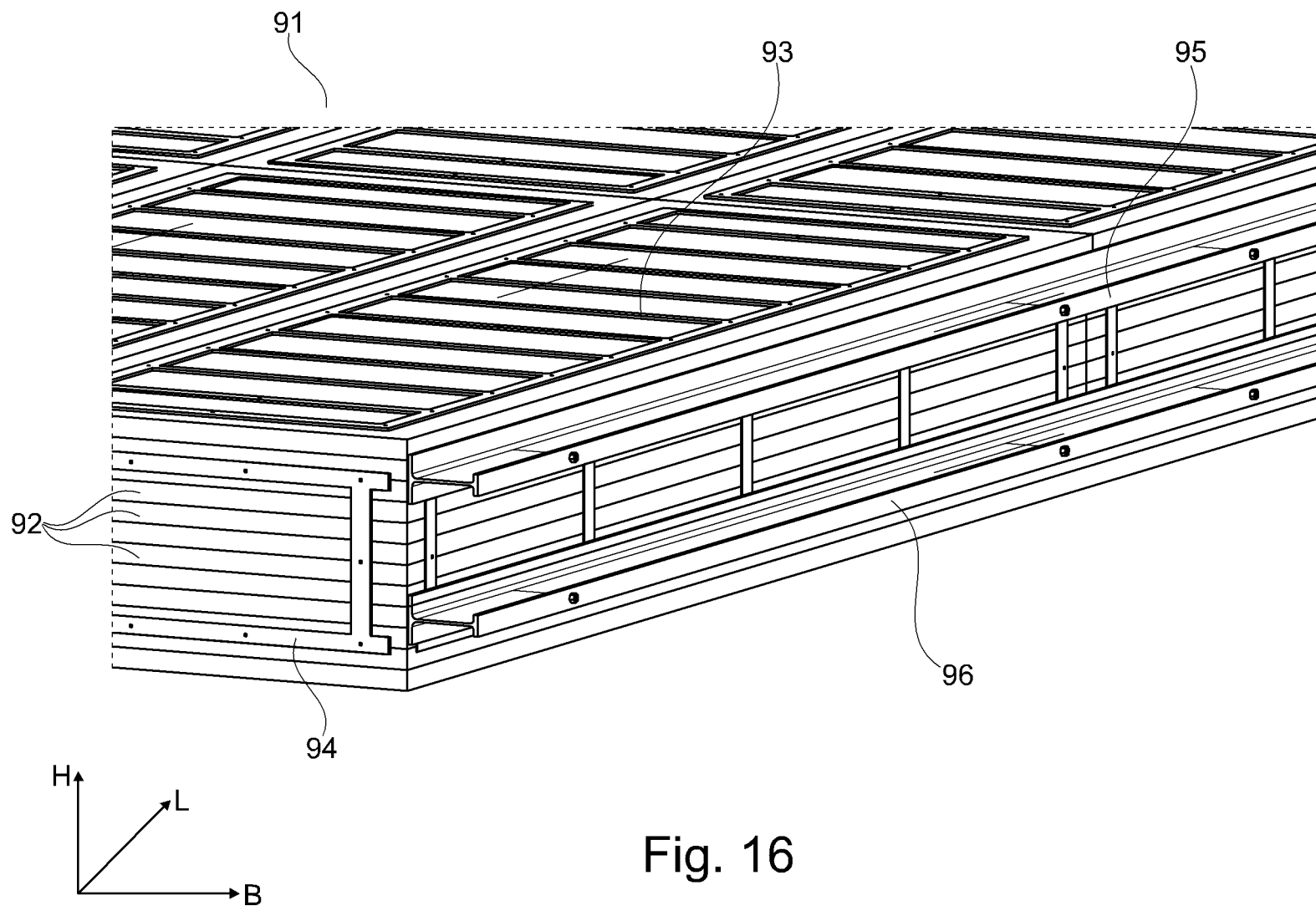
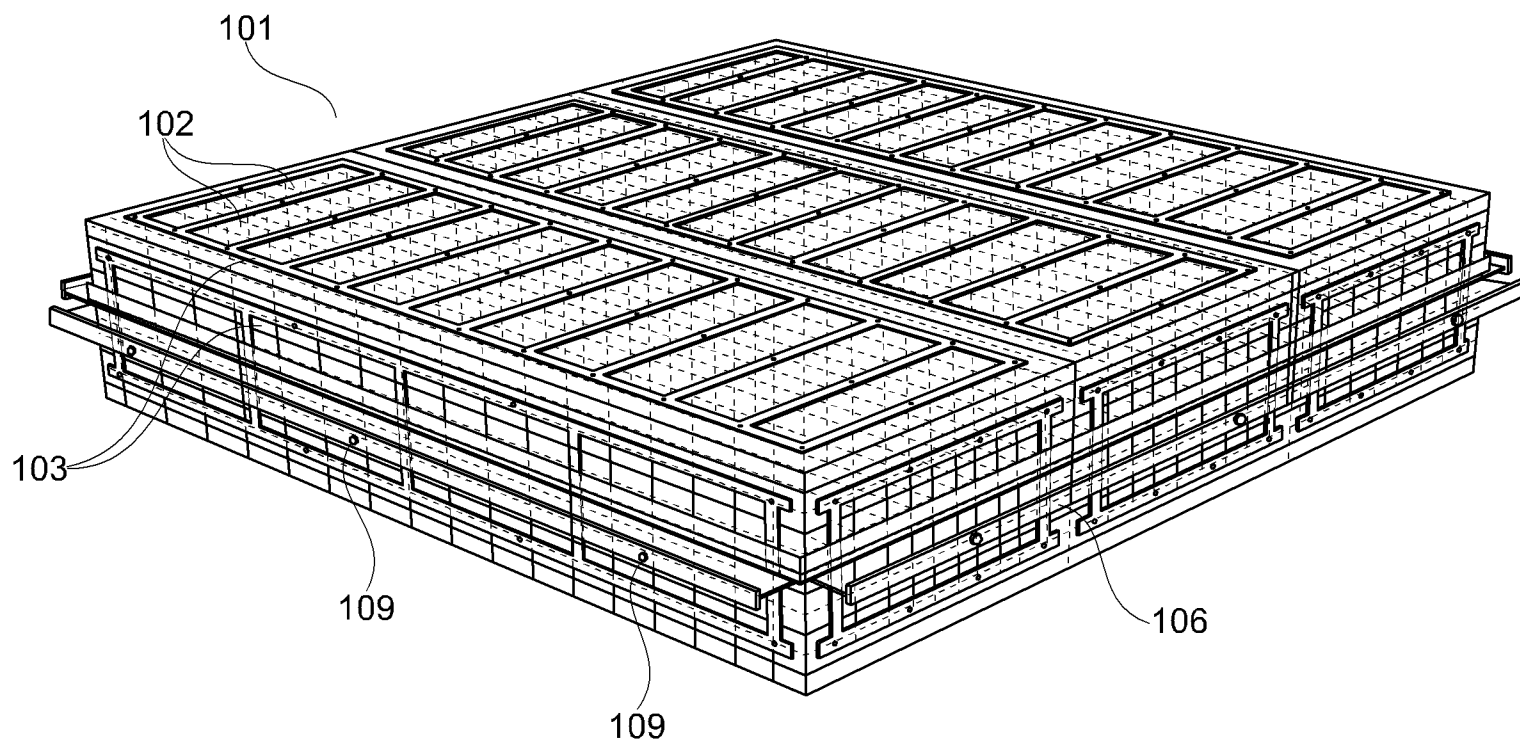
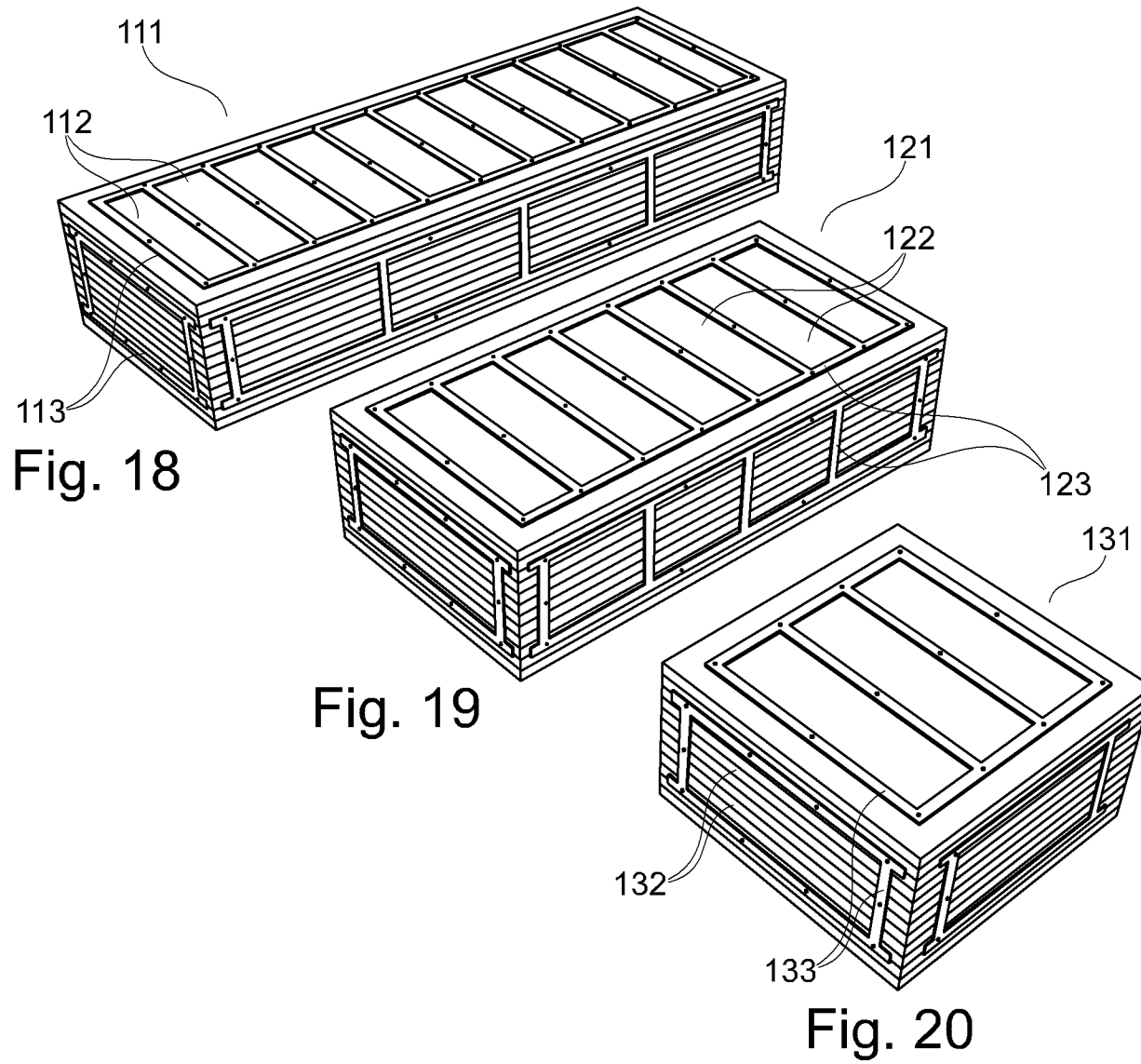


