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(54) **A panel comprising plywood**

(57) A panel (101) comprising a first planar surface (202) and a second opposite planar surface (204), the second surface (204) being parallel to the first surface (202). Plywood or oriented standard board layers are arranged between the first surface (202) and the second surface (204). The panel (101) comprises a first edge (206) extending from the boundary of the first surface (202) to the boundary of the second surface (204), and a second edge (208) extending from the boundary of the first surface (202) to the boundary of the second surface (204), wherein the second edge (208) is opposite to the first edge (206). The first edge (206) comprises a projection (230), wherein the projection (230) protrudes from the first edge (206) and extends in a direction of the first edge (206). The projection (230) is made of the same material as the panel (101) and is an integral part of the panel (101). The second edge (208) of the panel (101) comprises a supporting area (232), whereby the projection (230) and the supporting area (232), in combination, are arranged to leave a space (150) in between the panel (101) and a similar other panel (101), when the projection (230) of the panel (101) is in contact with the supporting area (232) of the other similar panel (101). In addition, a wall structure comprising at least two such panels (200a, 200b).

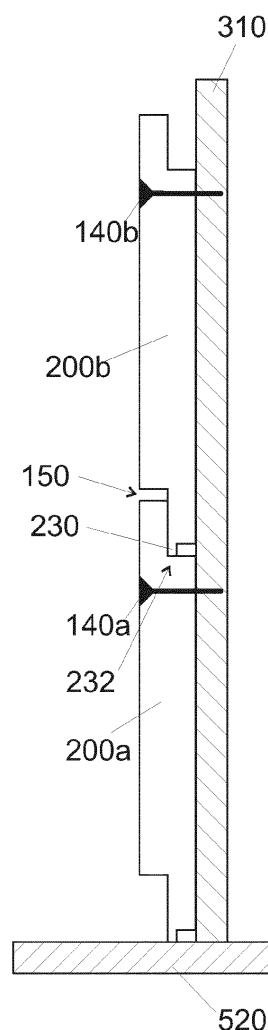


Fig. 7b

Description

Field of the Invention

[0001] The invention relates to panels, in particular plywood panels. The invention relates to a method for installing plywood panels. The invention relates to a structure, in which a plywood panel is attached to a substrate. The invention relates to a wall structure comprising a plywood panel.

Background of the Invention

[0002] Plywood panels are widely used. Plywood panels are used in construction, e.g. in walls of a building. Plywood panels can be used in floors. Moreover, plywood panels can be used in vehicles as structural material for floors or walls.

[0003] Plywood is a type of manufactured timber made from thin sheets of wood, i.e. plywood layers. Plywood layers (made of one or more veneers) are glued together to make plywood panels. Plywood is flexible, inexpensive, workable, re-usable, and can usually be locally manufactured. Plywood is used instead of plain wood because of its resistance to cracking, shrinkage, and twisting/warping, and its general high degree of strength. The veneers, which are used to produce plywood panels, are usually turned from wood. When turning the veneers from wood, micro cracks may be formed to the veneers. In addition to plywood panels, oriented standard boards (OSB) can be used for similar purposes.

Summary of the Invention

[0004] An embodiment of the invention eases the process of fixing panels to a substrate such that uneven swelling, contraction or expansion properties of the plywood panel and the substrate can be accounted for. Using the embodiment, a space may be left to most parts between two panels, wherein the space allows for swelling of the panel or contraction of the substrate.

[0005] According to a first aspect of the invention, there is provided a panel comprising

- a first planar surface,
- a second opposite planar surface, the second surface being parallel to the first surface,
- plywood or oriented standard board layers arranged between the first surface and the second surface, wherein the layers are parallel to the first surface,
- a first edge extending from the boundary of the first surface to the boundary of the second surface, and
- a second edge extending from the boundary of the first surface to the boundary of the second surface, wherein the second edge is opposite to the first edge, wherein
- the first edge comprises a projection,
- the projection protrudes from the first edge and ex-

tends in a direction of the first edge,

- the projection is made of the same material as the panel, and
- the projection is an integral part of the panel; and
- the second edge comprises a supporting area; whereby the projection and the supporting area, in combination, are arranged to leave a space in between the panel and a similar other panel, when the projection of the panel is in contact with the supporting area of the other similar panel.

[0006] There is also provided a panel, wherein

- the thickness of the projection, T_p , is at most one third ($1/3$) of the thickness of the panel, T_{pa} ; whereby compressive stress in the panel is arranged to concentrate into the projection.

