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(54) **REINFORCED WOODEN STRUCTURAL PANEL**

(57) The present invention relates to a wooden structural panel for use in construction applications, said wooden structural panel being a rectangular cuboid having a length, a width, and a height, wherein said length is equal to or greater than said width, and wherein said width is equal to or greater than said height, said wooden structural panel comprising: a plurality of laminated

wooden members; two opposite primary faces extending in the length-width direction; at least one space arranged between said two opposite primary faces; at least one material arranged in said at least one space; wherein the average density of the total amount of material in said at least one space is greater than the average density of said wooden members.

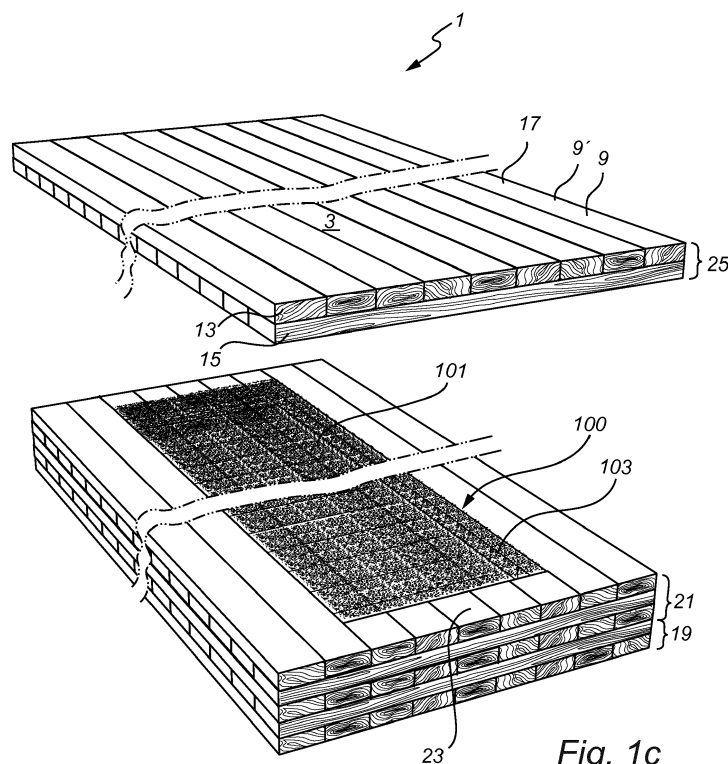


Fig. 1c

Description

Field of the Invention

[0001] The present invention relates to structural elements for use in the construction of buildings, and specifically to a prefabricated reinforced wooden structural panel.

Background

[0002] Historically, concrete elements have often been used in the construction of buildings. However, a desire to use more environmentally friendly materials has led to the search for alternative materials to be used when constructing buildings. When constructing buildings today, wooden structural panels are sometimes used as construction elements for the construction of roofs, floors, or walls. Commonly available wooden structural panels have at least the following drawbacks as compared to other traditional construction elements such as concrete blocks or panels: lower stability, less efficient sound insulation, lower stiffness, shorter span, more sensitive to moisture. Furthermore, one common area where the use of traditional wooden structural panels has drawbacks is in wind stability of building constructed using these panels.

[0003] Thus, when using wooden structural panels in the construction of floors, it is often necessary to coat the upper surface of the panels with cement, concrete, rubble, or gravel in order to achieve a stiff and stable surface on which a floor covering or flooring may be arranged. When using wooden structural panels to separate one level of a building from another, a ceiling material often has to be attached to the wooden structural panel in order to achieve improved sound insulation between floors. Applying any of these materials to the wooden structural panel after it has been mounted to the remaining construction elements is a time consuming and work intensive activity that adds an extra step to the construction process. Also, lead times increase as flooring cannot be applied to a cement or concrete covered surface of the wooden structural panel until the cement or concrete has set. Also, the addition of moisture through the cement or concrete may lead to a potentially unhealthy indoor climate.

Summary of the Invention

[0004] The present invention is based on the realization that by providing a wooden structural panel with improved structural properties, it will not be necessary to coat the wooden structural panel with cement or the like, thereby maintaining the aesthetic appearance of the wooden structural panel and saving time at the construction site.

[0005] An object of the present invention is therefore to alleviate the abovementioned problems and provide a

wooden structural panel that has improved structural properties. The wooden structural panel according to the present invention has improved stability, improved sound insulation and improved usability compared to commonly available wooden structural panels.

[0006] The above and other objects which will be evident from the following description are achieved by a wooden structural panel according to the present invention.

[0007] According to a first aspect of the present invention, a wooden structural panel for use in construction applications is provided, said wooden structural panel being a rectangular cuboid having a length, a width, and a height, wherein said length is equal to or greater than said width, and wherein said width is equal to or greater than said height, said wooden structural panel comprising:

a plurality of laminated wooden members,
two opposite primary faces extending in the length-width direction,
at least one space arranged between said two opposite primary faces,
at least one material arranged in said at least one space,
wherein the average density of the total amount of material in said at least one space is greater than the average density of said wooden members.

[0008] The term construction applications is to be understood as meaning e.g. the construction of buildings, verandas, walls, or similar. The wooden structural panel according to the present invention is suitable for use as a building material or construction element when constructing load bearing or supporting elements of a building.

[0009] According to one exemplary embodiment, the two opposite primary faces extend the entire length and width of the wooden structural panel.

[0010] A plurality of laminated wooden members is to be understood as meaning that the wooden structural panel comprises at least two wooden members that are adhered to each other. Furthermore, the term laminated is to be understood as meaning that each wooden member is adhered to its neighbors by means of e.g. adhesives and/or mechanical fasteners. Pressure and/or heat may additionally be applied to the wooden members to further strengthen their adherence to each other.

[0011] According to one exemplary embodiment, said plurality of laminated wooden members are laminated to each other in at least 3 layers, preferably at least 5 layers, and most preferably at least 7 layers, measured in the height direction of the wooden structural panel.

[0012] According to one exemplary embodiment, said plurality of laminated wooden members is a plurality of wooden boards, wherein each board has a thickness that is at between 2 mm and 100 mm, preferably between 10 mm and 75 mm, most preferably between 10 mm and 50

mm, and a width that is between 30 mm and 250 mm, preferably between 50 mm and 175 mm, most preferably between 75 mm and 125 mm. It should be noted that, regardless of if said wooden members are boards or not, according to at least one exemplary embodiment, each one of said plurality of laminated wooden members is formed from the same wooden material or the same species of wood. While this is beneficial from a practical (and sometimes aesthetic) point of view, in at least another exemplary embodiment at least one of said plurality of laminated wooden members is formed from a different wooden material or species of wood compared to at least another one of said plurality of laminated wooden members.

[0013] Thus, a wooden structural panel that is strong and stiff may be achieved, as the lamination of the wooden members has a strengthening and stiffening effect on the panel.

[0014] The lamination of wooden members to each other facilitates the creation of said at least one space. For example, a number of wooden members may be omitted or skipped during the process of laminating said wooden members, thus creating a space or a number of spaces in which said at least one material may be arranged in order to increase the density of the wooden structural panel. Additionally, or alternatively, the process of creating at least one space inside said wooden structural panel while laminating said plurality of wooden members may enable the creation of a space that is surrounded on all sides by said wooden members. In other words, the at least one space and the at least one material arranged therein may be built-in or encapsulated inside the wooden structural panel during its construction.

[0015] According to one exemplary embodiment, the total weight of the at least one material arranged in said at least one space is at least 10%, preferably at least 25%, and most preferably at least 50% of the total weight of the plurality of laminated wooden members.

[0016] According to one exemplary embodiment, the wooden structural panel according to the present invention weighs at least 125%, preferably at least 150%, most preferably at least 175% of what a solid block having the same length, width and height as said wooden structural panel, and having the same average density as said plurality of wooden members of the present invention.

[0017] According to one exemplary embodiment, each one of said at least one space is a rectangular cuboid. By having a space that is shaped as a rectangular cuboid, standard construction elements, such as concrete beams or steel beams, may be used to fill the at least one space in order to increase the density of the wooden structural panel. Other shapes of the at least one space are conceivable as well. According to one exemplary embodiment, each one of said at least one space has a triangular cross-section, a curved cross-section, or an irregular cross-section. Thus, an I-beam or other objects present inside said space may be built in by the lamination of said plurality of wooden members.

[0018] According to one exemplary embodiment, each one of said at least one space has a length that is between 10 % and 90 %, preferably between 30 % and 80 %, most preferably between 40 % and 70 % of the length of the wooden structural panel. According to one exemplary embodiment, said at least one space has a length that is at least 100% of the length of the wooden structural panel.

[0019] According to one exemplary embodiment, each one of said space has a width that is between 10 % and 90 %, preferably between 30 % and 80 %, most preferably between 40 % and 70 % of the width of the wooden structural panel. According to one exemplary embodiment, said at least one space has a width that is at least 100% of the length of the wooden structural panel.

[0020] According to one exemplary embodiment, each one of said space has a height that is between 10 % and 90 %, preferably between 30 % and 80 %, most preferably between 40 % and 70 % of the height of the wooden structural panel.

[0021] According to one exemplary embodiment, said wooden structural panel is a prefabricated wooden structural panel. In other words, said wooden structural panel may be manufactured off-site in a production facility, thus providing better conditions for high quality and efficient production of the wooden structural panels. Said wooden structural panel being prefabricated means that the wooden structural panel is ready to be used in the construction or assembly of a building without any further modification or adjustments.

[0022] According to one exemplary embodiment, said length of said wooden structural panel is at least 2500 mm, preferably at least 4000 mm, most preferably at least 6000 mm. By having a wooden structural panel that has a length of over 2500 mm, or over 4000 mm, or over 6000 mm, better usability in construction applications is achieved. For example, the distance between supporting walls may be increased. That the at least one material arranged inside said at least one space has higher density than the surrounding wooden members has at least the effect that the stiffness of the wooden structural panel is improved in a building application. This enables the wooden structural panel of the present invention to be produced in lengths that are greater than what was possible using previously known wooden structural panels.