Fig. 16



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Fig. 17



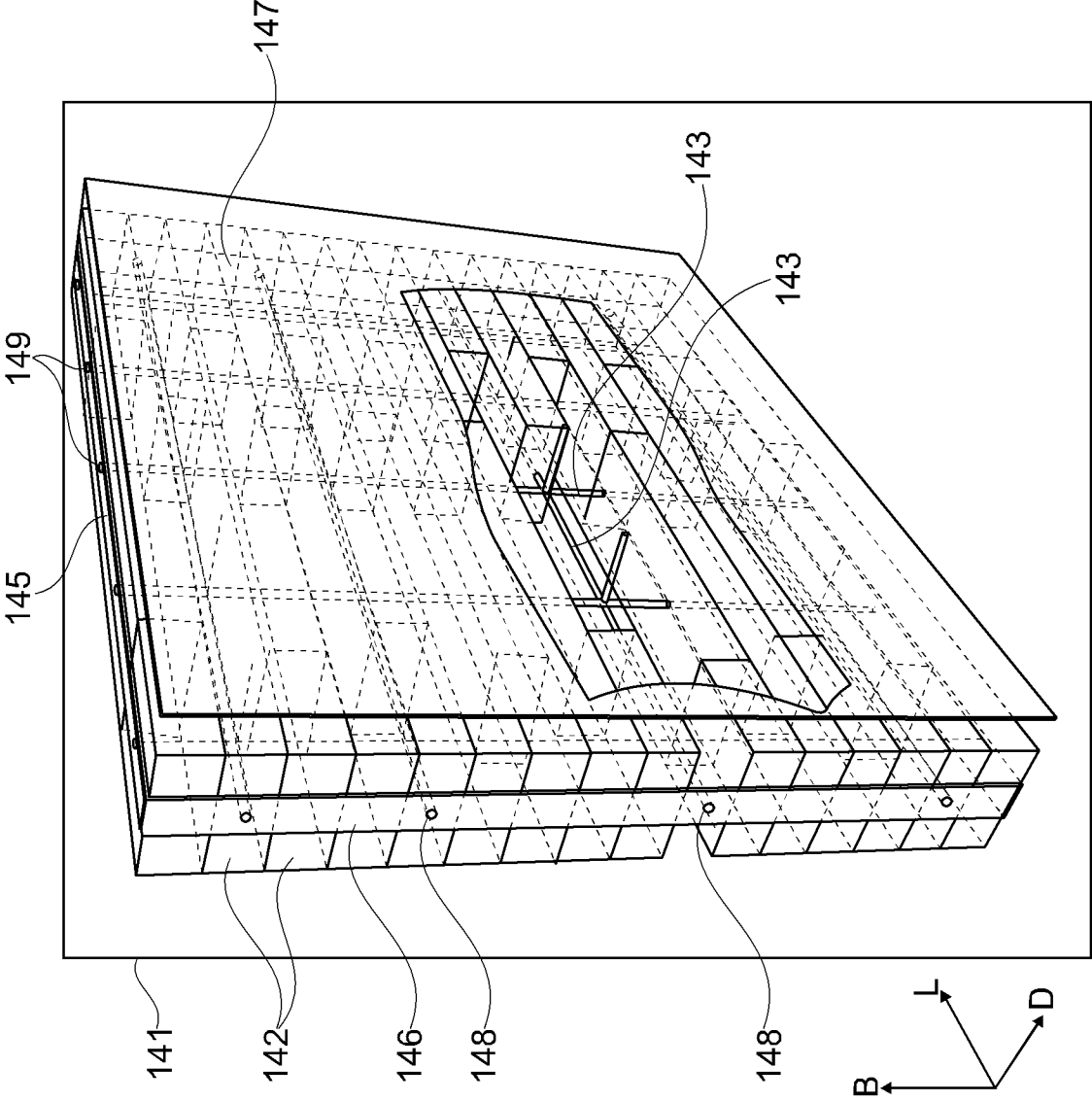
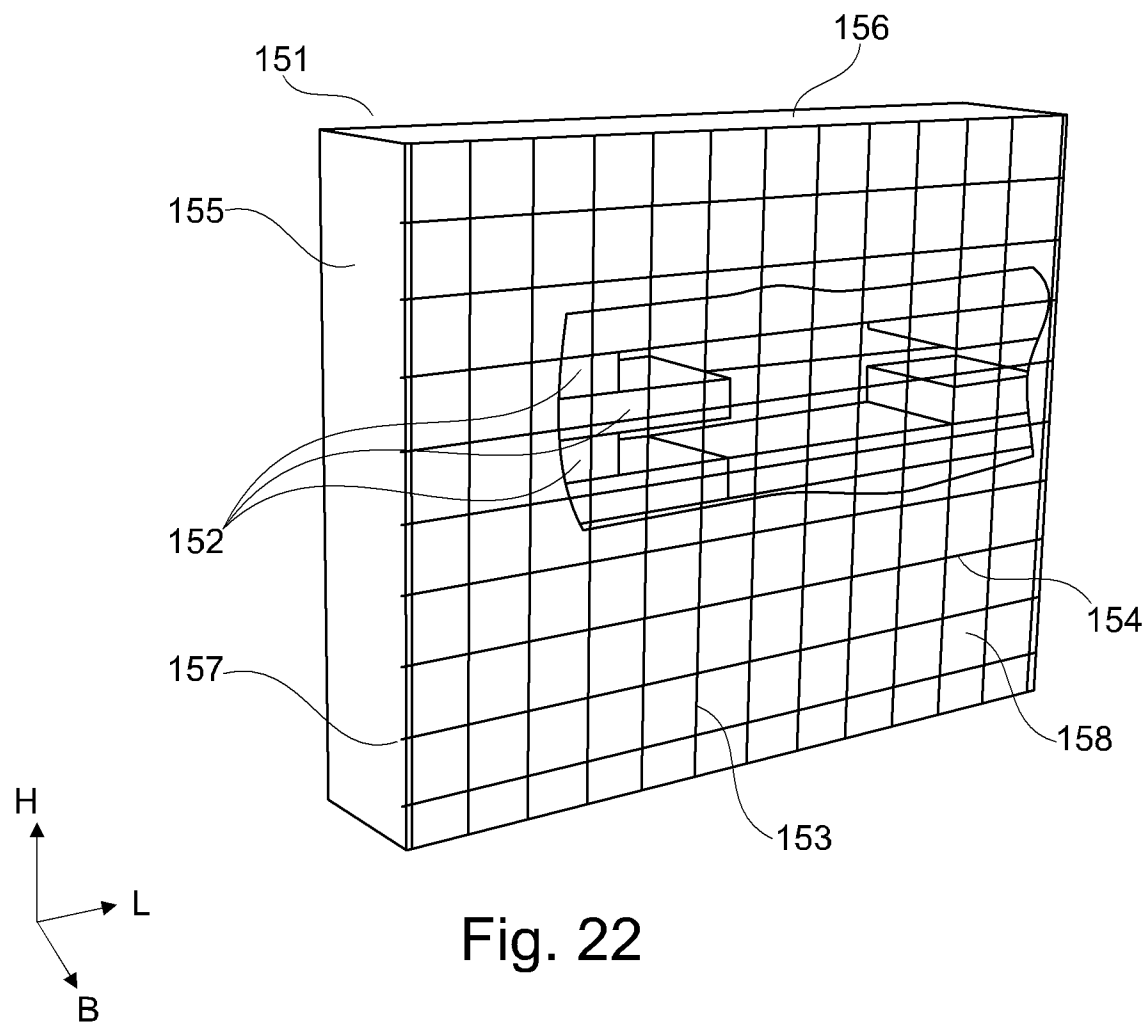