[0007] There is also provided a panel, wherein

- the first edge comprises at least one of a first tongue and a first groove, and
- the second edge comprises at least one of a second groove and a second tongue, respectively,
- the projection is arranged in at least one of the tongue and the groove, and
- the shape of a tongue is adapted to the shape of a groove when the projection is completely deformed; whereby two panels can be easily adapted to each other such that a space is left in between the panels.

[0008] There is also provided a panel, wherein

- the panel comprises plywood layers arranged between the first surface and the second surface, wherein the layers are parallel to the first surface,
- each plywood layer comprises at least one wooden veneer, the veneer being turned from wood having grains,
- a part of the grains in each plywood layer are oriented in a grain direction of the plywood layer, the grain direction being parallel to a direction in the first surface,
- the grain direction of each plywood layer is essentially perpendicular the grain direction of an adjacent plywood layer,
- the panel comprises at least one protruding plywood layer each having a grain direction,
- the projection comprises at least part of each of the said at least one protruding plywood layer,
- the projection protrudes in such a direction that at least at least 55 % of material in the projection has a preferred grain direction, wherein the preferred grain direction is perpendicular to the direction into which the projection protrudes and parallel to the plane of the panel; to enable easy deformation of the projection under compression.

[0009] There is also provided a panel, wherein

- the first edge comprises a first tongue and first groove, and
- the second edge comprises a second tongue and a second groove,
- the projection is arranged in the first tongue, and
- the panel comprises only one protruding plywood layer having a grain direction.

[0010] There is also provided a panel, wherein

- the panel comprises an odd number of plywood layers, wherein the odd number is $2 \times N + 1$, and N is an integer at least 1, and
- the thickness of each plywood layer is essentially equal to the thickness of a first plywood layer, the thickness of the first plywood layer being T_{pl} , whereby the thickness of the panel is $T_{pa} = (2 \times N + 1) \times T_{pl}$,
- the thickness of the first tongue, T_{t1} , is at least $N \times T_{pl}$ and thickness of the second tongue, T_{t2} , is at least $N \times T_{pl}$; to ensure the mechanical strength of both the first tongue and the second tongue,
- the thickness of the projection, T_p , is from $0.25 \times T_{pl}$ to $0.90 \times T_{pl}$; to diminish warping of a tongue,
- the thickness of the first tongue is the thickness of the projection, T_p , added by the thickness of the other plywood layers in the tongue, $N \times T_{pl}$, and
- the total thickness of the first and the second tongues equals to the thickness of the panel, $T_{t2} = T_{pa} - T_{t1}$.

[0011] According to a second aspect of the invention, there is provided a panel system comprising

- a first panel and a second panel according to an embodiment of the invention, the panels having first thermo-hygro-mechanical properties,
- an substrate having second thermo-hygro-mechanical properties, wherein at least one first thermo-hygro-mechanical property is different from the corresponding second thermo-hygro-mechanical property, wherein
- the first panel is attached to the substrate, and
- the second panel is attached to the substrate such that a projection of the first or the second panel is in contact with a supporting area of the second or the first panel, respectively; whereby a space is arranged in between the first panel and a second panel.

[0012] There is also provided a panel system, wherein

- the panel system comprises an overlying layer, wherein the first panel and the second panel are arranged in between the substrate and the overlying layer,
- the substrate comprises metal, and
- the overlying layer comprises gypsum.

[0013] According to a third aspect of the invention, there is provided a wall structure comprising

- a panel system according to an embodiment of the invention, wherein
- the wall structure is essentially vertical, whereby the panels are essentially vertical,
- each of the panels comprise a projection, a first tongue and first groove, wherein the projection of each panel is arranged in the first tongue of the panel, and
- the projections protrude essentially downwards.

[0014] According to a fourth aspect of the invention, there is provided a method for forming a space in between a panel and an object, the object having an essentially planar part, comprising

- obtaining a first panel according to an embodiment of the invention,
- forming the space by moving the first panel such that the projection of the first panel contacts the essentially planar part of the object, and
- fixing the first panel to the object or a second object.

[0015] There is also provided a method, wherein

- the object is a second panel, wherein the second panel is essentially parallel to the first panel,
- the panel is fixed to a second object, and
- the second object is a substrate comprising metal or gypsum.

[0016] There is also provided a method, wherein

- the object is a second panel, wherein the second panel is essentially perpendicular to the first panel,
- the panel is fixed to a second object, and
- the second object is a substrate comprising metal or gypsum.