[0023] According to one exemplary embodiment, said width of said wooden structural panel is at least 300 mm, preferably at least 1200 mm, most preferably at least 2000 mm. Thus, better usability in construction application may be achieved. That the at least one material arranged inside said at least one space has higher density than the surrounding wooden members has at least the effect that the stiffness of the wooden structural panel is improved in a building application. This enables the wooden structural panel of the present invention to be produced in widths that are greater than what was possible using previously known wooden structural panels.

[0024] The width of the wooden structural panel is de-

terminated partly by the intended use of the panel, with certain applications calling for wider panels and some for less wide panels, but also by external constraints such as the width of commonly available trucks and transportation vehicles for transporting the wooden structural panels from a production site to a construction site.

[0025] The wooden structural panel according to the present invention may be produced in sufficiently large dimensions to be effectively used in construction applications, without losing its desired stability and stiffness. Furthermore, the increased density of the wooden structural panel of the present invention provides it with improved sound insulating properties. This is due to the fact that lower density wooden structural panels more easily transmit sound from one side of the panel to the other. The increased density makes the wooden structural panels less susceptible to transmitting sound waves as the amount of energy required to set the wooden structural panel in motion is increased with increased weight and/or density. Thus, buildings may be constructed using the wooden structural panel of the present invention that have the above advantages over buildings constructed using traditional wooden structural panels.

[0026] According to one exemplary embodiment, said two opposite primary faces are defined by at least some of said plurality of laminated wooden members.

[0027] The two opposite primary faces may alternatively be referred to as a top surface and a bottom surface of said wooden structural panel. The top surface and the bottom surface may be substantially identical.

[0028] This is to be understood as meaning that the top surface and the bottom surface of the wooden structural panel may consist of laminated wooden members, and that the at least one material arranged in said at least one space is not accessible or visible from the top or bottom surface of the wooden structural panel. Thus, there is no need for a separate flooring to be placed on top of the wooden structural panel in order to have a wooden floor in a building constructed using the wooden structural panel of the present invention. Thus, construction of buildings may be made more efficient by using the wooden structural panel of the present invention. Similarly, there is no need to attach a ceiling material to the wooden structural panel of the present invention, as the wooden structural panel itself may function as a ceiling. The work task of attaching a ceiling material to a structural panel made of e.g. concrete or wood involves significant inconvenience for the construction worker. The present invention allows this work step to be removed altogether.

[0029] By using a wooden structural panel according to the present invention, the total amount of material used is less than when using commonly available wooden structural panels and covering or coating these with e.g. concrete, cement, sand, or gravel, upon which a flooring and/or ceiling material is applied. Thus, a more environmentally friendly construction element is achieved.

[0030] According to one exemplary embodiment, said at least one material comprises at least one granular filler

material.

[0031] A granular filler material is to be understood as being a material comprising a plurality of small, e.g. having an average diameter that is less than 100 mm, particles. The particles may or may not be of uniform size and shape. Examples of granular filler material are crushed concrete, gravel, sand, and ground granulated slag.

[0032] According to one exemplary embodiment, said at least one granular filler material comprises at least one material chosen from a group comprising the following materials: crushed concrete, gravel, sand, and ground granulated slag.

[0033] By using a granular filler material, a cheap and efficient way to increase the average density of the wooden structural panel is achieved. Thus, the stability, stiffness, and sound insulating properties may be improved in a cost efficient way. By choosing a material from the above group, cost efficiency is improved.

[0034] By using a granular filler material, a good packing fraction may be achieved. Thus, there is little room from the granular filler material to move around inside said at least one space and the stiffness and stability of the wooden structural panel is increased. Using a granular filler material allows a stable and stiff wooden structural panel to be created without introducing any liquid material, such as fluid cement, to the wooden structural panel. By using a liquid material such as fluid cement, unwanted moisture is introduced to the at least one space. If said space is then enclosed by said plurality of wooden members, the moisture is encapsulated therein, which may lead to a lowered lifetime of said wooden structural panel, along with decreased indoor air quality.

[0035] According to one exemplary embodiment, said at least one material comprises a combination of different granular filler materials. Said combination of different granular materials may be chosen from a group comprising the following materials: crushed concrete, gravel, sand, and ground granulated slag. By using a combination of different granular filler materials, an even better packing fraction may be achieved. The at least one space may for example first be filled with a first granular filler material having a first average grain size, after which said at least one space is filled with a second granular material having a second average grain size, wherein said second average grain size is smaller than said first average grain size. Said second average grain size may for example be between 1 % and 50 % of said first average grain size.

[0036] According to one aspect of the invention, said wooden structural panel is created by first laminating a plurality of wooden structural members to each other so as to form at least one space, after which said at least one space is filled with a first granular filler material, after which said at least one space is filled with a second granular filler material. Filled is to be understood as meaning that said material is introduced into said at least one space, and not necessarily that said at least one space is completely filled by said material. According to one

exemplary embodiment, said first and second granular filler material may be compacted by means of vibrating said wooden structural panel. According to one exemplary embodiment, said at least one space is covered by a plurality of laminated wooden members after having been filled with said granular filler material.

[0037] According to one exemplary embodiment, said at least one material comprises at least one reinforcement beam.

[0038] According to one exemplary embodiment, said at least one reinforcement beam comprises at least one steel beam, concrete beam or reinforced concrete beam.

[0039] A reinforcement beam is to be understood as being any kind of solid member having a length that is significantly greater than both its width and its height. Significantly greater in this case is meant to be interpreted as the length being at least 5 times the width and/or height. Examples of reinforcement beams are concrete beams, steel beams, and reinforced concrete beams.

[0040] According to one exemplary embodiment, said reinforcement beam may be surrounded on all sides by said wooden members. In other words, said reinforcement beam may be arranged in a space that has substantially the same cross-sectional geometry and dimensions as the reinforcement beam.

[0041] By providing the wooden structural panel with a reinforcement beam, the stability and stiffness of the panel is further increased. Thus, less sound is translated through the panel, and the wooden structural panel requires fewer supporting walls and/or pillars in order to prevent the wooden structural panel from arching downwards when it is used in a horizontal orientation. This enables a wooden structural panel to be used in the construction of very large rooms which have few and far between supporting elements.

[0042] According to one exemplary embodiment, said at least one material comprises at least one reinforcement beam and at least one granular filler material.

[0043] According to one exemplary embodiment, said at least one reinforcement beam has a bending stiffness that is at least 2 times, preferably at least 3 times, and most preferably at least 4 times as high as that of said plurality of laminated wooden members.

[0044] According to one exemplary embodiment, said at least one material comprises at least one insulation material.

[0045] It should be understood that said at least one insulation material may be at least one sound insulation material or at least one thermal insulation material, or a combination of both.

[0046] By arranging at least one insulation material inside said at least one space, improved thermal insulation or sound insulation may be achieved while maintaining the stability and stiffness of the wooden structural panel.

[0047] According to one exemplary embodiment, said at least one material comprises at least one reinforcement beam and at least one insulation material.

[0048] According to one exemplary embodiment, said

at least one insulation material is a material chosen from a group comprising the following materials: glass wool, mineral wool, wool, Styrofoam, and polymer foam.

[0049] According to one exemplary embodiment, said plurality of laminated wooden members are cross laminated.

[0050] By cross laminating said plurality of wooden members, a stronger and stiffer structural panel is achieved. A cross laminated wooden structural panel has a strength to weight ratio that is greater than that of other laminated wooden structural panels and that of concrete elements. Thus, the desired strength can be achieved using relatively little weight, which gives the manufacturer of the wooden structural panel the possibility to add denser material to the wooden structural panel in order to further increase its stability, stiffness, and sound insulating properties, even before it is transported to the construction site. Cross lamination means that a massive wood construction product is created using bonded single-layer panels arranged at right angles to one another. The layers may be bonded together using adhesives and/or mechanical fasteners.

[0051] According to one exemplary embodiment, said at least one space is created by cross laminating a plurality of wooden members in a predefined pattern so as to create at least one space inside said wooden structural panel. For example, said wooden structural panel may be created by first cross laminating at least one bottom layer using a plurality of wooden members, said at least one bottom layer having the same width and length as the wooden structural panel that is to be created. Then, at least one middle layer is created by cross laminating a plurality of wooden members on top of said at least one bottom layer so as to form a frame around at least one space that is to be created. In other words, said at least one middle layer is laminated onto some portions of said at least one bottom layer, and not onto other portions of said at least one bottom layer. In other words, the cross sectional area of said middle layer is lower than the cross sectional area of said at least one top layer or said at least one bottom layer, in said length-width direction. Said at least one middle layer may for example have the cross-sectional shape of a numerical digit 0 or a numerical digit 8. Other shapes are also conceivable, for example a circle with a cross. The outer dimensions of said at least one middle layer may be the same as the outer dimensions of the wooden structural panel that is to be created. Finally, at least one top layer is created by cross laminating a plurality of wooden members on top of said at least one middle layer, covering both said at least one middle layer and the at least one space created therebetween. Said at least one top layer may have the same width and length as the outer dimensions of the wooden structural panel that is to be created.

[0052] According to one exemplary embodiment, said wooden structural panel further comprises:

two opposite side faces extending in the length-

height direction, and wherein said at least one space is arranged between said two opposite side faces.

[0053] According to one exemplary embodiment, said two opposite side faces are defined by at least some of said plurality of laminated wooden members.

[0054] This is to be understood as meaning that the two side faces of the wooden structural panel consist of laminated wooden members, and that the at least one material arranged in said at least one space is not accessible or visible from either side of the wooden structural panel. The construction of buildings may be made more efficient by using the wooden structural panel of the present invention.

[0055] The two opposite side faces may be substantially identical.

[0056] According to one exemplary embodiment, said wooden structural panel further comprises:

two opposite end faces extending in the width-height direction, and wherein said at least one space is arranged between said two opposite end faces.

[0057] According to one exemplary embodiment, said two opposite end faces are defined by at least some of said plurality of laminated wooden members.