Fig. 21



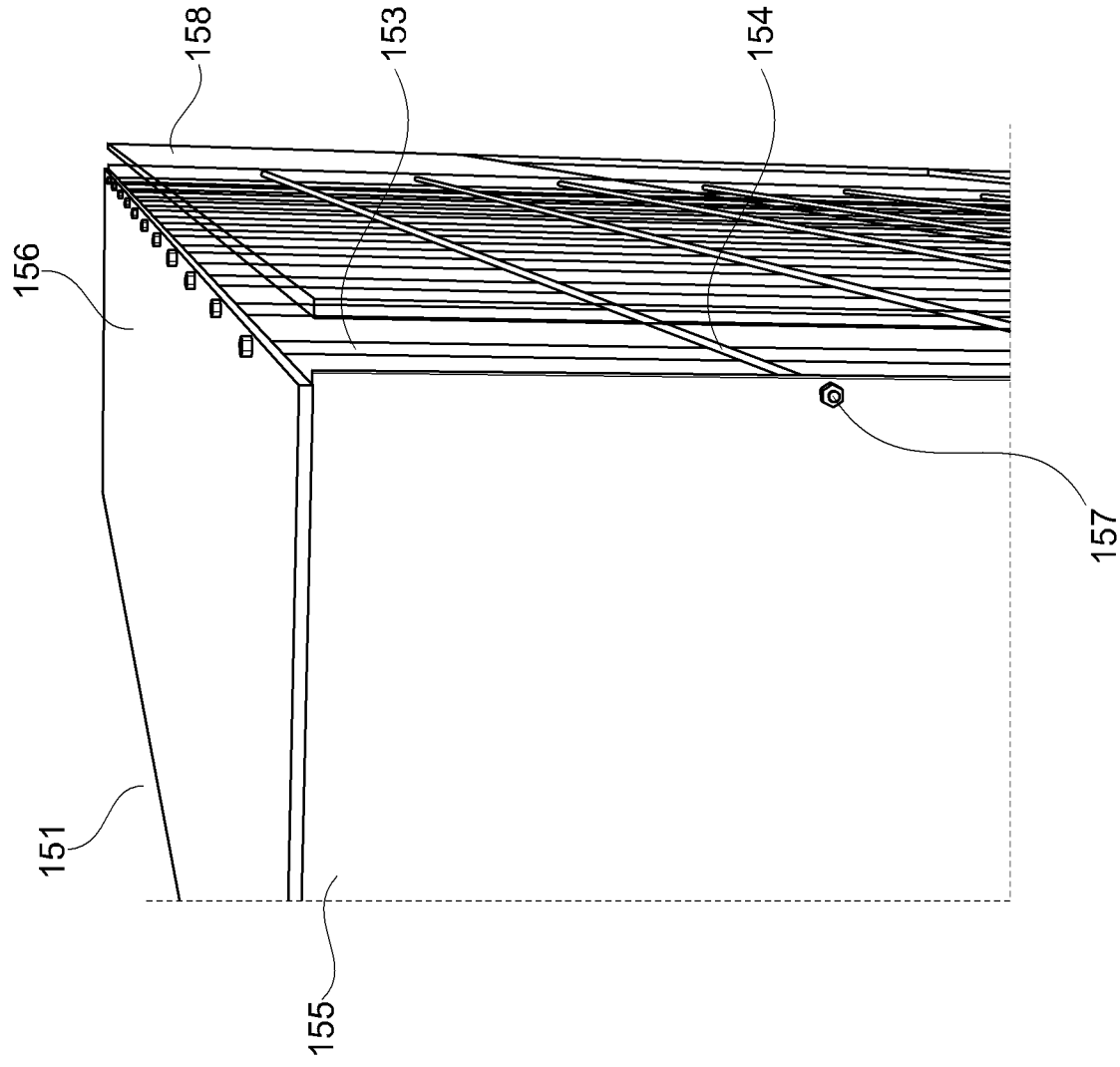


Fig. 23

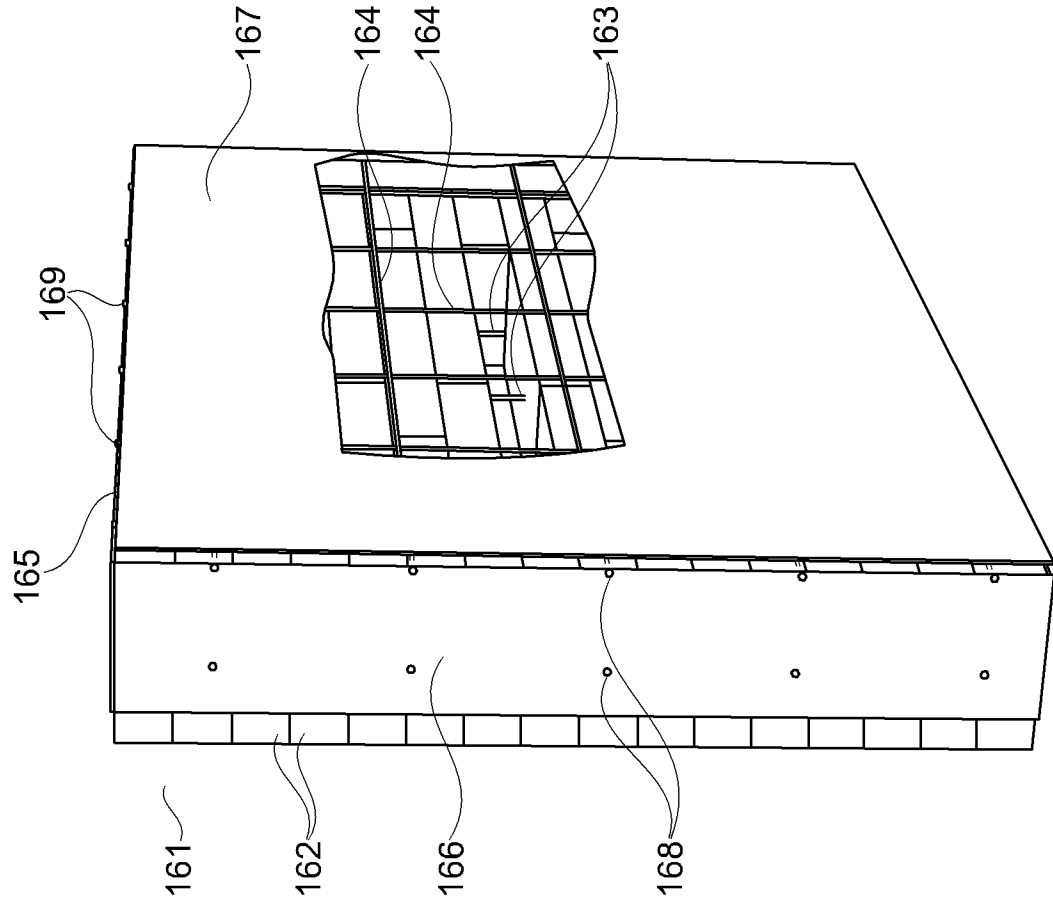


Fig. 24

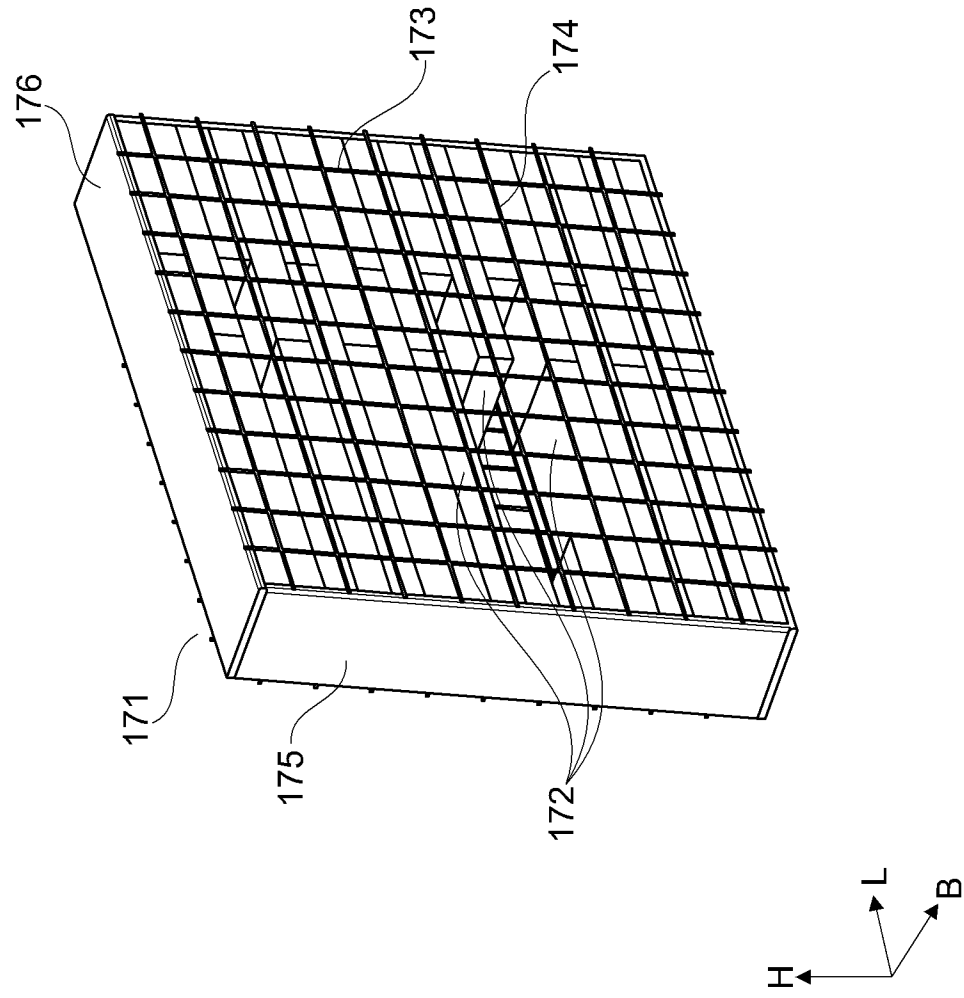


Fig. 25

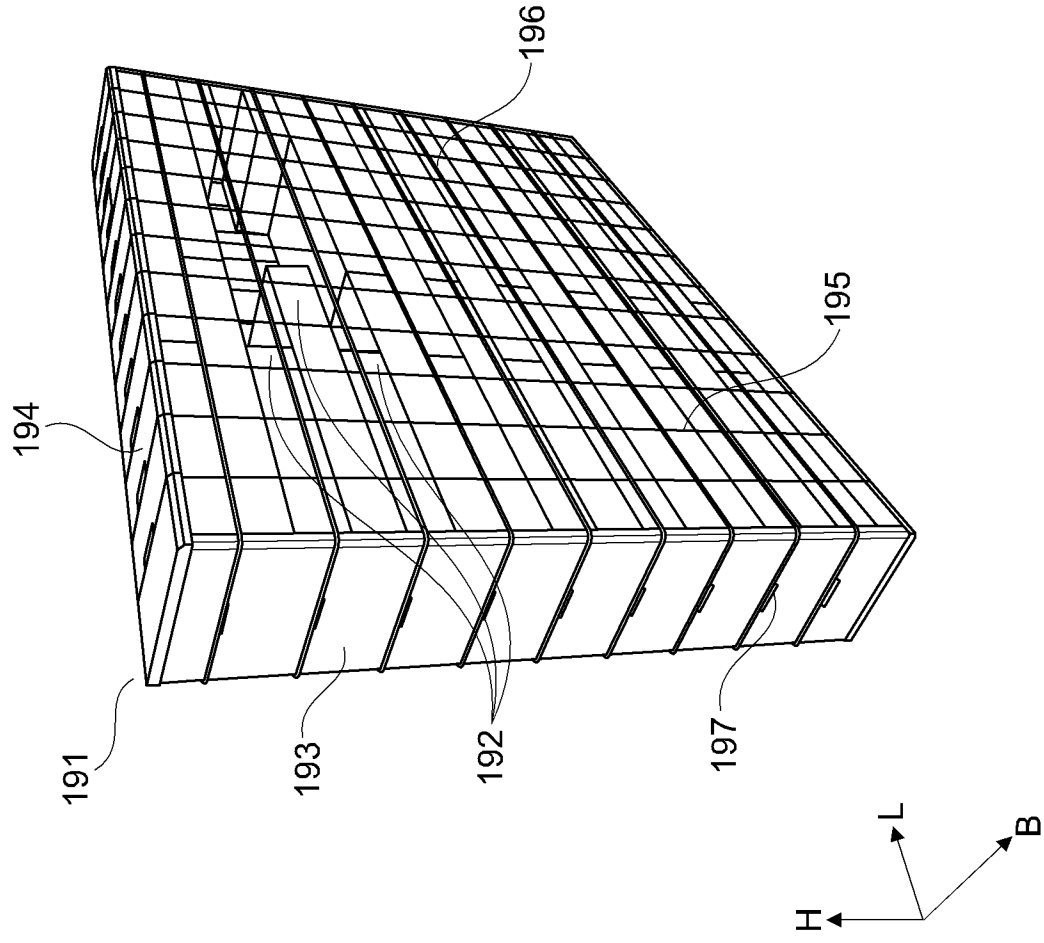


Fig. 26