[0017] According to a fifth aspect of the invention, there is provided uses of a panel according to an embodiment of the invention. There is provided a use of the panel in a building. There is also provided a use of the panel in a wall of a building. There is also provided a use of the panel in a vehicle.

Description of the Drawings

[0018] The embodiments of the invention will be described with reference to Figs. 1-10, in which

- Fig. 1 shows, in a perspective view, a panel and some measures of the panel,
- Fig. 2a shows, in a side view, a panel according to an embodiment of the invention,
- Fig. 2b shows, in the side view of Fig. 2a, the pan-

- el of Fig. 2a,
 Fig. 3a shows, in the side view of Fig. 2a, two panels of Fig. 2a, wherein the shapes of the panels are adapted to each other such that a space is left to most parts between two panels,
 Fig. 3b shows the structure of Fig. 3a after the panels have swelled or the substrate has contracted,
 Figs. 4a-4f shows, in a side view, other embodiments of the invention,
 Fig. 5 shows, in a side view, using the panel of Fig. 4d in a floor structure,
 Figs. 6a-6c show, in a side view, using the panel of Fig. 2a in a wall structure,
 Figs. 7a-7c show, in a side view, using the panel of Fig. 2a in a wall structure,
 Fig. 8a shows, in a side view, a plywood panel with three plywood layers,
 Fig. 8b shows, in a perspective exploded view, the plywood panel, of Fig. 8a, and the grain directions of the plywood layers,
 Fig. 8c shows, in a perspective view, a plywood layer comprising veneers,
 Fig. 8d shows, in a perspective view, an example of a veneer and its grain direction,
 Fig. 9a shows, in a side view, a plywood panel according to an embodiment of the invention, the plywood layers of the panel, and the grain directions of the plywood layers,
 Fig. 9b shows, in a side view, a plywood panel according to an embodiment of the invention, the plywood layers of the panel, and the grain directions of the plywood layers,
 Fig. 10a shows, in a side view, a plywood panel according to a preferred embodiment of the invention, the plywood layers of the panel, and the grain direction of the plywood layers,
 Fig. 10b shows, in a side view, a plywood panel according to a preferred embodiment of the invention, the plywood layers of the panel, the grain direction of the plywood layers, and the thicknesses of the plywood layers.

Detailed Description of the Invention

[0019] Plywood is a type of manufactured timber made from thin sheets of wood, i.e. plywood layers. Plywood layers (made of one or more veneers) are glued together using an adhesive to make plywood panels. As the adhesive, e.g. a liquid resin may be used. The liquid resin may be dried, such that the adhesive of the finished panel may comprise resin. Plywood panels are widely used. Plywood panels are used in construction, e.g. in walls of a building. Plywood panels can be used in floors. Moreover, plywood panels can be used in vehicles as floor or

wall material. Typically a plywood panel is attached to a substrate. In addition to plywood panels, oriented standard boards (OSB) can be used for similar purposes.

[0020] Wood, such as plywood, is known to absorb moisture in humid conditions. Moistening of wood depends on the environment in which wood is used. The moisture content of wood in saturation (i.e. 100 % relative humidity) is about 30 %. Thus, 1 kg of dry wood may absorb up to 300 g of humidity. When the relative humidity decreases, the amount of water absorbed by wood is defined as an equilibrium moisture content, EMC. For example, when the relative humidity is 60 %, the EMC for wood is about 10- 12 %, depending on temperature, meaning that 1 kg of dry wood may absorb about 100 g of water (humidity) .

[0021] Wood and plywood is also known to swell because of moisture absorption in humid conditions. Swelling may be characterized by coefficient of moisture expansion (CME) or hygrometric coefficient of expansion (HCE). Or, conversely, wet wood (i.e. freshly sawn green wood) is known to shrink when dried. Shrinkage is proportional to total shrinkage and moisture content. The total shrinkage of wood depends on the type of wood and the shrinkage direction (radial or tangential). Therefore, a dry plywood panel may swell, when brought to humid (RH=60 %) conditions.

[0022] A plywood panel may be fixed to a substrate. The substrate may be e.g. a metal structure. The substrate may be e.g. a metal frame comprising metal bars. Metals are known not to absorb moisture. Therefore metals do not swell in humid conditions. Alternatively, the substrate may be a gypsum substrate. However, the hygrometric coefficient of expansion (HCE) for gypsum is relatively low, about 7 ppm/%RH. Therefore, a gypsum board is expected to swell only very little (about 0,04 %), when brought from dry condition to humid (RH=60 %) conditions.