[0058] This is to be understood as meaning that the two end faces of the wooden structural panel may consist of laminated wooden members, and that the at least one material arranged in said at least one space is not accessible or visible from either end of the wooden structural panel. The construction of buildings may be made more efficient by using the wooden structural panel of the present invention.

[0059] The two opposite end faces may be substantially identical.

[0060] According to one exemplary embodiment, the smallest dimension of said space is equal to or greater than the smallest dimension of each one of said plurality of wooden members.

[0061] This is to be understood as meaning that according to one exemplary embodiment, the at least one space has a height that is equal to or greater than the height of each one of the plurality of wooden members. For instance, in a cross-laminated wooden structural panel, such a space can be created by leaving out one or more wooden member compared to if a solid cross-laminated wooden structural panel would have been produced.

[0062] According to one exemplary embodiment, said wooden structural panel further comprises at least one wooden sheet. Said at least one wooden sheet may be used to cover the top or bottom of said wooden structural panel, or it may be used to cover any of the sides or end surfaces of the wooden structural panel.

[0063] According to one exemplary embodiment, said wooden structural panel may for example comprise at least one bottom layer of laminated wooden members,

at least one middle layer of laminated wooden members, and at least one wooden sheet used to cover the top of said wooden structural panel. Alternatively, said wooden structural panel may comprise a bottom wooden sheet, at least one middle layer of laminated wooden members and at least one top wooden sheet. Said wooden sheets may be laminated onto said plurality of laminated wooden members, or adhered thereto in any other fashion.

[0064] According to one exemplary embodiment, the average density of the total amount of material in said space is at least 2 times greater, preferably at least 2.5 times greater, most preferably at least 3 times greater, than the average density of said wooden members.

[0065] By having a denser material arranged inside said at least one space, a strengthening and sound insulating effect is achieved.

[0066] According to a second aspect of the present invention, there is provided a use of a wooden structural panel according to any embodiment of the first aspect of the present invention for constructing a building, wherein said wooden structural panel is prefabricated.

Brief description of the drawings

[0067] The above, as well as additional objects, features and advantages of the present invention, will be better understood through the following illustrative and non-limiting detailed description of exemplary embodiments of the present invention, with reference to the appended drawing, wherein:

Figure 1 a is a perspective view of a cross-laminated wooden structural panel according to at least one exemplary embodiment of the present invention, Figure 1 b is a cross-sectional view of the cross-laminated wooden structural panel of Fig. 1 a, Figure 1 c is an exploded perspective view of the cross-laminated wooden structural panel of Fig. 1 a, Figure 2 is a cross-sectional view of a cross-laminated wooden structural panel according to at least one exemplary embodiment, Figure 3 is a cross-sectional view of a cross-laminated wooden structural panel according to at least one exemplary embodiment, Figure 4 is a cross-sectional view of a cross-laminated wooden structural panel according to at least one exemplary embodiment, Figure 5a is a perspective view of a laminated wooden structural panel according to at least one exemplary embodiment of the present invention, Figure 5b is a cross-sectional view of the laminated wooden structural panel of Fig. 5a, Figure 6a is a perspective view of a laminated wooden structural panel according to at least one exemplary embodiment of the present invention, Figure 6b is a cross-sectional view of the laminated wooden structural panel of Fig. 6a, Figure 7 is a cross-sectional view of a laminated

wooden structural panel according to at least one exemplary embodiment,

Figure 8 is a cross-sectional view of a laminated wooden structural panel according to at least one exemplary embodiment,

Figure 9a is a perspective view of a laminated wooden structural panel according to at least one exemplary embodiment of the present invention,

Figure 9b is a cross-sectional view of the laminated wooden structural panel of Fig. 9a.

Detailed description of the drawings

[0068] In the present detailed description, embodiments of a wooden structural panel according to the present invention are mainly discussed with reference to drawings showing a wooden structural panel with components and portions being relevant in relation to various embodiments of the invention. It should be noted that this by no means limits the scope of the invention, which is also applicable in other circumstances for instance with other types or variants of wooden structural panels than the embodiments shown in the appended drawings. Further, that specific features are mentioned in connection to an embodiment of the invention does not mean that those components cannot be used to an advantage together with other embodiments of the invention.

[0069] The invention will now by way of example be described in more detail by means of embodiments and with reference to the accompanying drawings.

[0070] Figure 1 a is a perspective view of a cross-laminated wooden structural panel 1 according to at least one exemplary embodiment of the present invention. The wooden structural panel 1 is shaped as a rectangular cuboid having a length L, a width W, and a height H. The length is larger than the width, and the width is larger than the height. Thus, the wooden structural panel 1 may be used in the construction of walls, floors, roofs, or similar panel shaped construction elements.

[0071] The wooden structural panel 1 has two primary faces 3 extending in the length-width direction, two side faces 5 extending in the length-height direction, and two end faces 7 extending in the width-height direction. The two primary faces 3 are parallel with each other, the two side faces 5 are parallel with each other, and the two end faces 7 are parallel with each other. The primary faces 3 are perpendicular to both the side faces 5 and the end faces 7, and the side faces 5 are perpendicular to the end faces 7.

[0072] The wooden structural panel 1 of Fig. 1 a is made from a plurality of cross-laminated wooden members 9. The wooden members 9 are attached to each other using a combination of adhesive, pressure and heat, and they are arranged in a number of layers 11. In Fig. 1 a, a 7-layer wooden structural panel 1 is shown. An odd or even number of layers are both possible. For example, a 3-layer wooden structural panel, a 4-layer wooden structural panel, a 5-layer structural panel, or a

6-layer wooden structural panel is possible. Every other layer 11 is arranged so that each wooden member 9 of that layer has its longitudinal extension in a length-direction, and every other layer 11 is arranged so that each wooden member 9 of that layer 11 has its longitudinal extension in a width-direction. In other words, the wooden structural panel 1 alternately comprises lengthwise layers 11 a and widthwise layers 11 b. The wooden members 9 all have substantially identical cross-sectional geometry, namely that of a rectangle. The length of the wooden members 9 varies depending on their position in the wooden structural panel 1. For example, the wooden members 9 extending in the length-direction of the wooden structural panel 1 are significantly longer than the wooden members 9 extending in the width-direction of the wooden structural panel 1. Each one of the wooden members 9 is shaped as a board 9', meaning that they have a substantially longer length than their width and height.

[0073] All the outward facing surfaces 3, 5, 7 of the wooden structural panel 1 of Fig. 1 a consists of wooden members 9 that are laminated to each other. This means that the wooden structural panel 1 has wooden surfaces on all sides. The two side faces 5 and the two end faces 7 consist of a combination of board ends 13 and board sides 15, while the two primary faces 3 consist of upper and lower sides 17 of the boards, respectively. Thus, when used as a building element, there is no need to add a floor covering or ceiling material in order to achieve a wooden finish as this is already present on all sides of the wooden structural panel 1. This means that the density increasing material 100 that is arranged inside the wooden structural panel 1 cannot be seen from outside the wooden structural panel 1.

[0074] Figure 1 b is a cross-sectional view of the cross-laminated wooden structural panel 1 of Fig. 1 a. Here, the alternating lengthwise and widthwise layers of wooden members 9 are clearly seen. In Fig. 1 b, the space 101 that is arranged inside the wooden structural panel 1 is shown. The space 101 is arranged between the two primary faces 3, between the two side faces 5, and between the two end faces 7 of the wooden structural panel 1. The space 101 has a height that is smaller than the height of the wooden structural panel 1, and that is greater than the height of the individual wooden members 9 used to create the wooden structural panel 1. In other embodiments, the height of the space 101 may be equal to or greater than the height of the individual wooden members 9. Specifically, the space 101 in Fig. 1 b has a height that is equal to three times that of the wooden members 9, and a width that is equal to five times that of the wooden members 9. The space 101 has been created by cutting some of the wooden members 9 that are arranged in the middle layers 21, in this case the third, fourth and fifth layers, to a shorter length so as to create a space 101 when these wooden members 9 are laminated together to form a panel. This is discussed below in relation to Figure 1 c. Inside the space 101, a granular

filler material 103 is arranged. The granular filler material 103 increases the density and stiffness of the wooden structural panel 1. The entire space 101 is filled with the granular filler material 103.

[0075] Figure 1 c is an exploded perspective view of the cross-laminated wooden structural panel 1 of Fig. 1 a. As seen herein, the wooden structural panel 1 comprises a space 101 arranged inside the wooden structural panel 1. In this exemplary embodiment, this space 101 has substantially the same shape (although of smaller dimension) as the wooden structural panel 1 as a whole. In other embodiments the space may have a different shape, such as triangular, circular or curved, as seen from a width-height cross-section. The space 101 is filled with a granular filler material 103, such as sand or gravel. The granular filler material 103 has a higher density than the wooden members 9, thus increasing the average density of the wooden structural panel 1.

[0076] The space shown in Figure 1 c is created by first cross laminating two bottom layers 19 using a plurality of wooden members 9. The two bottom layers 19 have the same width and length as the wooden structural panel 1 that is to be created. Then, three middle layers 21 are created by cross laminating a plurality of wooden members 9 on top of said two bottom layers 19 so as to form a frame 23 around the space 101 that is to be created. In other words, the three middle layers 21 are laminated onto the outer portions of the two bottom layers 19, and not onto the middle portions of the bottom layers 19. As such, the cross sectional area of each one of the three middle layers 21 is smaller than the cross sectional area of each one of the two bottom layers 19, as measured in the length-width direction. The three middle layers 21 have the cross-sectional shape of a numerical digit 0. The outer dimensions of the three middle layers 21 are the same as the outer dimensions of the wooden structural panel 1 that is to be created. Finally, the space created inside the frame 23 formed by the middle layers 21 is filled with a density increasing material, after which two top layers 25 are created by cross laminating a plurality of wooden members 9 on top of said three middle layers 21, thus covering both the middle layers 21 and the space 101 created between the bottom layers 19, the top layers 25, and the middle layers 21. The top layers 25 have the same width and length as the outer dimensions of the wooden structural panel 1 that is to be created.