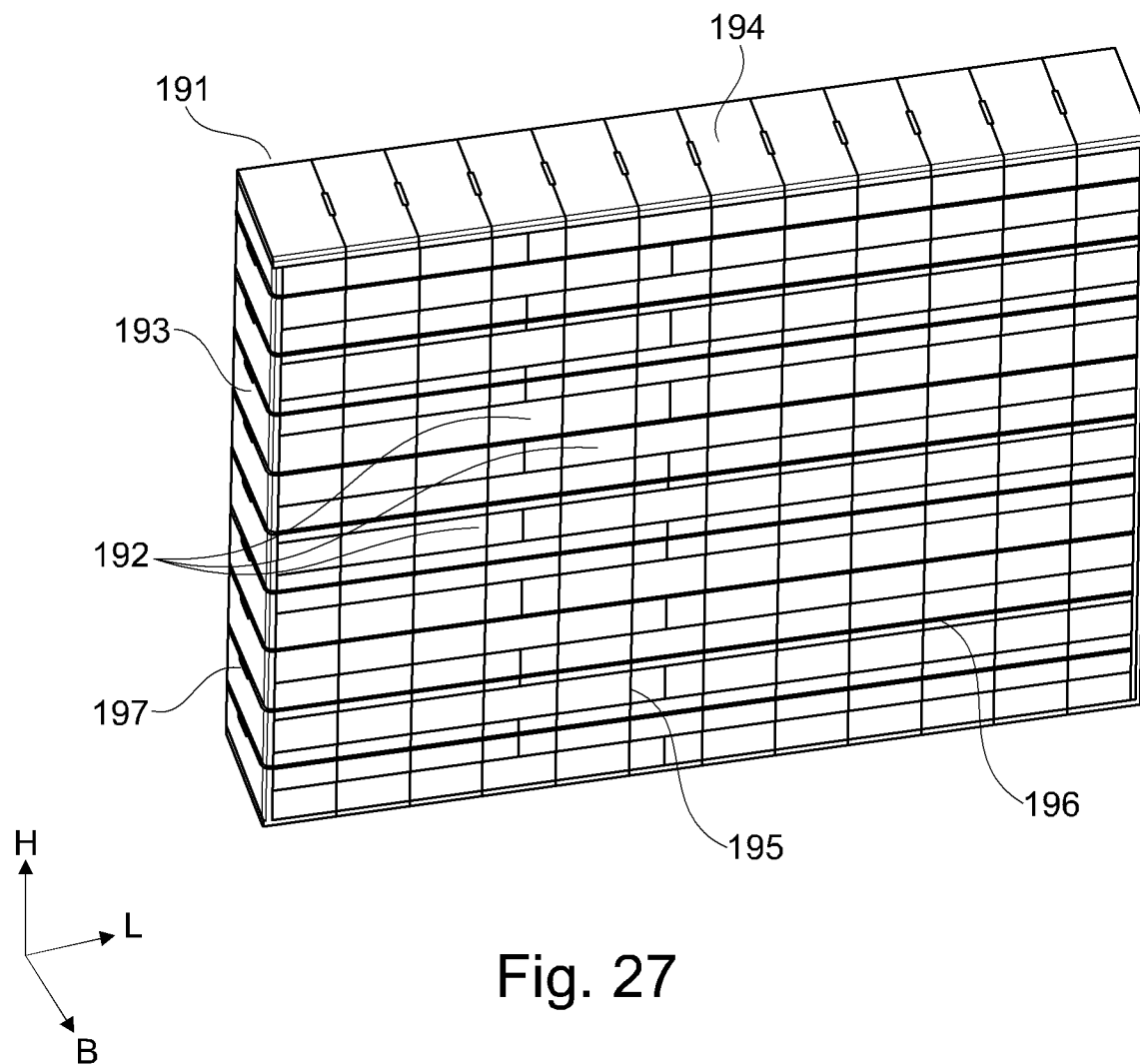


Fig. 27

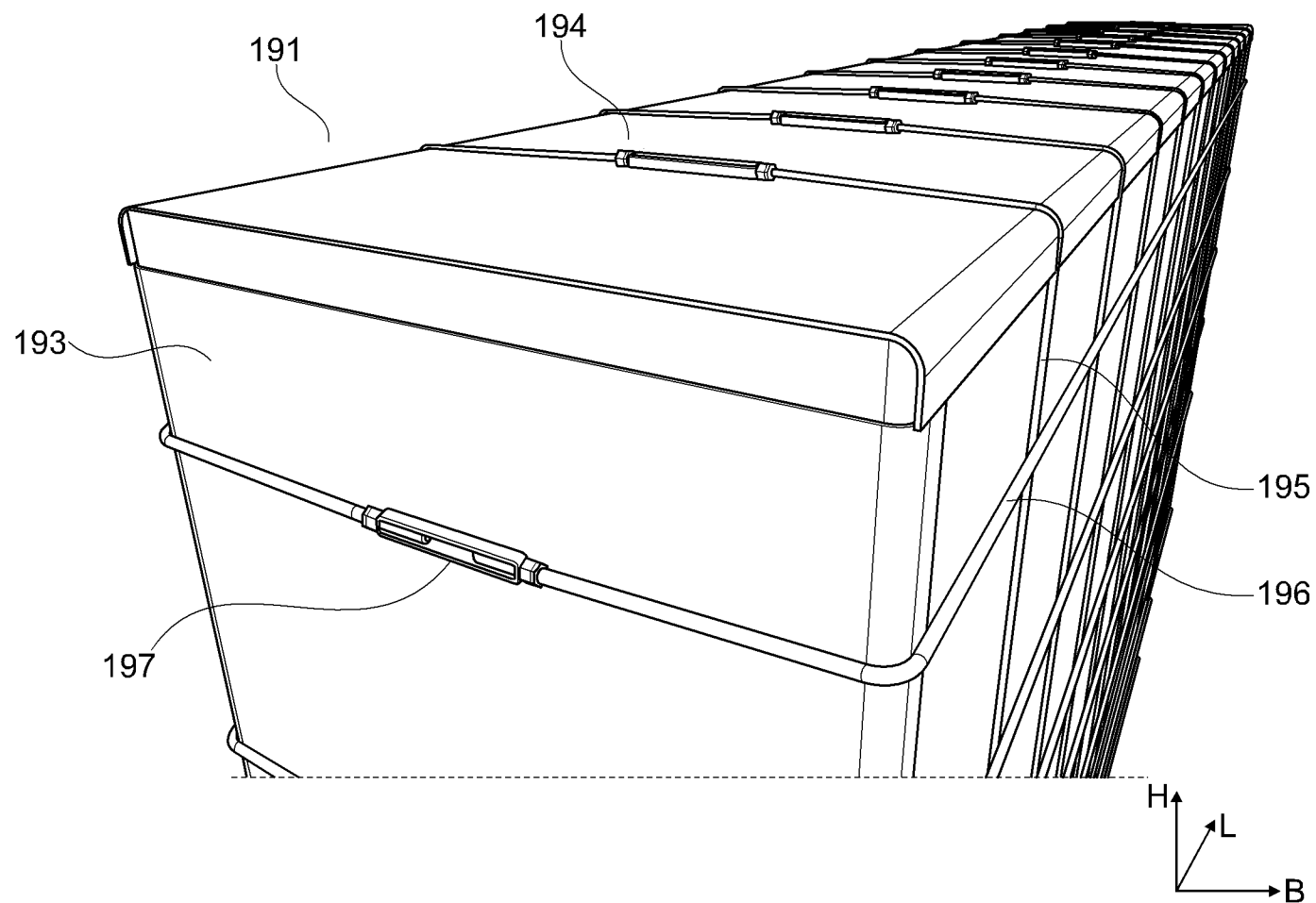


Fig. 28

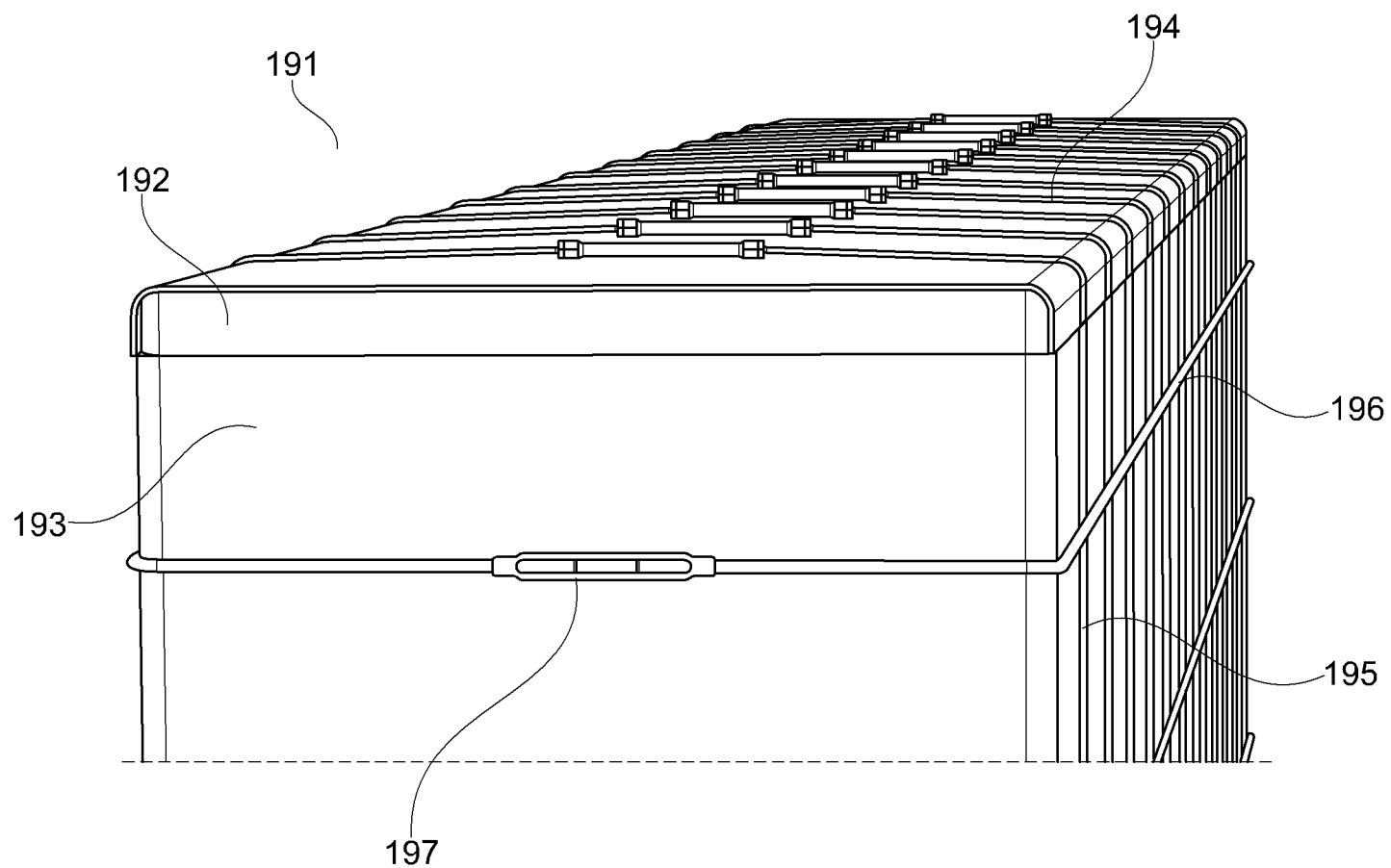


Fig. 29

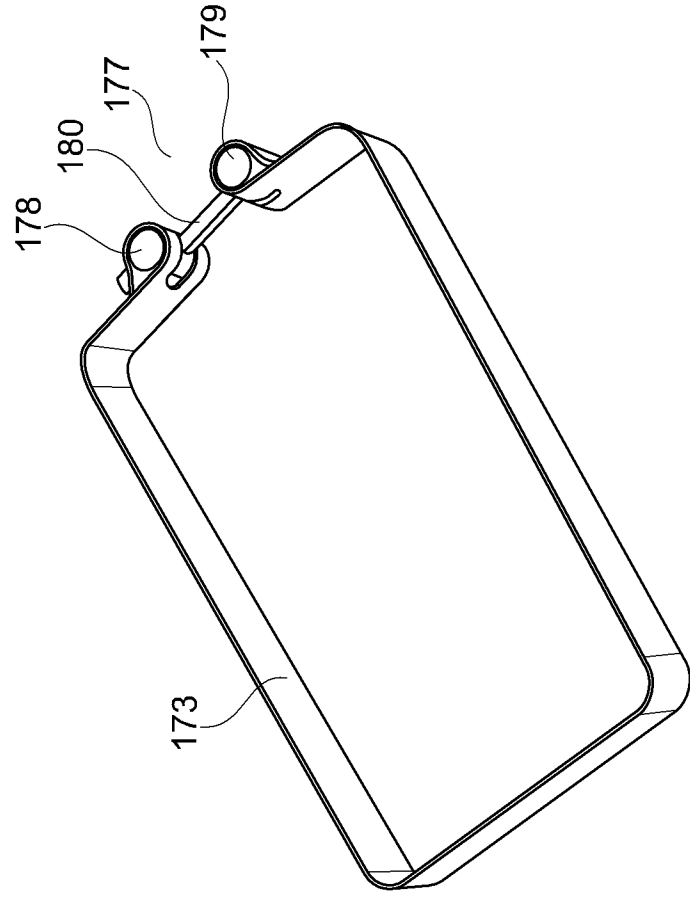


Fig. 30

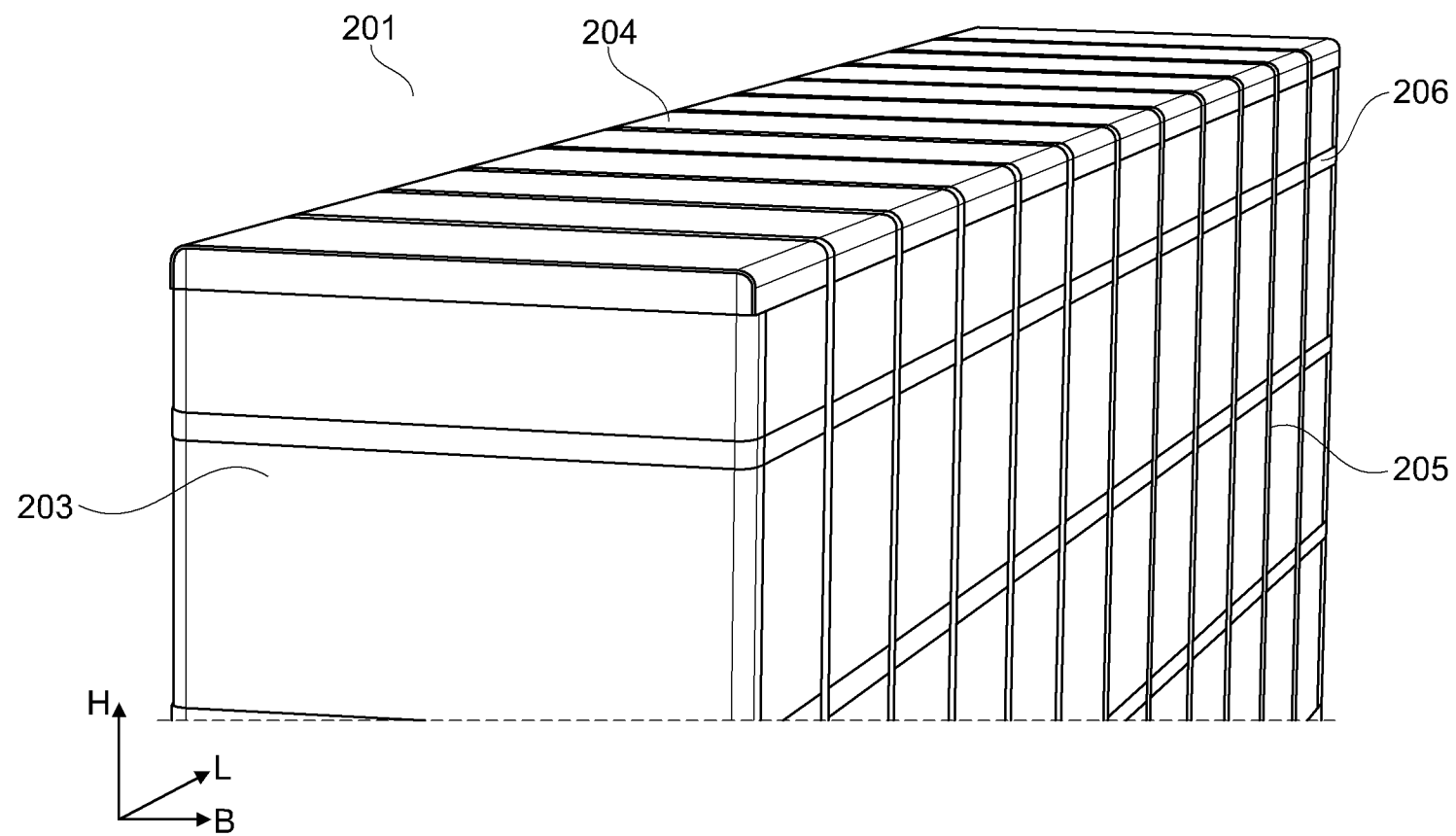


Fig. 31

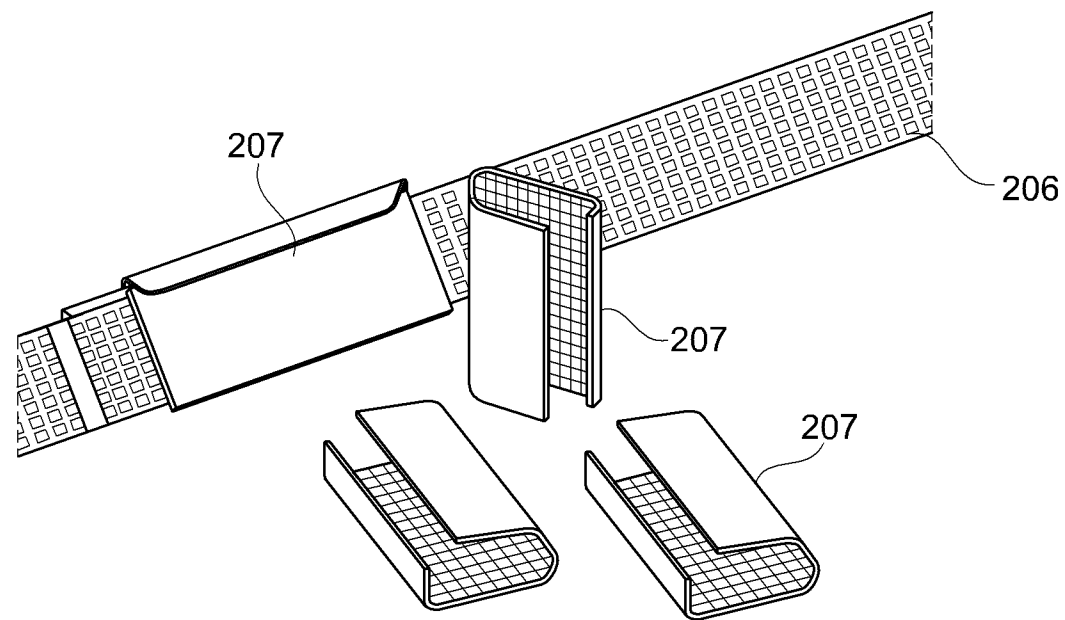


Fig. 32

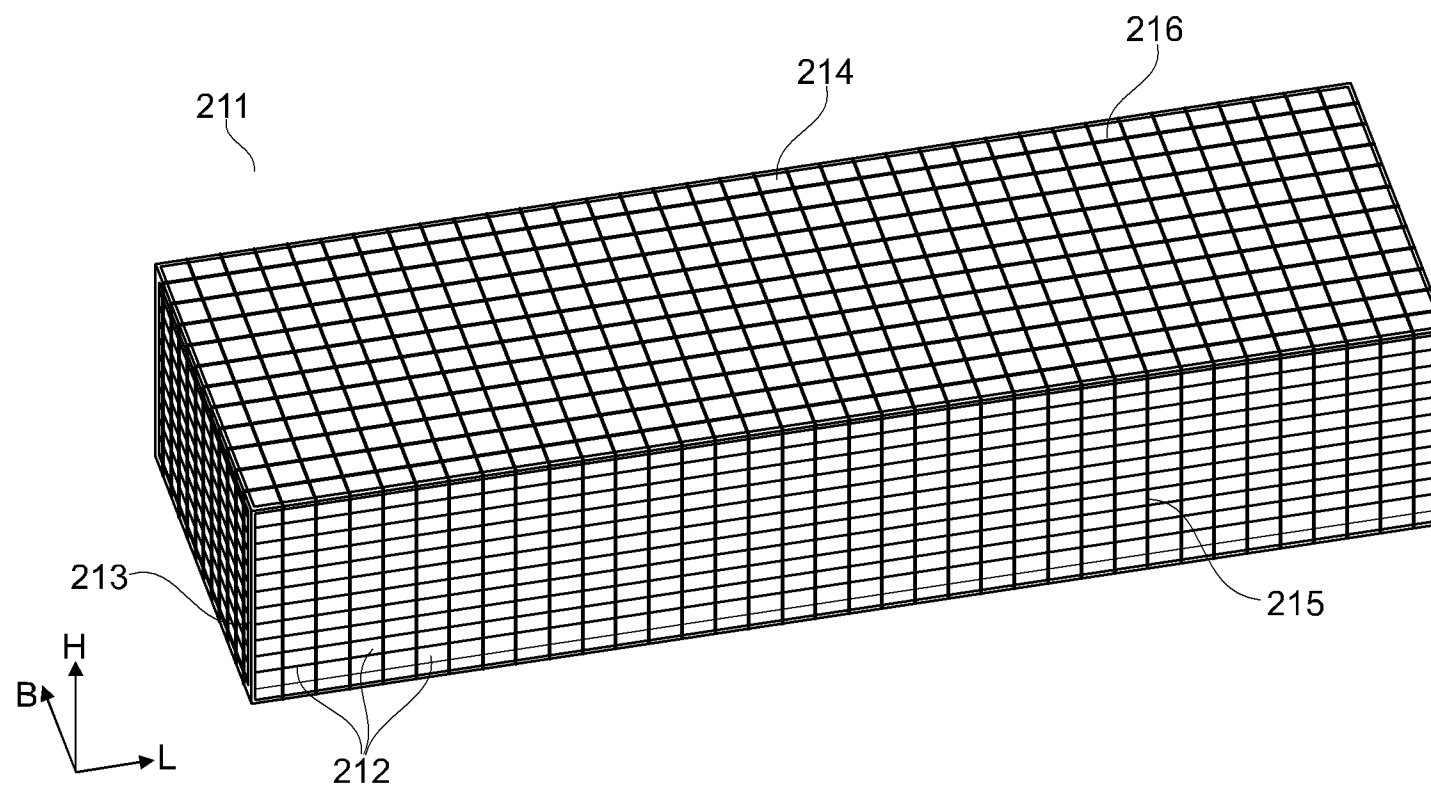


Fig. 33

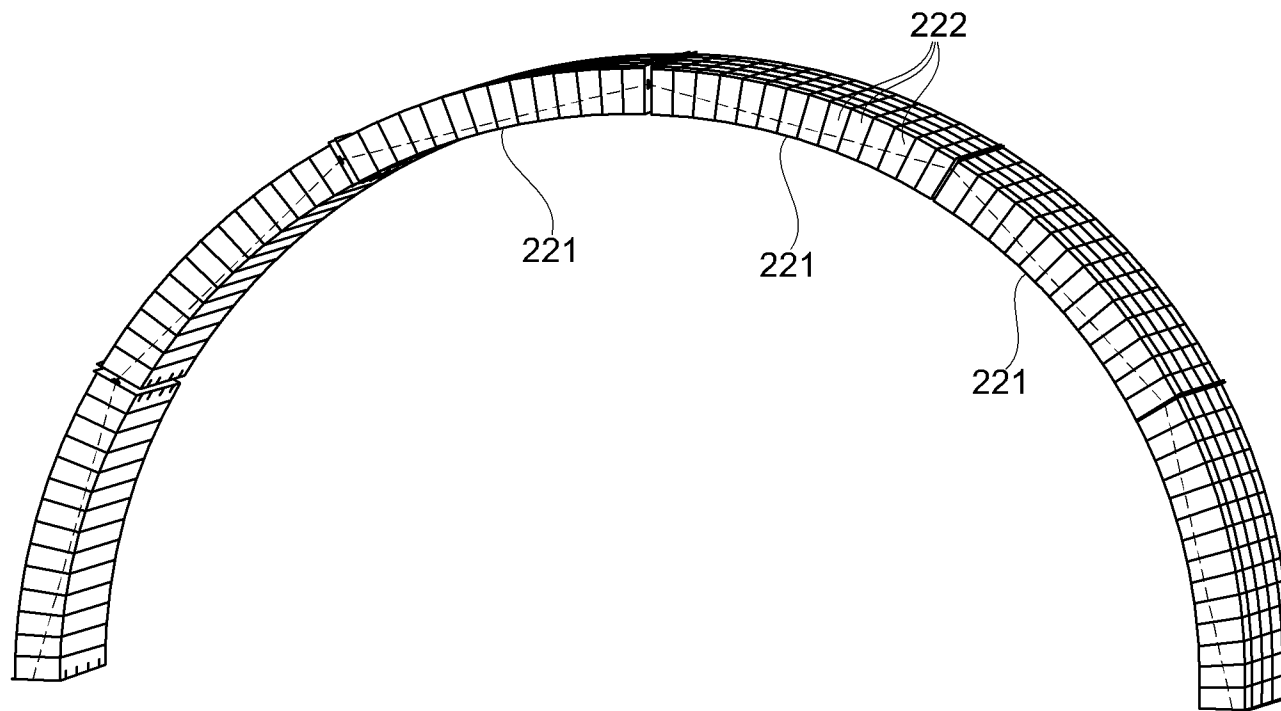


Fig. 34

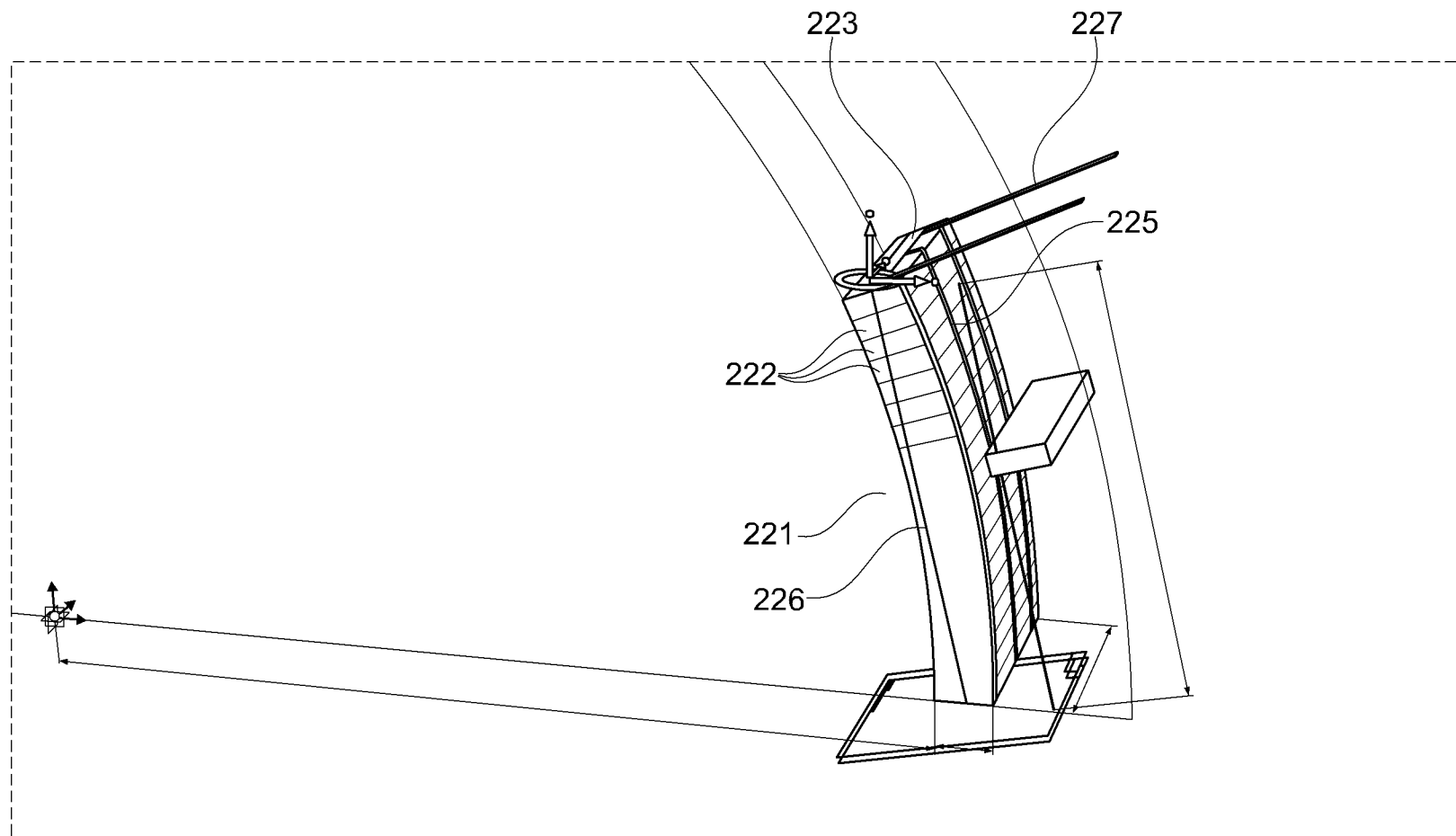


Fig. 35