[0077] Figure 2 is a cross-sectional view of a cross-laminated wooden structural panel 1' according to at least one exemplary embodiment. The wooden structural panel 1' and the space 101 created therein are similar to those shown in Fig. 1 b. Inside the space 101, two concrete beams 105 are arranged at a distance from each other and from side walls 107 of the space 101. The two concrete beams 105 run substantially in parallel with each other and each one has a longitudinal extension in the length direction of the panel 1'. A respective subspace between the side walls 107 of the space 101 and each one of the two concrete beams 105 is filled with a granular

filler material 103, as is a subspace between the two concrete beams 105. The granular filler material 103 increases the density of the wooden structural panel 1' and helps keep the concrete beams 105 in place. The concrete beams 105 increase the density of the wooden structural panel 1', as well as its stiffness.

[0078] Figure 3 is a cross-sectional view of a cross-laminated wooden structural panel 1'' according to at least one exemplary embodiment. The wooden structural panel 1'' and the space 101 created therein are similar to those shown in Fig. 1 b. Inside the space of Fig. 3, two steel I-beams 109 are arranged at a distance from each other and from the side walls 107 of the space 101. The subspace between the side walls 107 of the space 101 and each one of the two steel I-beams 109 is filled with a granular filler material 103, as is the subspace between the two steel I-beams 109. The granular filler material 103 increases the density of the wooden structural panel 1'' and helps keeping the steel I-beams 109 in place. The steel I-beams 109 may be attached to the wooden structural panel 1'' by means of mechanical fasteners (not shown). The steel I-beams 109 increase the density of the wooden structural panel 1'', as well as its stiffness.

[0079] Figure 4 is a cross-sectional view of a cross-laminated wooden structural panel 1''' according to at least one exemplary embodiment. The wooden structural panel 1''' and the space 101 created therein are similar to those shown in Fig. 1 b. Inside the space of Fig. 4, two concrete beams 105 are arranged at a distance from each other and from the side walls 107 of the space 101. The subspace between the side walls 107 of the space 101 and each one of the two concrete beams 105 is filled with an insulation material 111, as is the subspace between the two concrete beams 105. The insulation material 111 increases the thermal and/or sound insulation properties of the wooden structural panel 1'''. The concrete beams 105 may be attached to the wooden structural panel 1''' by means of mechanical fasteners (not shown). The concrete beams 105 increase the density of the wooden structural panel 1''', as well as its stiffness.

[0080] Figure 5a is a perspective view of a laminated wooden structural panel 1'''' according to at least one exemplary embodiment of the present invention.

[0081] The wooden structural panel 1'''' has two primary faces 3'''' extending in the length-width direction, two side faces 5'''' extending in the length-height direction, and two end faces 7'''' extending in the width-height direction. The two primary faces 3'''' are parallel with each other, the two side faces 5'''' are parallel with each other, and the two end faces 7'''' are parallel with each other. The primary faces 3'''' are perpendicular to both the side faces 5'''' and the end faces 7''', and the side faces 5'''' are perpendicular to the end faces 7''''.

[0082] The wooden structural panel 1'''' of Fig. 5a is made from a plurality of cross-laminated wooden members 9 and two steel beams 113. The wooden members 9 are arranged in two top layers 25 and two bottom layers 19, and three middle layers 21''' covering the two end

faces 7''' of the wooden structural panel. The two top layers 25 and the two bottom layers 19 may be substantially identical as those disclosed in the embodiment of Fig. 1 a. The middle layers 21''' however may be arranged differently, as will now be explained. The two steel beams 113 are arranged between the two top layers 25 on one side, and the two bottom layers 19 on the other side. The two steel beams 113 are arranged at either side face 5''' of the wooden structural panel 1'''. Thus, each one of the two side faces 5''' of the wooden structural panel 1''' comprises the two steel beams 113, respectively. In Fig. 3, a 7-layer wooden structural panel 1''' is shown, having two cross-laminated top layers 25, two cross-laminated bottom layers 19, a plurality of wooden members 9 laminated to each other so as to cover each one of the end faces 7''' of the wooden structural panel 1''', and two steel beams 113 arranged along either side face 5''' of the wooden structural panel 1'''. Different number of layers are also conceivable, such as a 3-layer wooden structural panel, or a 5-layer wooden structural panel. The plurality of wooden members 9 arranged to cover either end face 7''' of the wooden structural panel 1''' extend in the width-direction. The two steel beams 113 extend in the length-direction.

[0083] The wooden members 9 all have substantially identical cross-sectional geometry, namely that of a rectangle. The length of the wooden members 9 varies depending on their position in the wooden structural panel 1'''. For example, the wooden members 9 extending in the length-direction of the top and bottom layers 25, 19 of the wooden structural panel 1''' are significantly longer than the wooden members 9 covering the end faces 7''' of the wooden structural panel 1'''. Each one of the wooden members 9 is shaped as a board 9', meaning that they have a substantially longer length than their width and height.

[0084] The two primary faces 3''' and the two end faces 7''' of the wooden structural panel 1''' of Fig. 5a consists of wooden members 9 that are laminated to each other. Each one of the two side faces 5''' comprises a steel beam 113. This means that the wooden structural panel 1''' has wooden surfaces on four out of six sides. The two end faces 7''' consist of a combination of board ends 13 and board sides 15, while the two primary faces 3''' consist of upper and lower sides 17 of the boards, respectively. Thus, when used as a building element, there is no need to add a floor covering or ceiling material in order to achieve a wooden finish as this is already present on the primary faces 3''' of the wooden structural panel 1'''. This means that the density increasing material that is arranged inside the wooden structural panel cannot be seen from outside the wooden structural panel 1''' when arranged in a construction application, except on the side faces 5''' of the wooden structural panel 1'''.

[0085] Figure 5b is a cross-sectional view of the laminated wooden structural panel 1''' of Fig. 5a. Here, the wooden members 9 of the top and bottom layers 25, 19 of the wooden structural panel 1''' are clearly seen, as

are the two steel beams 113 defining a portion of each respective side face 5''' of the wooden structural panel 1'''. The two outermost layers, in a height-direction, consist of boards 9' extending in the length-direction of the wooden structural panel, while each respective neighboring layer consists of wooden members extending in the width-direction.

[0086] In Fig. 5b, the space 101''' that is arranged inside the wooden structural panel 1''' is shown. The space 101''' is arranged between the two primary faces 3''', between the two side faces 5''', and between the two end faces 7''' of the wooden structural panel 1'''. The space 101''' has a height that is less than the height of the wooden structural panel 1''', and that is greater than the height of the wooden members 9 used to create the wooden structural panel 1'''. The space 101''' has been created by attaching steel beams 113 to the two bottom layers 19 of the wooden structural panel 1''', thus creating side faces 5''' of the wooden structural panel 1'''. A plurality of wooden members 9 extending in a width-direction have been laminated onto each other at either end face 7''' of the wooden structural panel 1'''. The two top layers 25 are then attached to the steel beams 113 and to the wooden members 9 covering the end faces 7''' of the wooden structural panel 1'''.

[0087] Inside the space 101''', one steel I-beam 109 is arranged at a distance from the two steel beams 113 arranged at either side of the space 101'''. The subspaces between the respective two steel beams 113 and the single I-beam 109 is filled with a granular filler material 103. The granular filler material 103 increases the density of the wooden structural panel 1''' and helps keep the steel I-beam 109 in place. The steel I-beam 109 increase the density of the wooden structural panel 1''', as well as its stiffness.

[0088] Figure 6a is a perspective view of a laminated wooden structural panel 1 a according to at least one exemplary embodiment of the present invention. The wooden structural panel 1 a of Fig. 6a is similar to that of Fig. 1 a with the exception that the wooden structural panel 1 a of Fig. 6a does not comprise cross-laminated wooden members 9, but instead comprises normally laminated wooden members 9.

[0089] The wooden structural panel 1a of Fig. 6a is made from a plurality of laminated wooden members 9. The wooden members 9 are arranged in a number of layers 11. In Fig. 6a, a 7-layer wooden structural panel 1 a is shown. Different number of layers are also conceivable, such as a 3-layer wooden structural panel, or a 5-layer structural panel. Every other layer is offset relative to the adjacent layers in the width-direction by half a width of the wooden members 9. In other words, the wooden structural panel 1 a alternately comprises a first type of layer 11 a and a second type of layer 11 b that is widthwise offset relative to the first type of layer 11 a.

[0090] All the outward facing surfaces 3a, 5a, 7a of the wooden structural panel 1 a of Fig. 6a consists of wooden

members 9 that are laminated to each other. This means that the wooden structural panel 1 a has wooden surfaces on all sides. The two side faces 5a of the wooden structural panel consist of a number of side faces 15 of boards that have been laminated onto each other and the two end faces 7a of the wooden structural panel 1 a consist of a number of board end faces 13. The two primary faces 3a of the wooden structural panel 1 a consist of upper and lower sides of the boards 17, respectively. Thus, when used as a building element, there is no need to add a floor covering or ceiling material in order to achieve a wooden finish as this is already present on all sides of the wooden structural panel 1 a. This means that the density increasing material that is arranged inside the wooden structural panel 1 a cannot be seen from outside the wooden structural panel 1a.

[0091] Figure 6b is a cross-sectional view of a laminated wooden structural panel 1 a according to Fig. 6a. Here, the alternating offset and non-offset layers 11 a, 11 b of wooden members 9 are clearly seen. Fig. 6b discloses a 7-layer wooden structural panel 1 a. In Fig. 6b, the space 101 a that is arranged inside the wooden structural panel 1 a is also shown. The space 101 a is arranged between the two primary faces 3a, between the two side faces 5a, and between the two end faces 7a of the wooden structural panel 1 a. The space 101 a has a height that is less than the height of the wooden structural panel 1 a, and that is greater than the height of the wooden members 9 used to create the wooden structural panel 1 a. Specifically, the space 101 a in Fig. 6a has a height that is equal to three times that of the wooden members 9, and a width that is equal to five times that of the wooden members 9. The space 101 a has been created by cutting some of the wooden members 9 that are arranged in the middle layers 21, in this case layers 3-5, to a shorter length so as to create a space 101 a when these wooden members 9 are laminated together to form a panel. Inside the space 101 a of Fig. 6a, a granular filler material 103 is arranged. The granular filler material 103 increases the density and stiffness of the wooden structural panel 1 a.