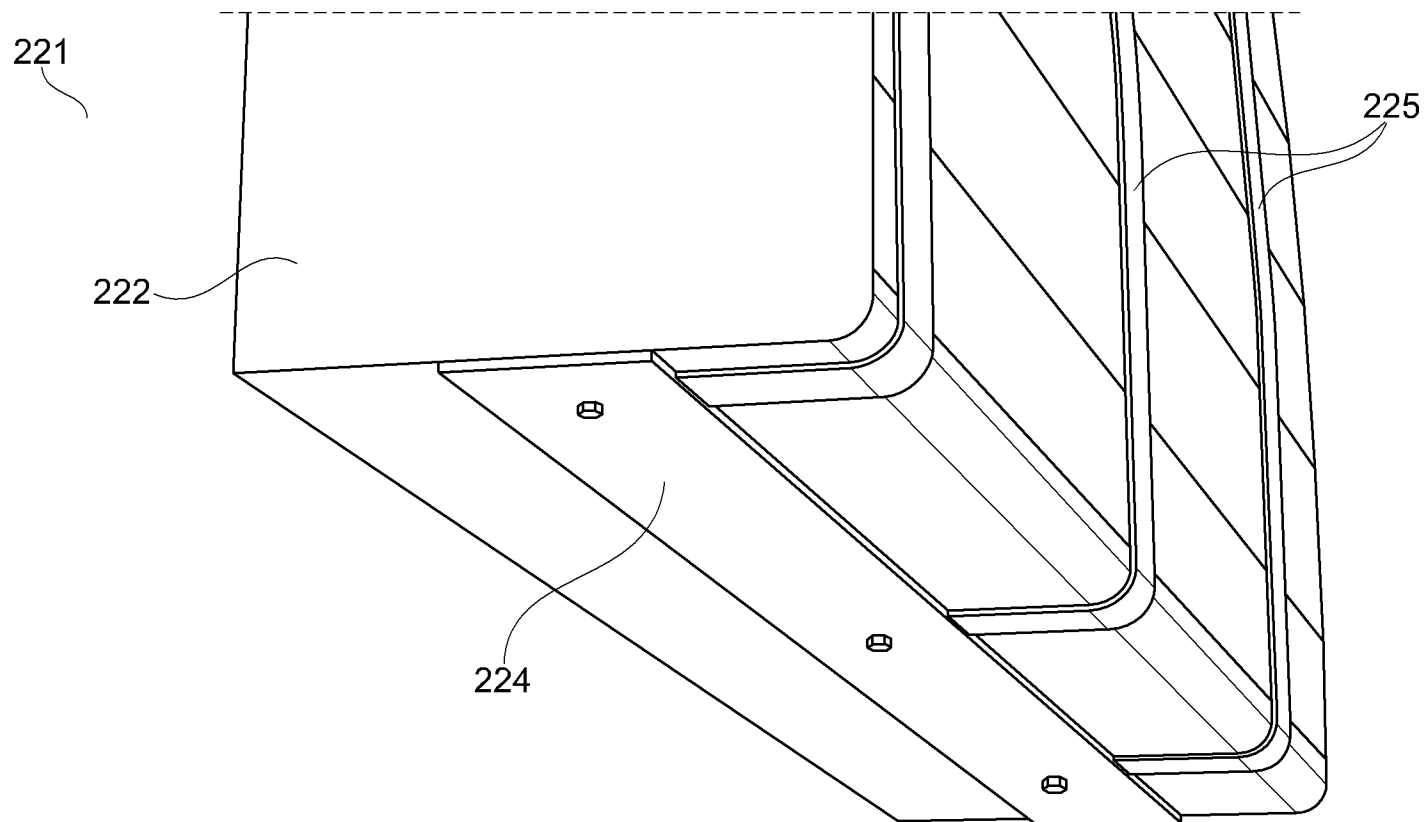


Fig. 36

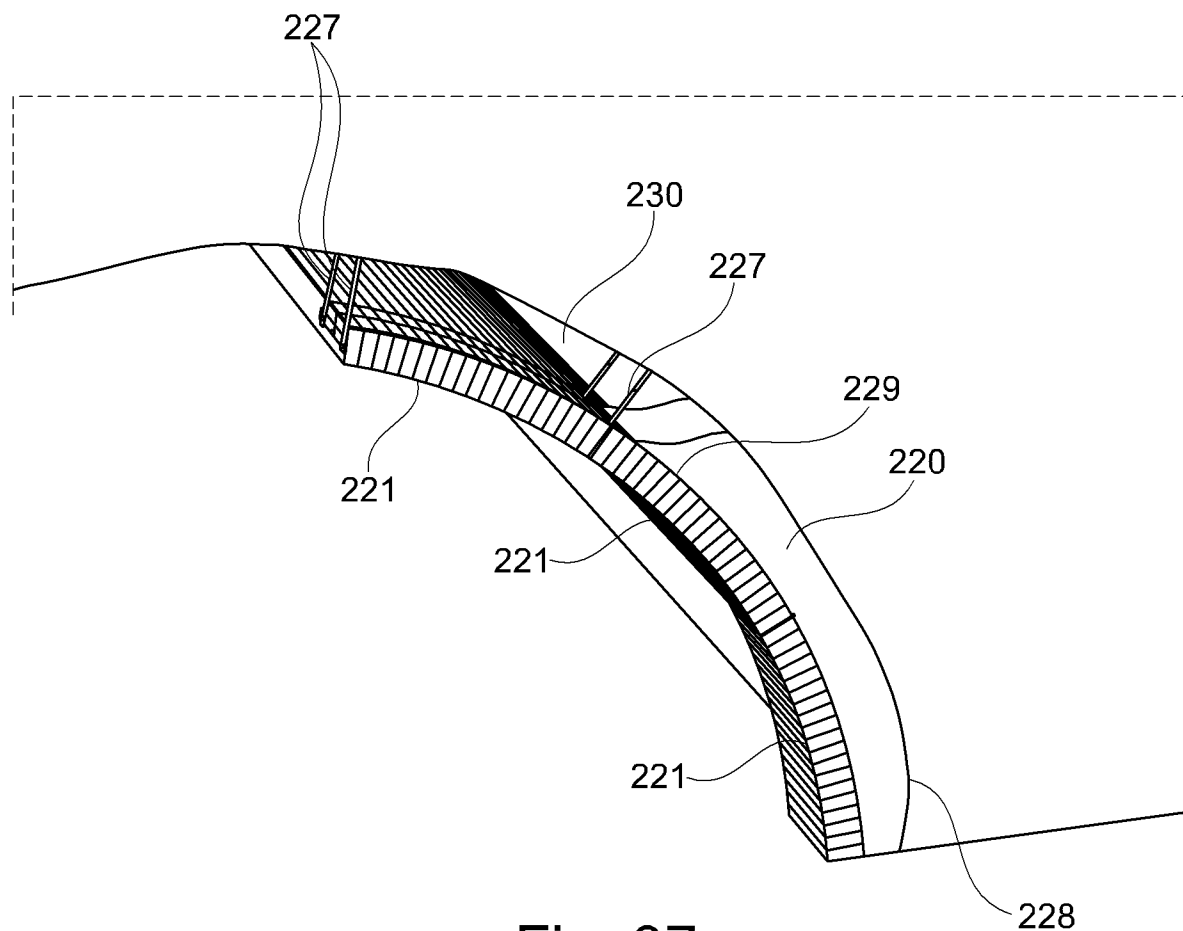


Fig. 37

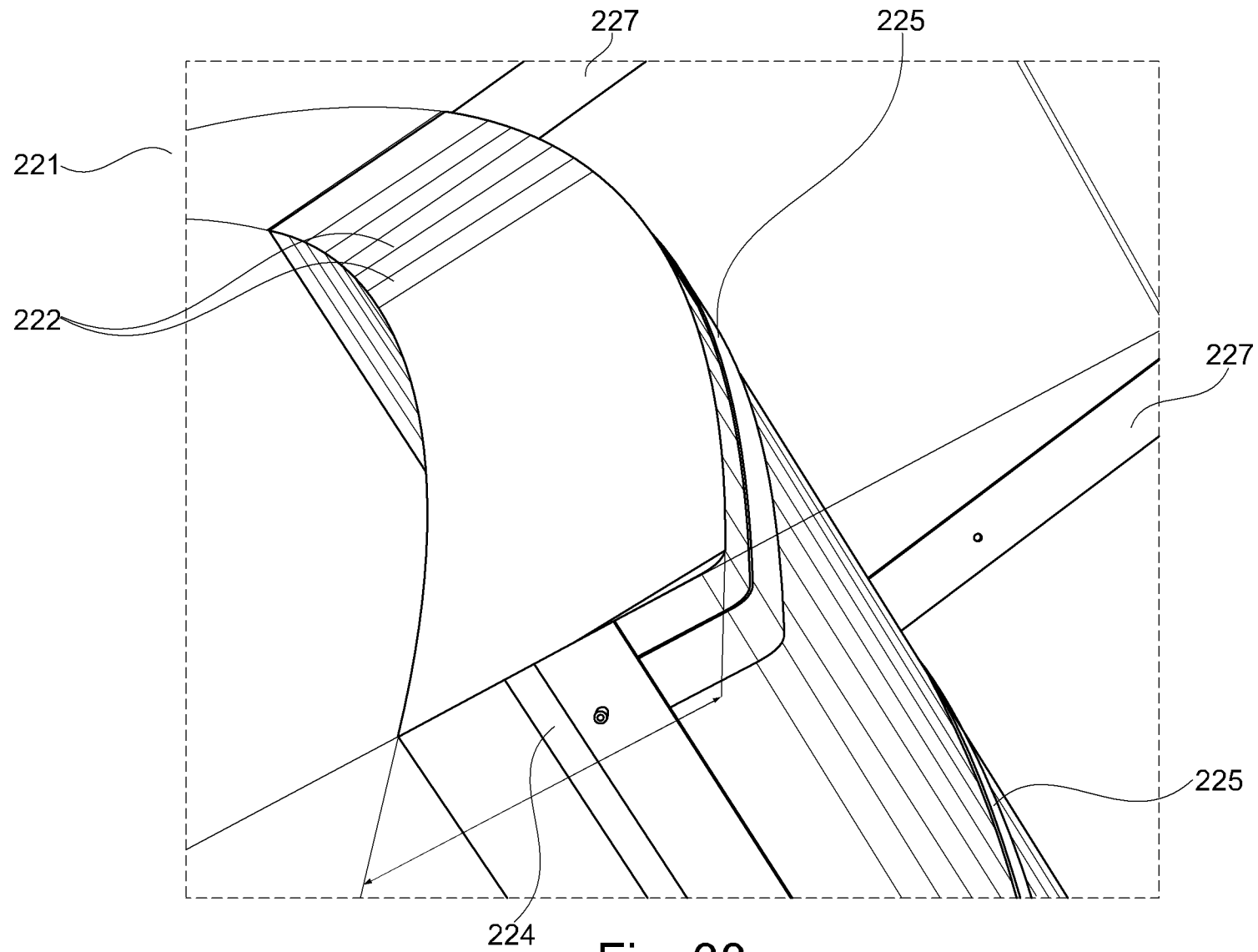


Fig. 38

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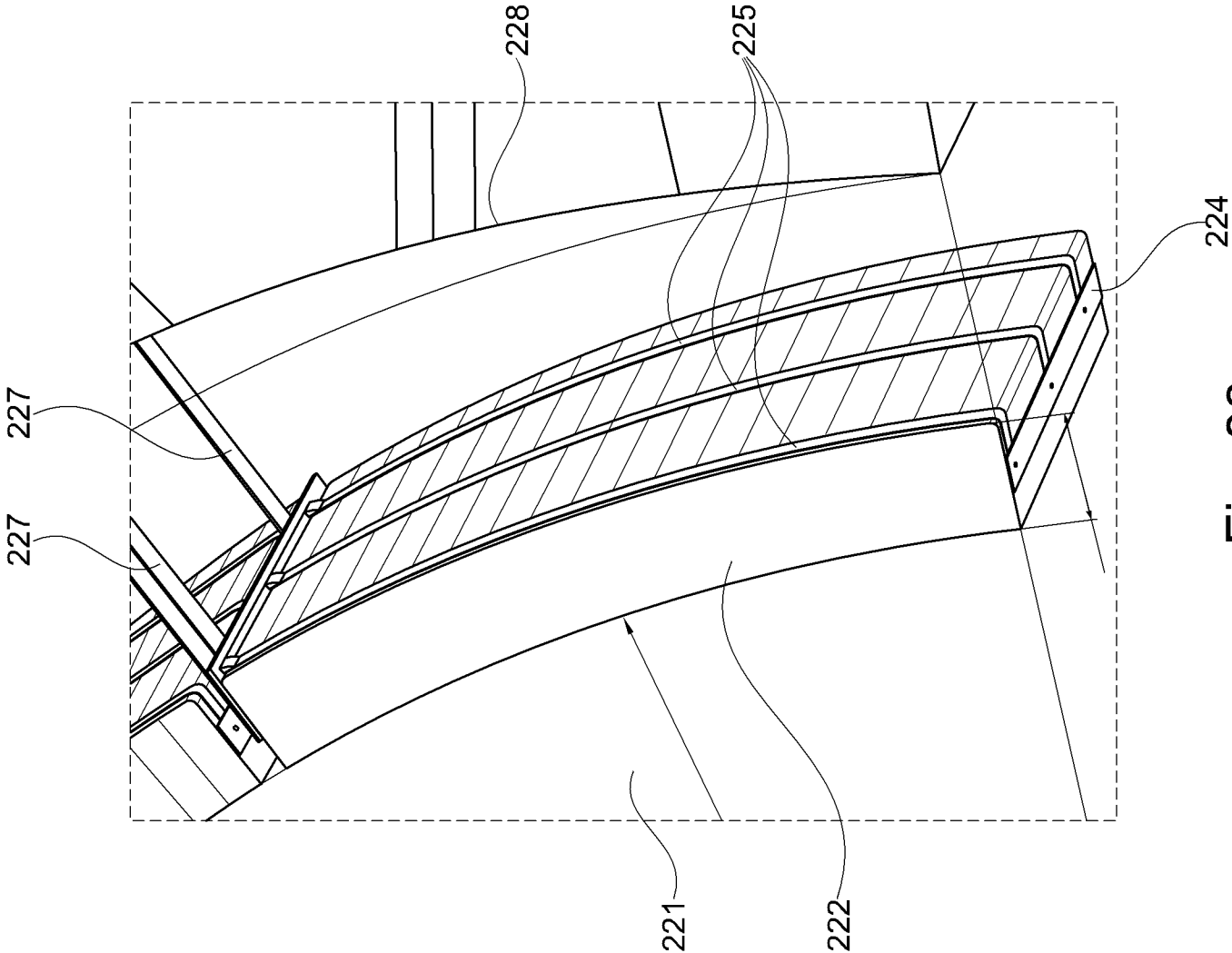


Fig. 39

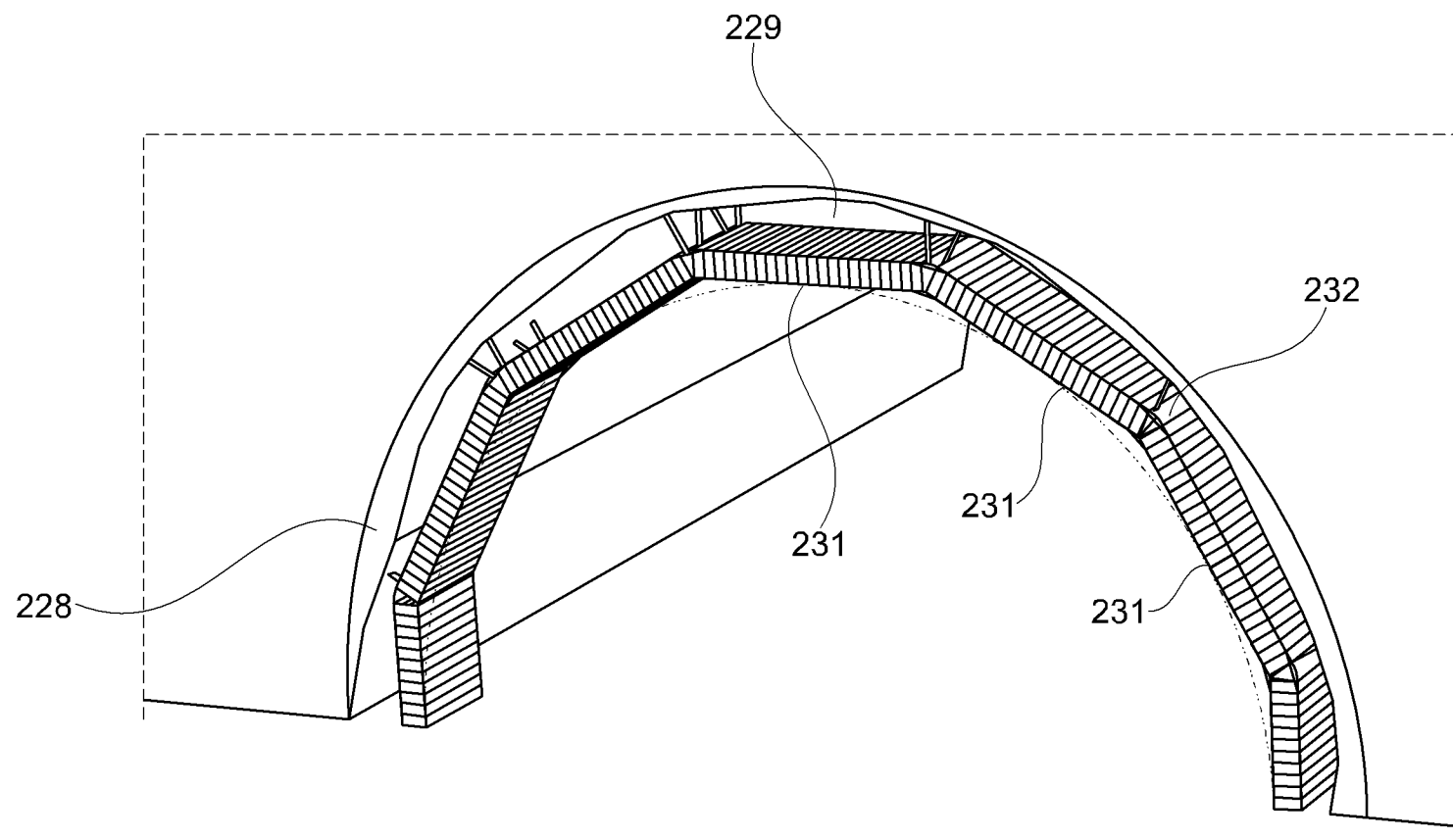


Fig. 40

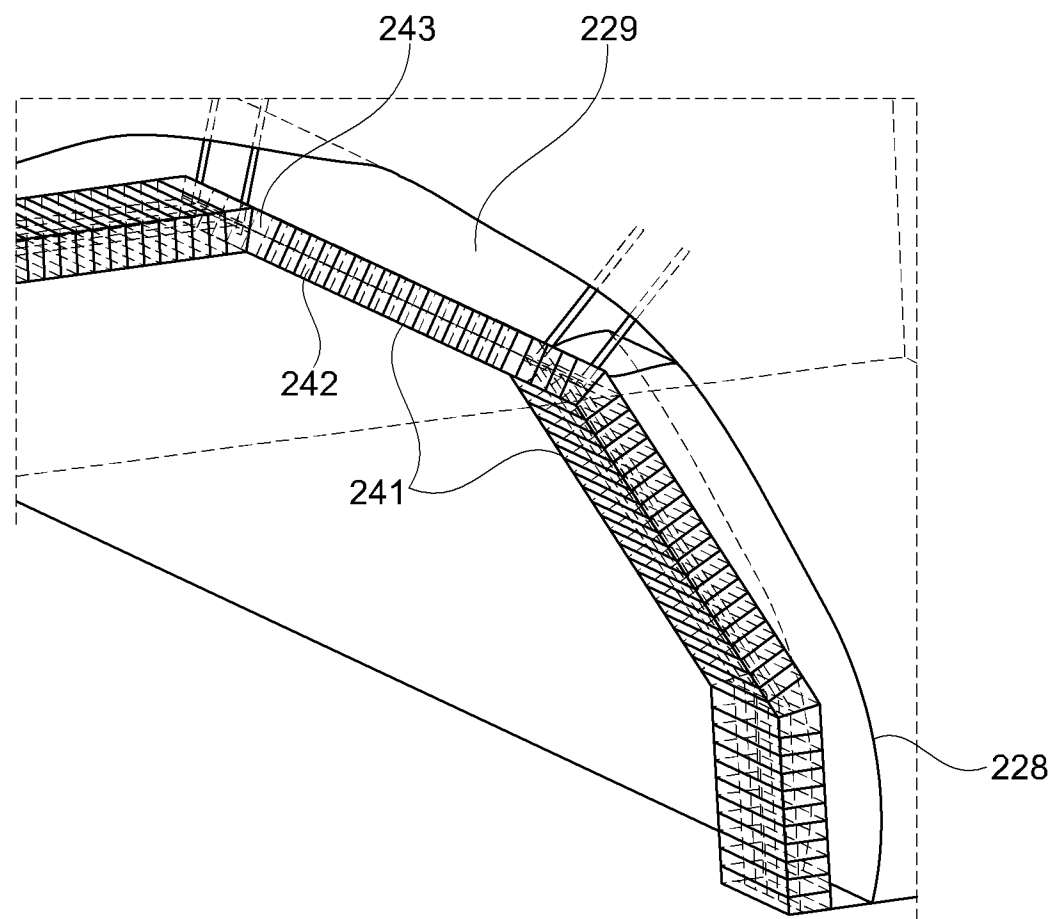


Fig. 41

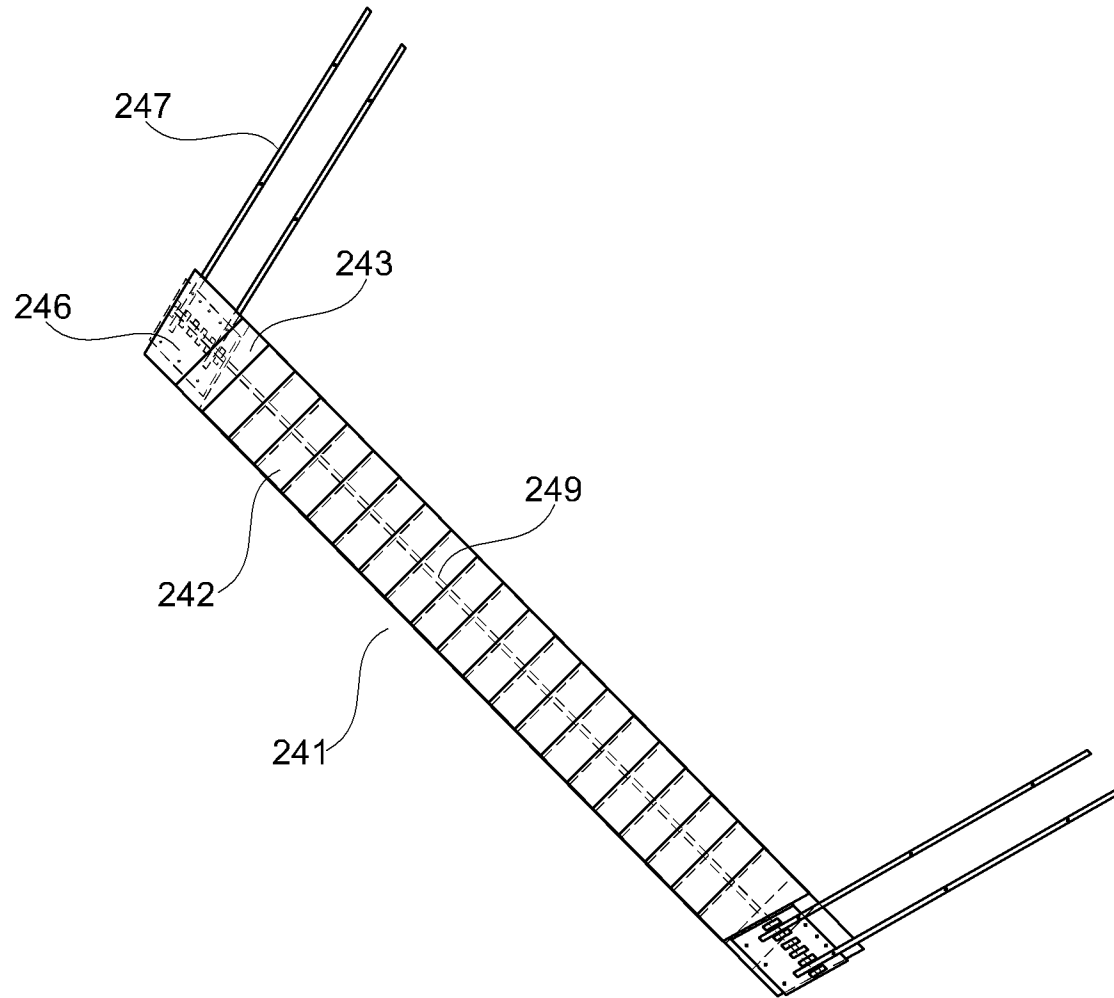


Fig. 42

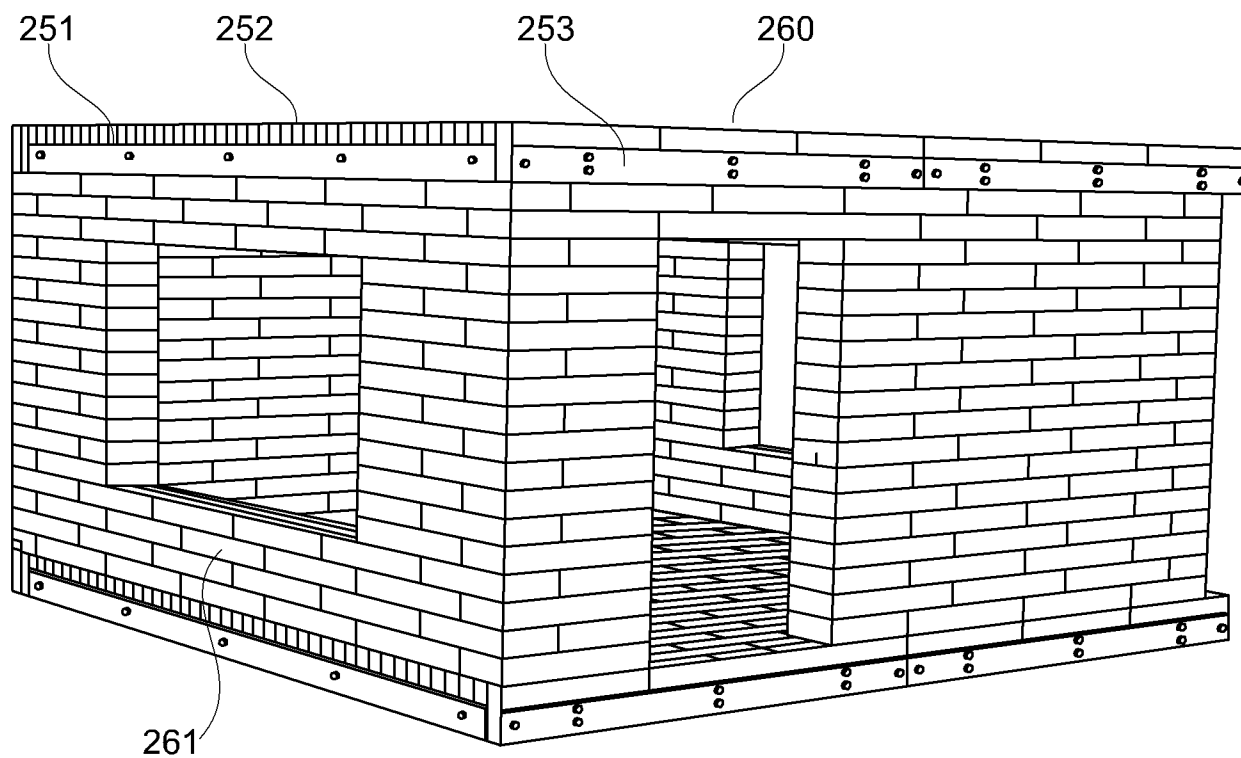


Fig. 43

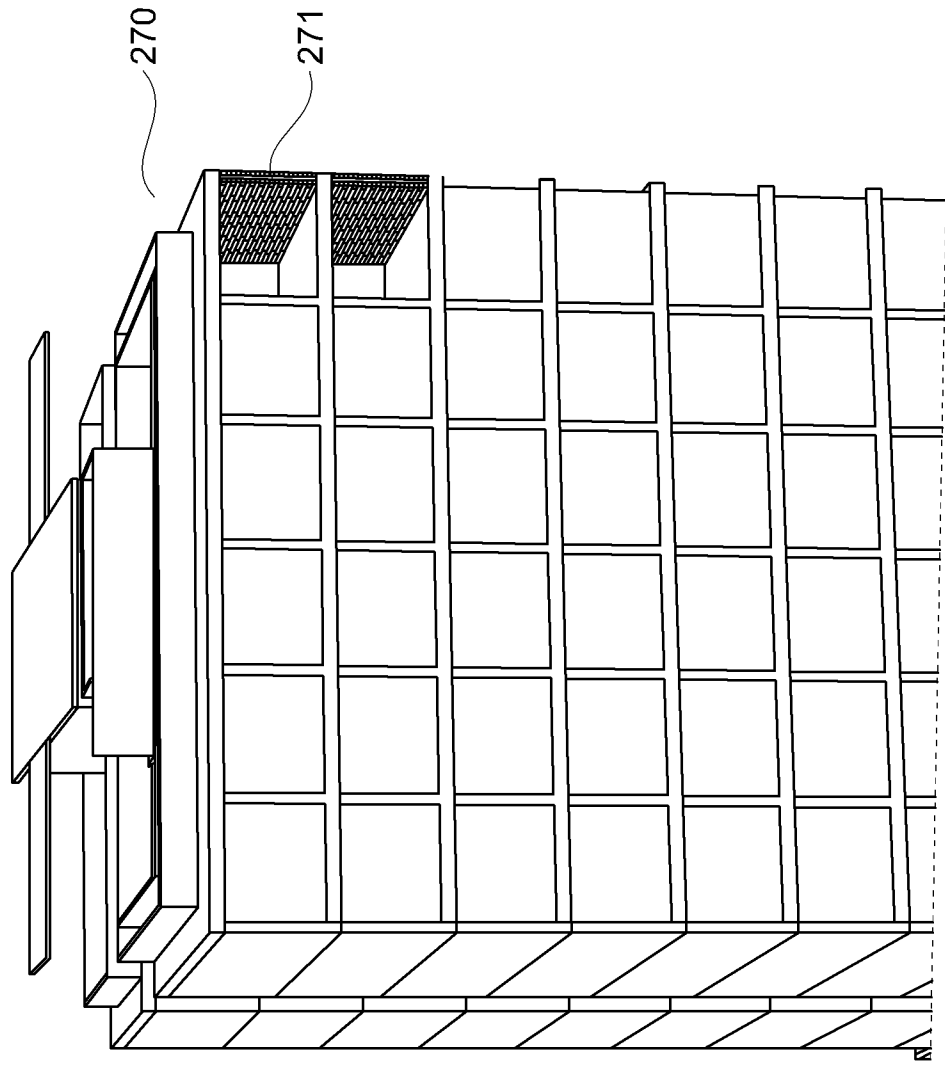