[0092] Figure 7 is a cross-sectional view of a laminated wooden structural panel 1 a' according to one exemplary embodiment. Here, the wooden members 9 are laminated in such a way so that they completely surround and envelope two steel I-beams 109 that are arranged inside the wooden structural panel 1a'. Compared to the previous embodiments, where a space has first been created by laminating the wooden members 9 to each other in a predefined pattern and which then has been filled with a material, Fig. 7 shows an embodiment in which the density-increasing material (the two steel I-beams 109) have been completely integrated in the lamination of the wooden members 9. In other words, the wooden structural panel 1 a' of Fig. 7 has been built around the two steel I-beams 109. Apart from this, the wooden structural panel 1 a' is similar to the wooden structural panel 1 a of Figs. 6a-b.

[0093] Figure 8 is a cross-sectional view of a laminated wooden structural panel 1 a" according to one exemplary embodiment. This embodiment is identical to that of Figs. 6a-b with the exception that two spaces 101 a have been created inside the wooden structural panel 1 a" by providing a central wooden member 115 attached to both the top layers 25 and the bottom layers 19 so that it divides the space into two spaces 101 a. Apart from this, the wooden structural panel 1 a' is similar to the wooden structural panel 1 a of Figs. 6a-b.

[0094] Figure 9a is a perspective view of a laminated wooden structural panel 1 b according to at least one exemplary embodiment of the present invention. The laminated wooden structural panel 1 b of Fig. 9a comprises two substantially identical wooden halves 2b. Each one of the two wooden halves 2b has a length, a width, and a height. The length is larger than the width, and the width is larger than the height. Thus, the wooden structural panel 1 b created using these two halves 2b may be used in the construction of walls, floors, roofs, or similar panel shaped construction elements. Each one of the two halves 2b has a recess 4b formed on their inward facing surface 6b, so that when these two inward facing surfaces 6b are put together and the two halves 2b are laminated onto each other, a space 101 b is formed between them.

[0095] The wooden structural panel 1 b has two primary faces 3b extending in the length-width direction, two side faces 5b extending in the length-height direction, and two end faces 7b extending in the width-height direction. The two primary faces 3b are parallel with each other, the two side faces 5b are parallel with each other, and the two end faces 7b are parallel with each other. The primary faces 3b are perpendicular to both the side faces 5b and the end faces 7b, and the side faces 5b are perpendicular to the end faces 7b.

[0096] The wooden structural panel 1 b of Fig. 9a is made from two laminated wooden members, or wooden halves 2b. All the outward facing surfaces 3b, 5b, 7b of the wooden structural panel 1 b of Fig. 9a consists of a portion of either one of the two wooden halves 2b. This means that the wooden structural panel 1 b has wooden surfaces on all sides. Thus, when used as a building element, there is no need to add a floor covering or ceiling material in order to achieve a wooden finish as this is already present on all sides of the wooden structural panel 1 b. This means that the density increasing material that is arranged inside the wooden structural panel 1 b cannot be seen from outside the wooden structural panel 1 b.

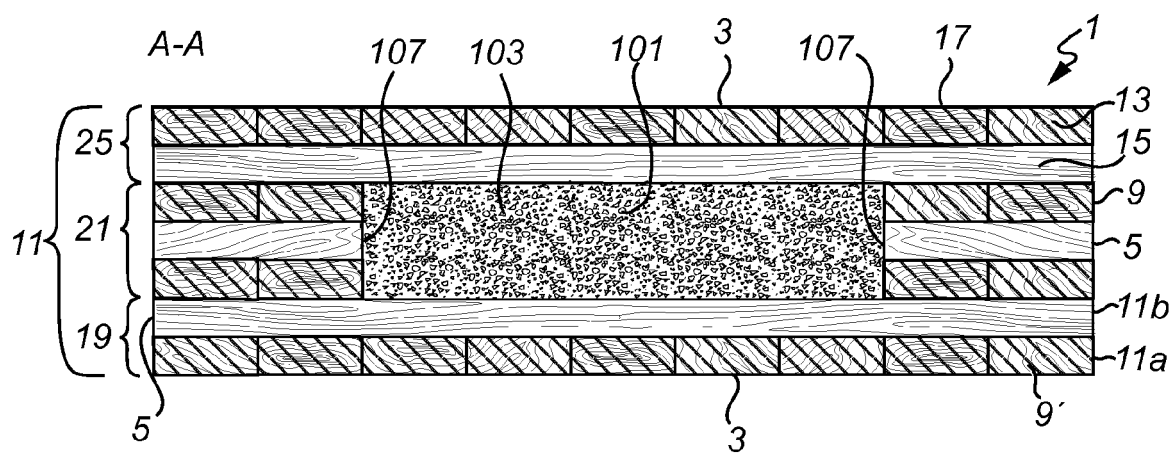
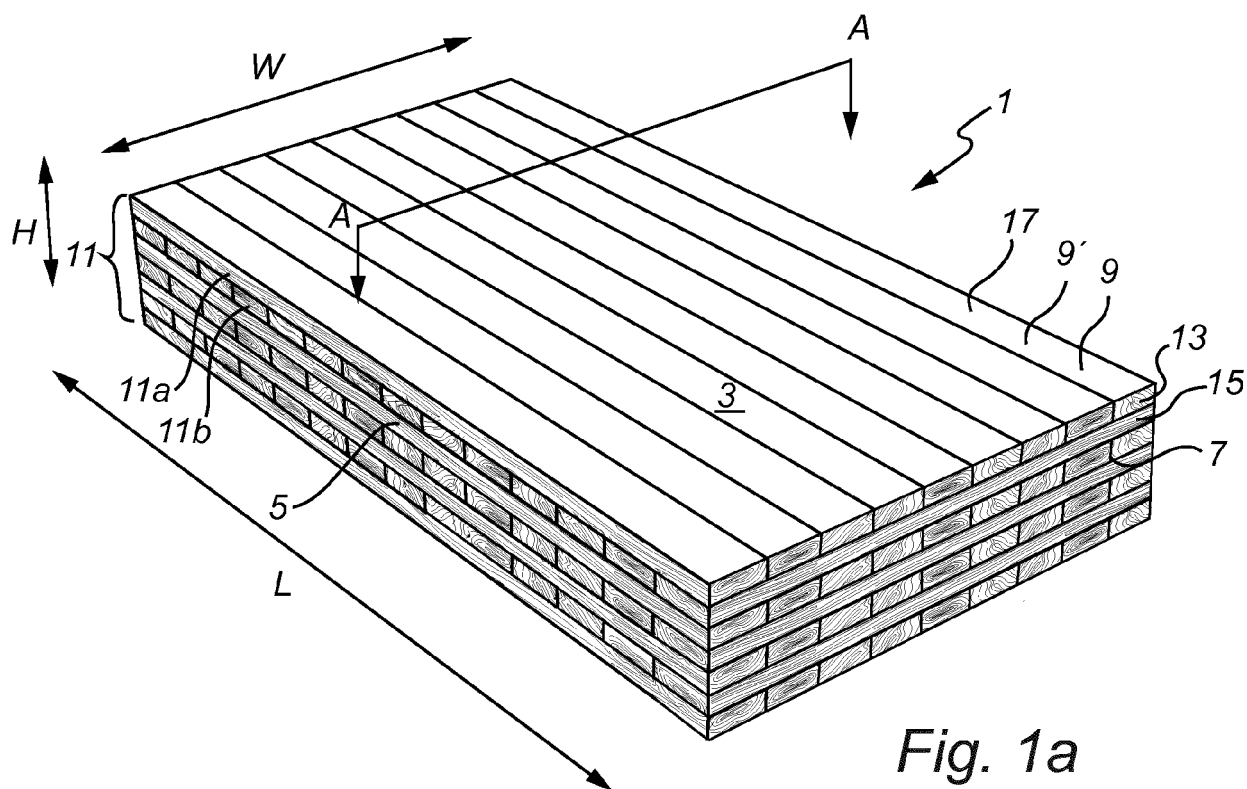
[0097] Figure 9b is a cross-sectional view of the laminated wooden structural panel 1 b according to Fig. 9a. In Fig. 9b, the space 101 b that is arranged inside the wooden structural panel 1 b is shown. The space 101 b is arranged between the two primary faces 3b, between the two side faces 5b, and between the two end faces 7b of the wooden structural panel 1 b. The space 101 b has a height that is less than the height of the wooden

structural panel 1 b. The space 101 b has been created by cutting or milling away a portion of each one of the two wooden halves 2b that are laminated onto each other. Inside the space 101 b of Fig. 8, a granular filler material 103 is arranged. The granular filler material 103 increases the density and stiffness of the wooden structural panel 1 b.

[0098] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the [element, device, component, means, step, etc.]" are to be interpreted openly as referring to at least one instance of said element, device, component, means, step, etc., unless explicitly stated otherwise. Furthermore, any reference signs in the claims should not be construed as limiting the scope.