Fig. 44

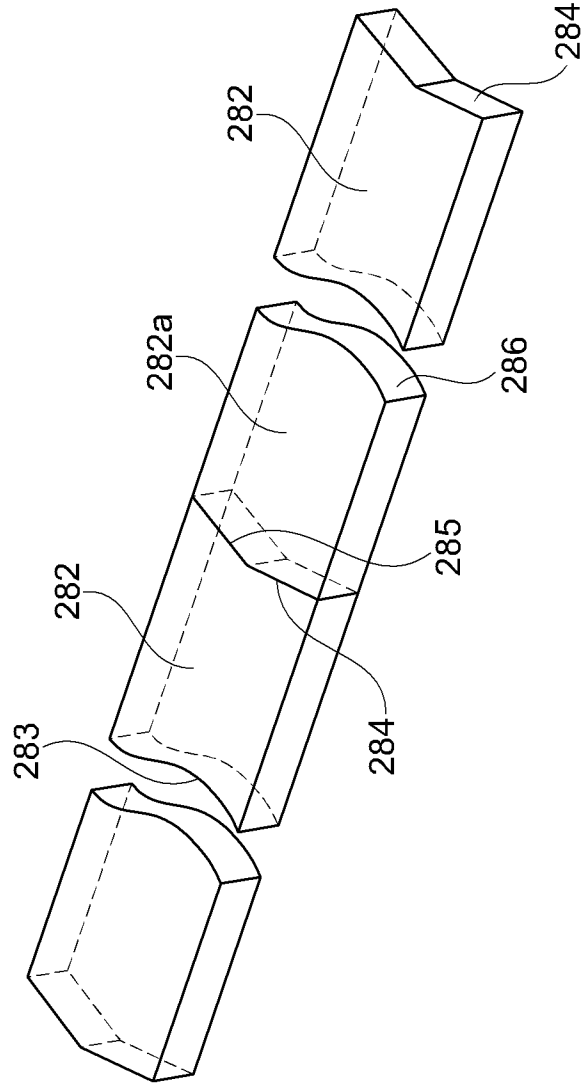


Fig. 45

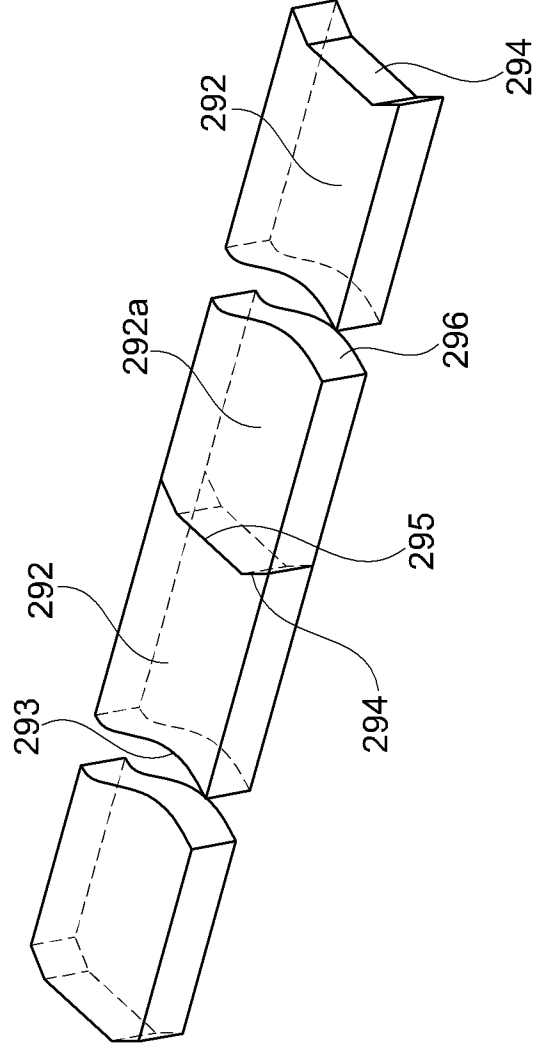


Fig. 46

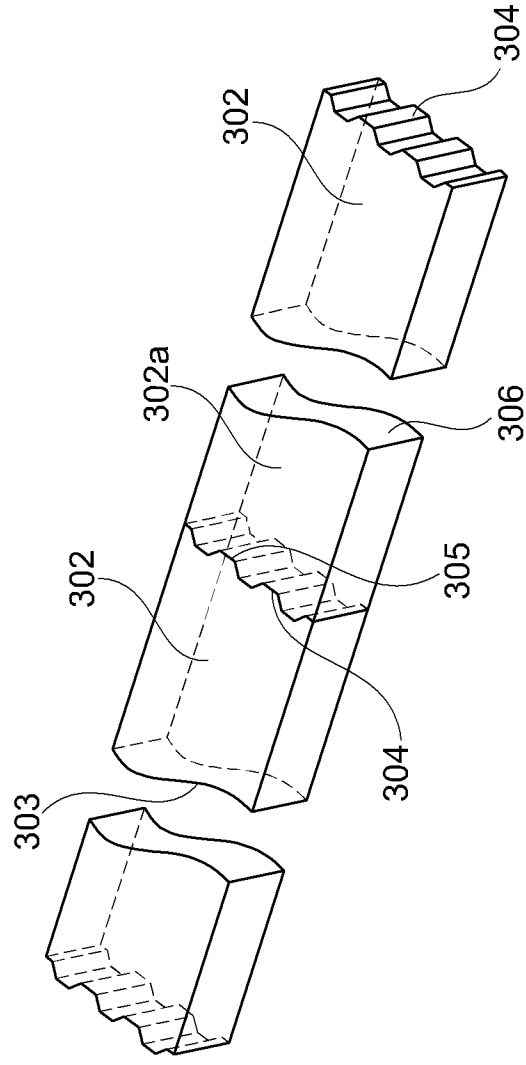


Fig. 47

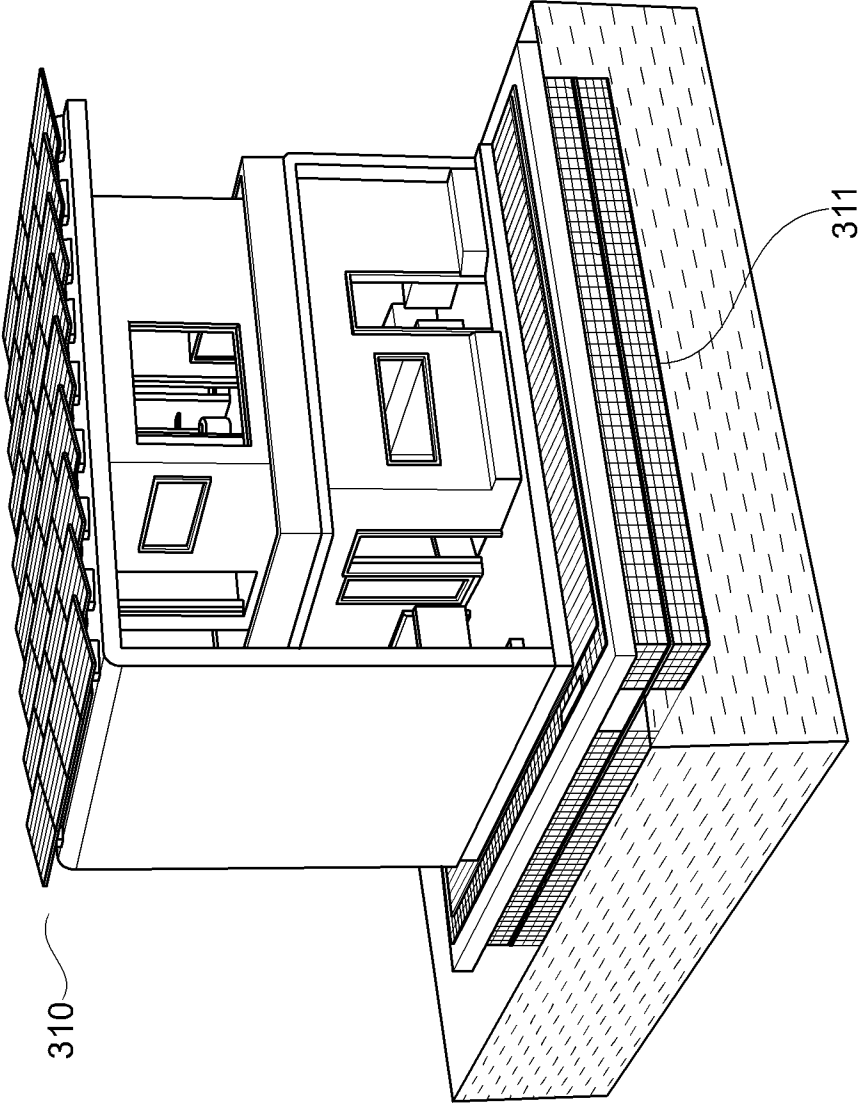


Fig. 48

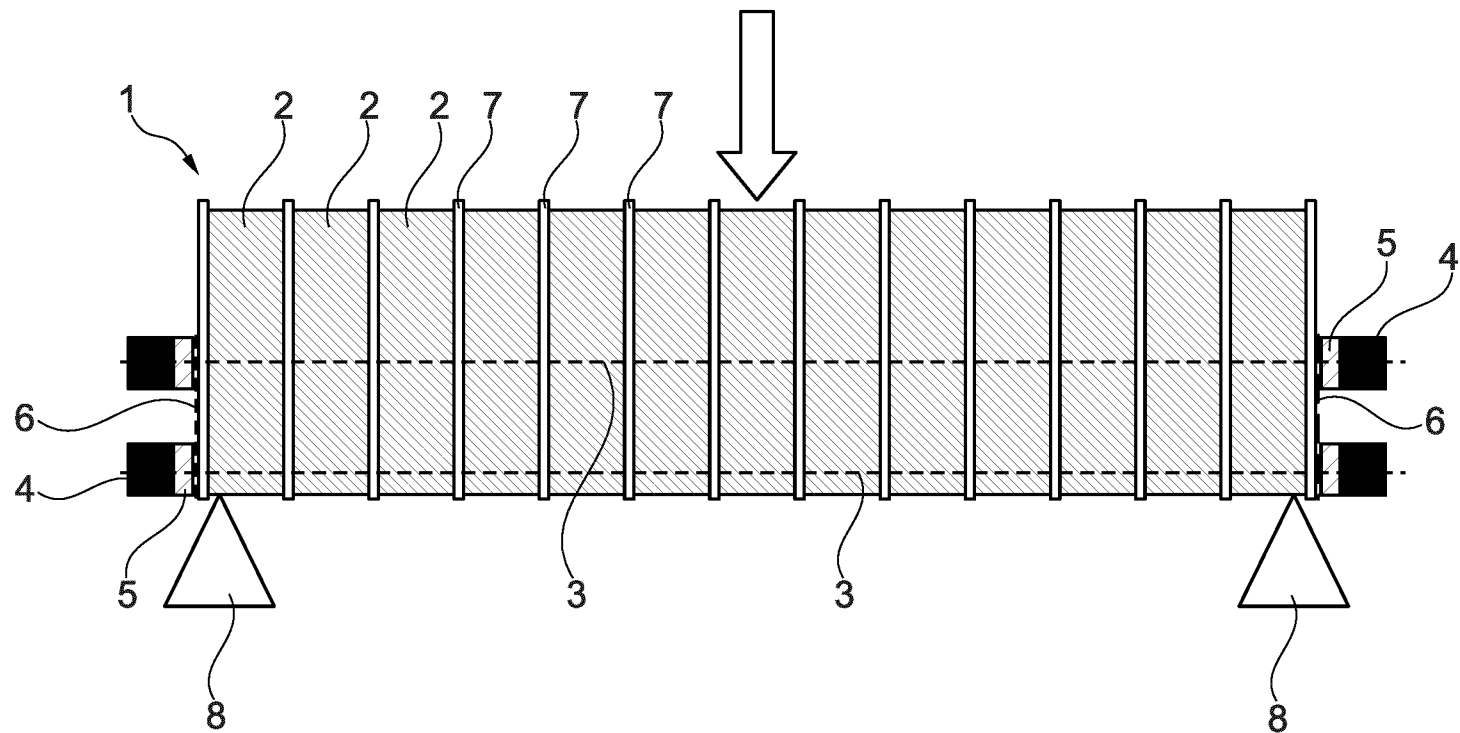


Fig. 1