Claims

1. A wooden structural panel for use in construction applications, said wooden structural panel being a rectangular cuboid having a length, a width, and a height, wherein said length is equal to or greater than said width, and wherein said width is equal to or greater than said height, said wooden structural panel comprising:
 - a plurality of laminated wooden members, two opposite primary faces extending in the length-width direction,
 - at least one space arranged between said two opposite primary faces,
 - at least one material arranged in said at least one space,
 - wherein the average density of the total amount of material in said at least one space is greater than the average density of said wooden members.
2. The wooden structural panel according to claim 1, wherein said two opposite primary faces are defined by at least some of said plurality of laminated wooden members.
3. The wooden structural panel according to any one of the preceding claims, wherein said at least one material comprises at least one granular filler material.
4. The wooden structural panel according to any one of the preceding claims, wherein said at least one material comprises at least one reinforcement beam.
5. The wooden structural panel according to any one of the preceding claims, wherein said at least one material comprises at least one insulation material.
6. The wooden structural panel according to claim 5, wherein each one of said at least one insulation material is a material chosen from a group comprising the following materials: glass wool, mineral wool, wool, Styrofoam, and polymer foam.
7. The wooden structural panel according to any one of the preceding claims, wherein said plurality of laminated wooden members are cross laminated.
8. The wooden structural panel according to any one of the preceding claims, wherein said wooden structural panel further comprises:
 - two opposite side faces extending in the length-height direction, and wherein said at least one space is arranged between said two opposite side faces.
9. The wooden structural panel according to claim 8, wherein said two opposite side faces are defined by at least some of said plurality of laminated wooden members.
10. The wooden structural panel according to any one of the preceding claims, wherein said wooden structural panel further comprises:
 - two opposite end faces extending in the width-height direction, and wherein said at least one space is arranged between said two opposite end faces.
11. The wooden structural panel according to claim 10, wherein said two opposite end faces are defined by at least some of said plurality of laminated wooden members.
12. The wooden structural panel according to any one of the preceding claims, wherein the smallest dimension of said space is equal to or greater than the smallest dimension of each one of said plurality of wooden members.
13. The wooden structural panel according to any one of the preceding claims, wherein the average density of the total amount of material in said space is at least 2 times greater, preferably at least 2.5 times greater, most preferably at least 3 times greater, than the average density of said wooden members.



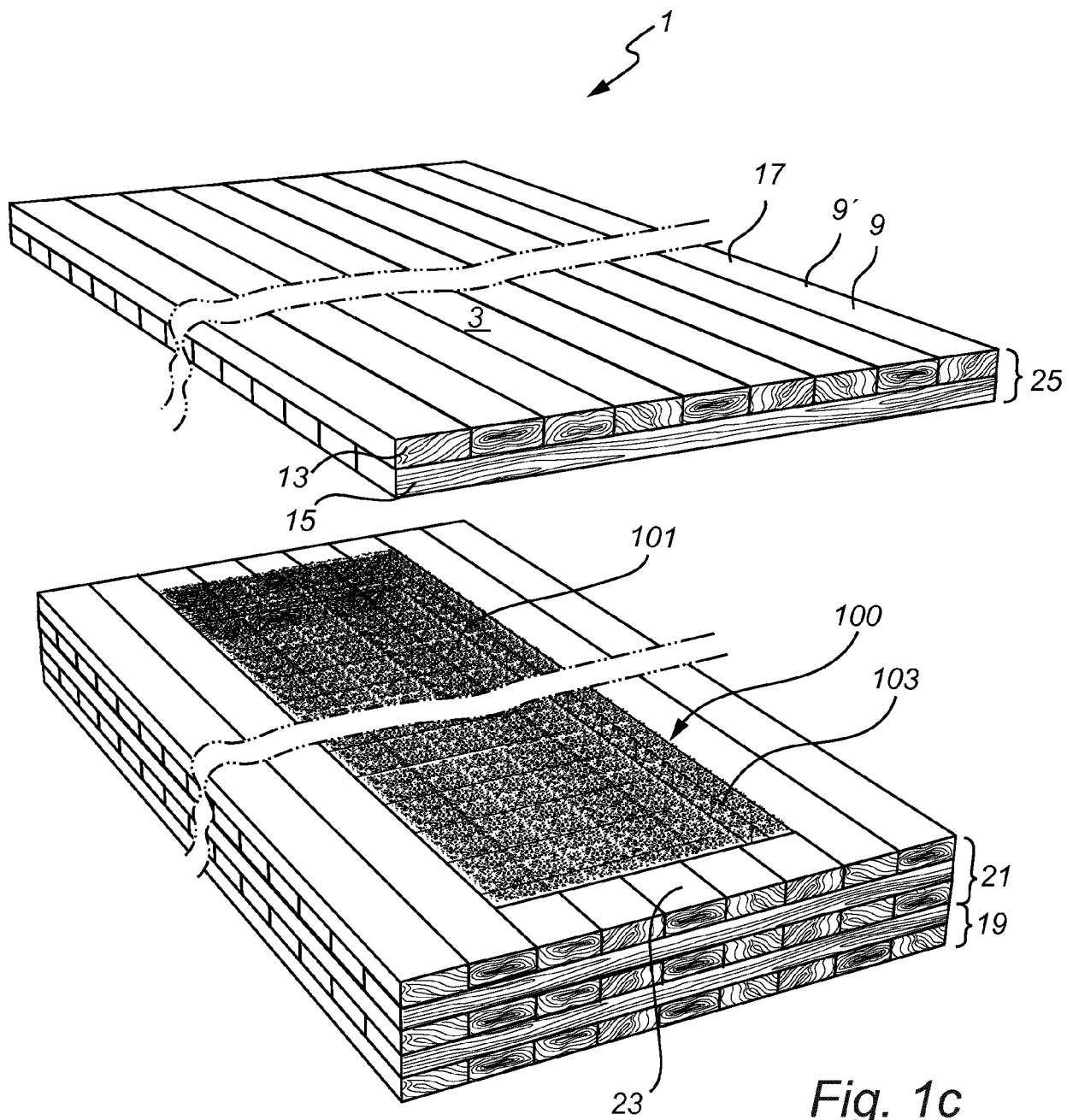
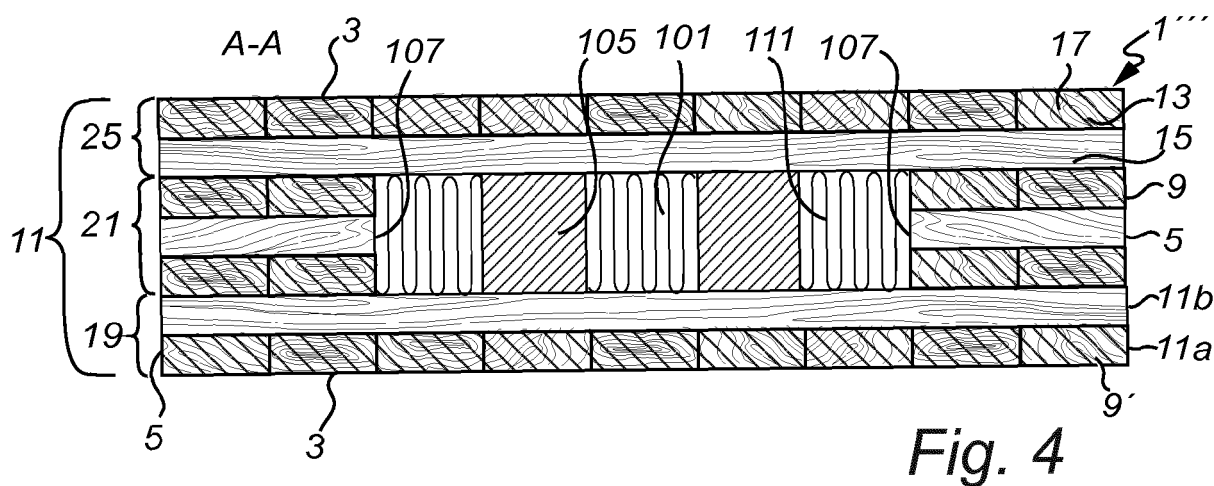
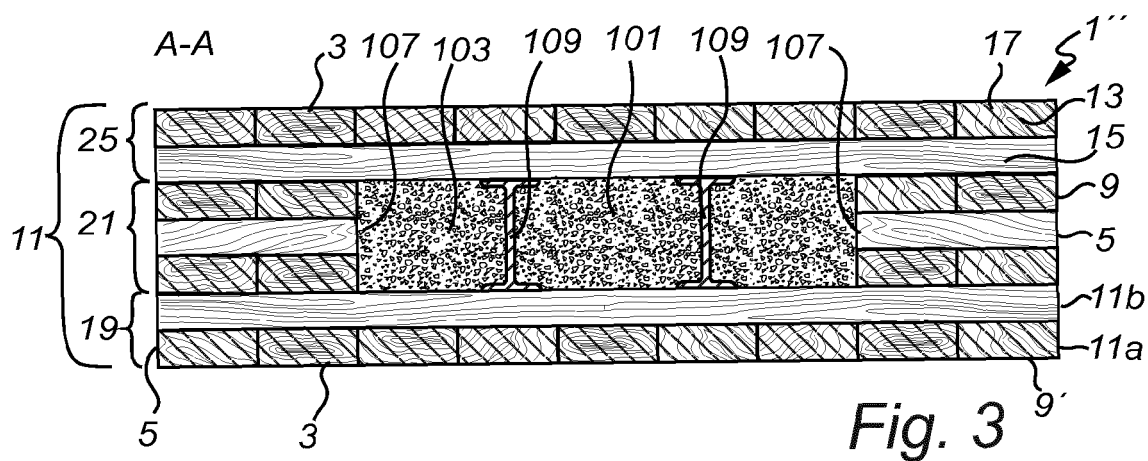
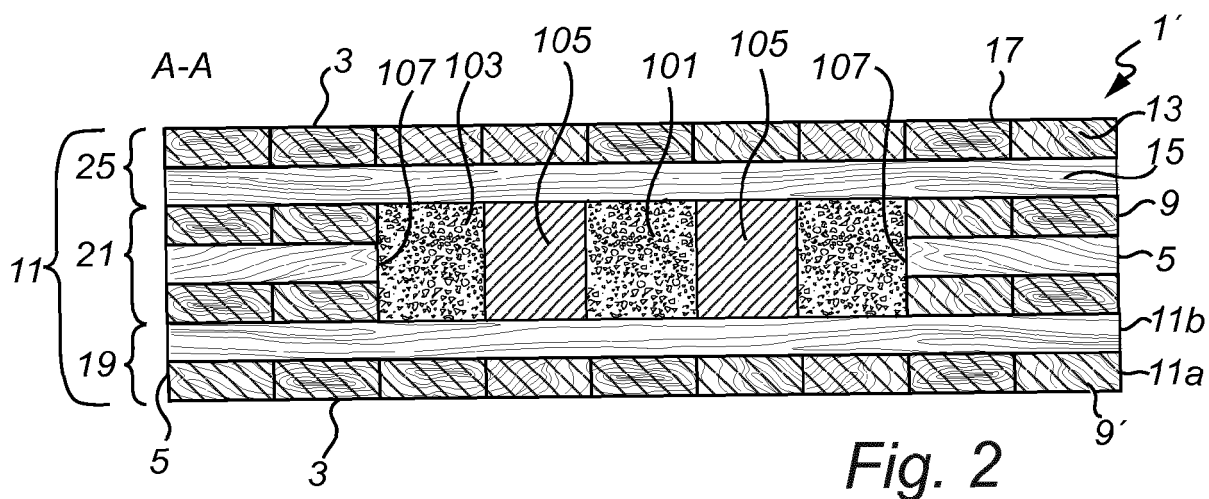


Fig. 1c



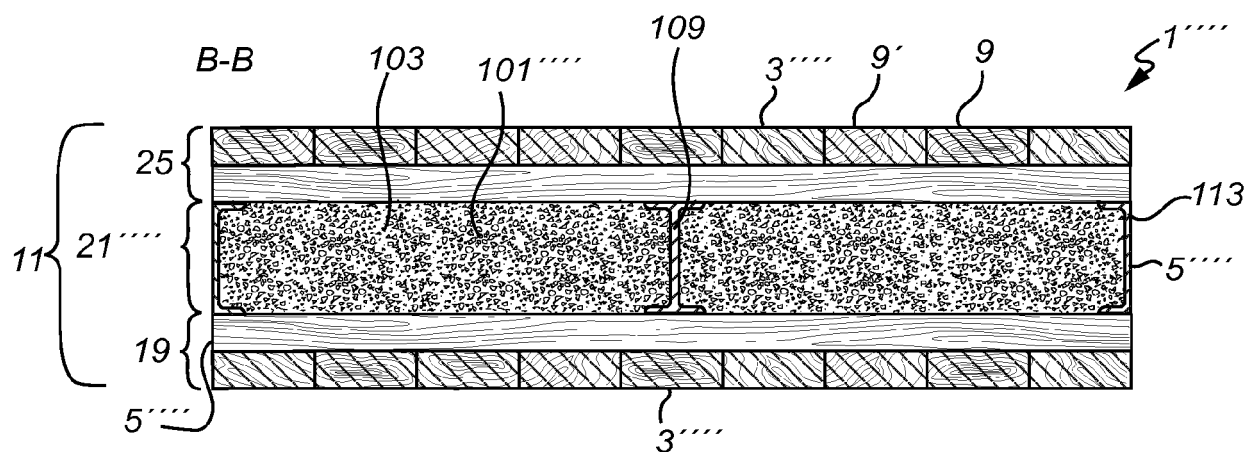


Fig. 5b

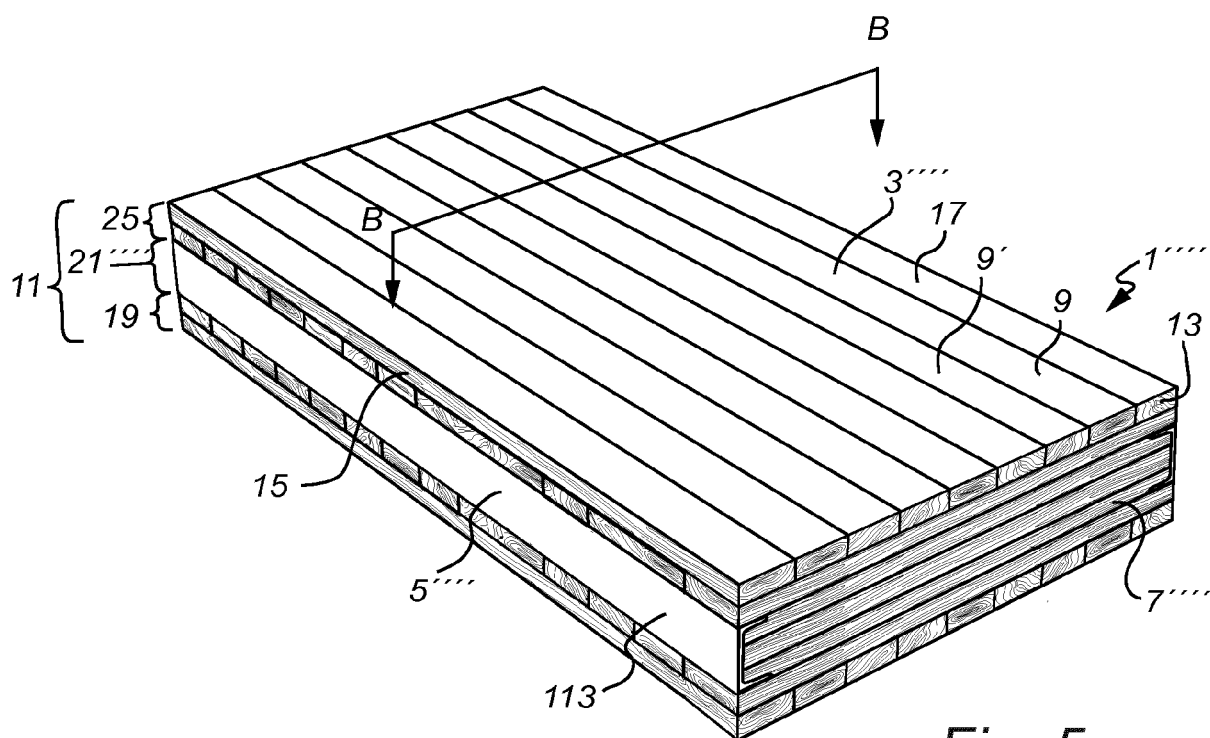


Fig. 5a

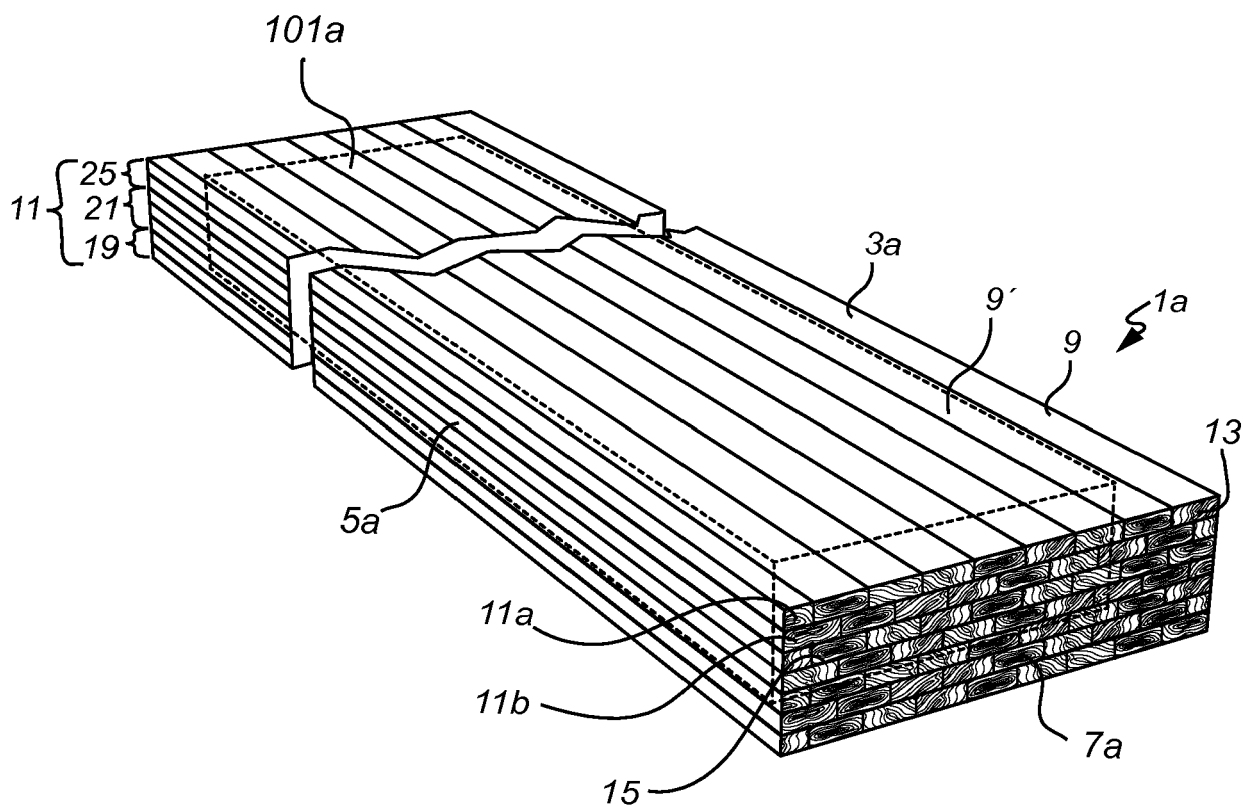


Fig. 6a

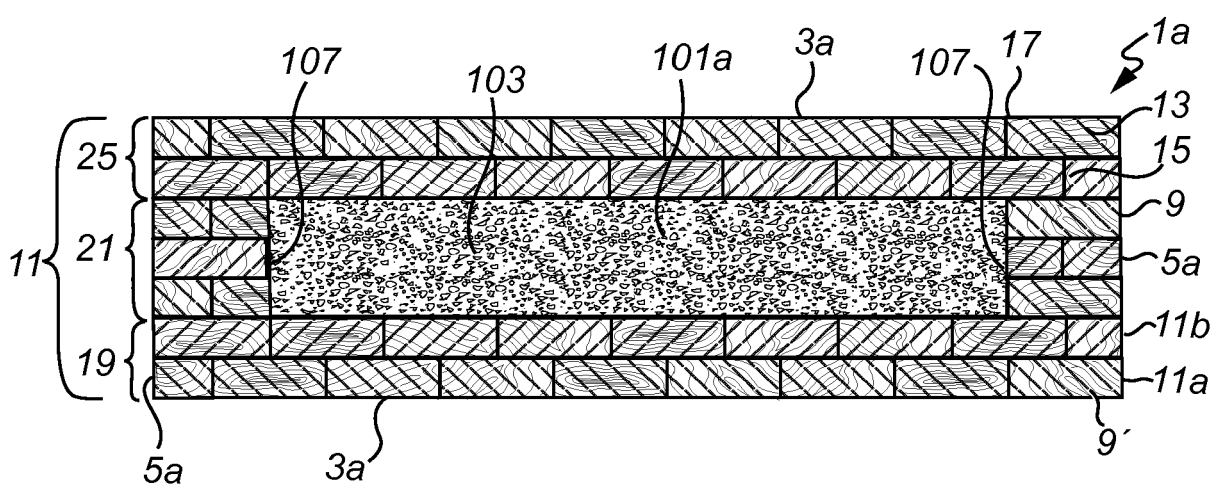


Fig. 6b

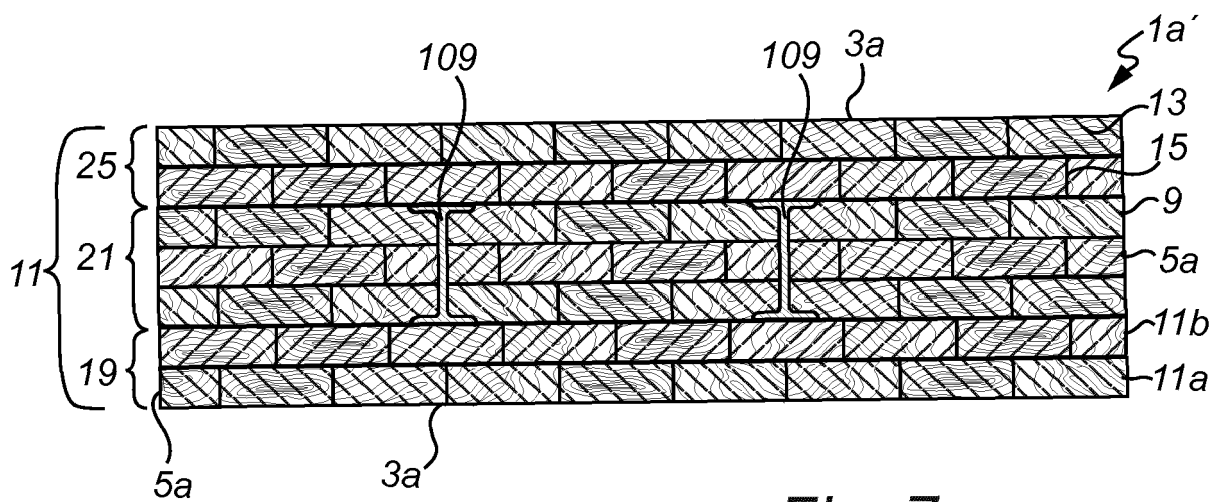


Fig. 7

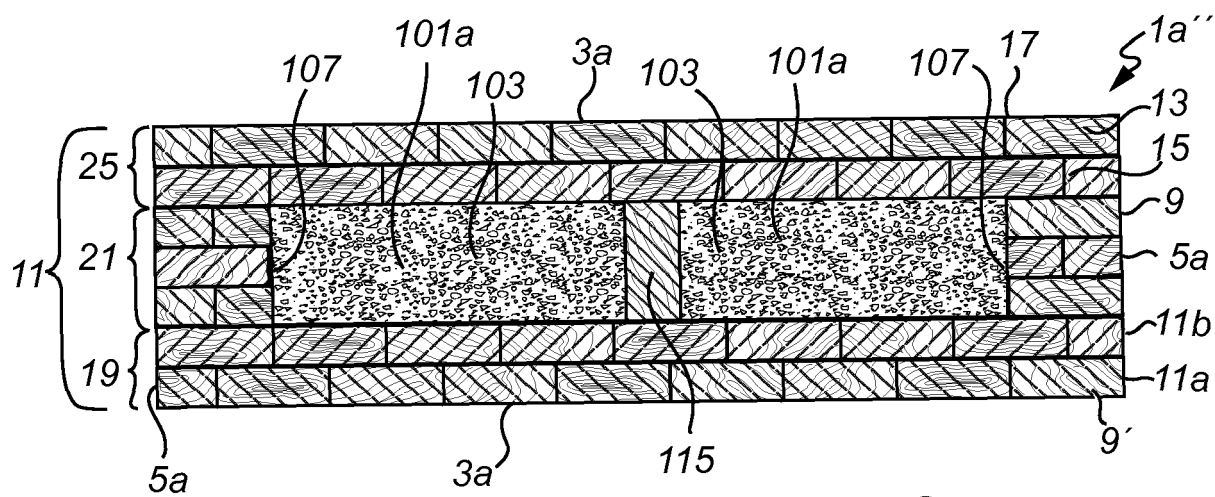
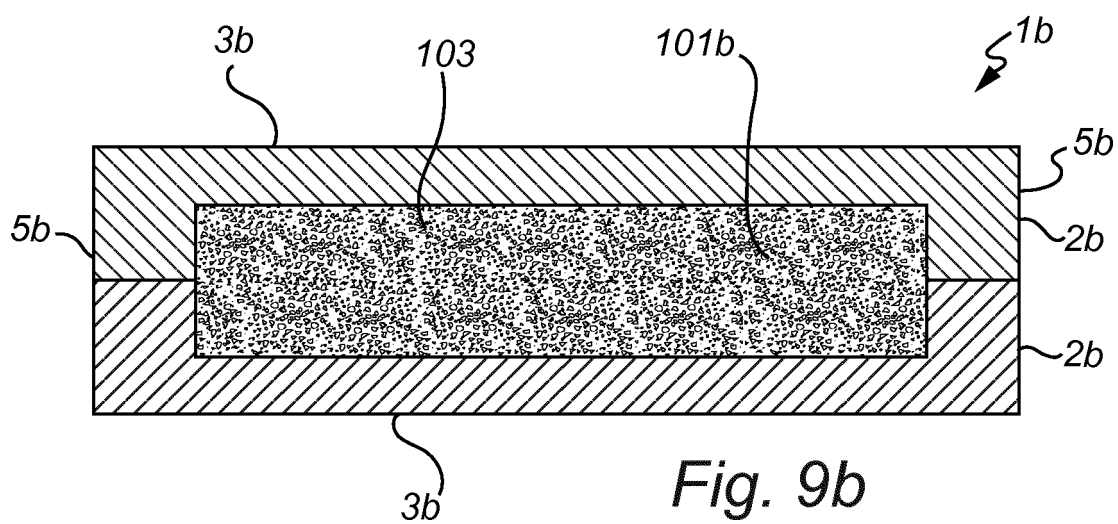
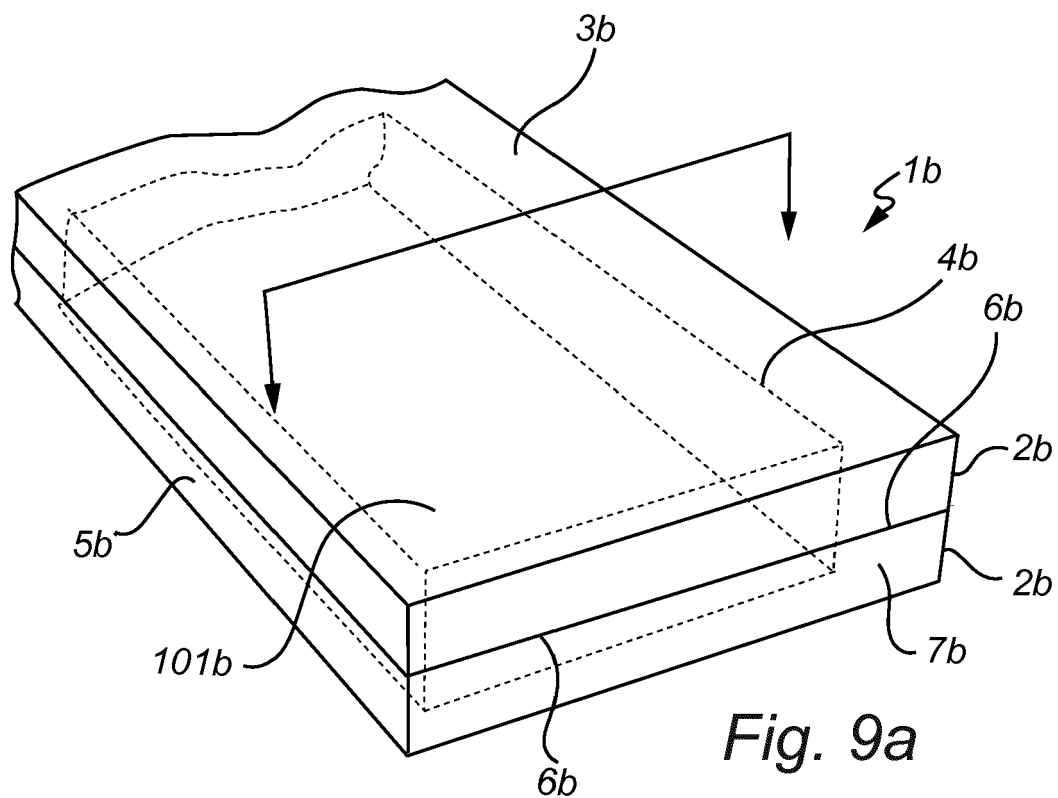


Fig. 8





EUROPEAN SEARCH REPORT

Application Number
EP 17 17 4084

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			E04C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 9 November 2017	Examiner Stern, Claudio
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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