[0023] The substrate may have different thermo-hygro-mechanical properties, such as thermal expansion and/or moisture swelling properties. Thus, plywood panels are known to swell in humid conditions much more than either metal or gypsum substrates. Therefore, if the panels are fixed to a substrate such that a panel is in contact with another panel, swelling may result in internal stress in the panels. These internal stresses may set off warping or cracking of the panels.

[0024] Materials are also known to expand due to temperature. Thermal expansion is characterized by the coefficient of thermal expansion (CTE). The CTE for many wooden materials is in the range 5 - 55 ppm/°C, depending on wood and the direction. The CTE for many metals is in the range 12 - 20 ppm/°C. The CTE for a gypsum board is about 16 ppm/°C. Therefore, the plywood panel may expand or shrink differently from a metallic or a gypsum substrate when the temperature changes.

[0025] The moisture swelling and thermal expansion properties of a material are generally referred to thermo-hygro-mechanical properties of the material. These prop-

erties include the above mentioned properties. These different thermo-hygro-mechanical of different materials should be taken into account in a structure comprising materials with different thermo-hygro-mechanical properties.

[0026] Fig. 1 shows a perspective view of a plywood panel 101. One of the edges of the panel 101 comprises a tongue 111. The panel limits a groove 121 on the same edge. Some typical measures of the panel are shown in the figure: the length of the panel, L_{pa} , the thickness of the panel, T_{pa} , and the width of the panel, W_{pa} .

[0027] On the edge opposite to the tongue 111, the panel may comprise a respective tongue and respective groove. The shapes of tongue 111 and the groove 121 may be adapted to the shapes of the respective groove and respective tongue of another similar panel. The panels may be attached to a rigid substrate. However, the plywood panel may deform during its service life. E.g. moisture may swell the panel, or temperature may contract substrate more than the panel. As described in the background, swelling of the panel 101 in the arrangement may result in internal stresses in the panel, further resulting in warping and/or cracking.

[0028] Therefore, a space may be left between the two panels. The space allows for a second panel to expand (swell), even if the second panel is fixed to the substrate. However, the panels should be attached relatively close to each other in order to build an even surface. Such a narrow space may be formed e.g. by using a spacer. The spacer may be kept between the panels while fixing the second panel to the substrate (assuming that a first panel has already been fixed to the substrate). Thereafter, the spacer may be removed from the space. However, using a spacer takes some time in the assembling process.

[0029] Fig. 2a shows, in a side view, a panel 200 according to an embodiment of the invention. The panel 200 comprises a first planar surface 202 and a second opposite planar surface 204, wherein the second surface is parallel to the first surface. The panel 200 of Fig. 2a is made of plywood. The panel 200 comprises plywood layers arranged between the first surface and the second surface, wherein the plywood layers are parallel to the first surface 202 (and the second surface 204). The panel further comprises edges 206 and 208 extending from the boundaries of the first surface 202 to the boundaries of the second surface 204. As a side view of the panel is shown, only two edges are shown. The panel 200 of Fig. 2a has a rectangular shape, whereby the panel comprises four edges.

[0030] At least one edge 206 comprises a projection 230. The projection 230 protrudes from the first edge 206. The projection 230 protrudes in a direction essentially perpendicular to the first edge 206. In Fig. 2a, this direction is horizontal. The projection 230 extends in a direction of the first edge 206, the direction being perpendicular to the plane of the figure 2a. The projection 230 of Fig. 2a extends in the direction of the width of the panel 200, the width being shown in Fig. 1. The projection

230 extends preferably throughout the edge 206 of the panel 200 in the direction of the width of the panel. If the projection 230 does not extend throughout the edge of the panel, the panel may comprise several projections 230 in the direction of the width of the panel 200.

[0031] The projection 230 comprises a part of at least one plywood layer. That is, the projection is an integral part of the panel. Therefore, the projection 230 is made of wood or wood and adhesive, wherein the adhesive is used to attach the plywood layers to each other to form the plywood panel. The adhesive may comprise resin, as discussed above. Moreover, the projection 230 is made of the same material as the rest of the panel 200. The projection 230 can be made to the panel 200 e.g. by machining, milling, or cutting. The projection 230 is arranged on a distance d_p from the first surface 202 (Fig. 2b). The distance is defined as the distance between the plane of the first surface 202 and the centre of the projection 230.

[0032] The projection 230 is arranged to support the panel 200. Under compression, e.g. when the plywood panel swells, the projection 230 is arranged to deform. If the compression is small, the projection 230 is elastically, i.e. reversibly, deformed. However, if the compression is large, the projection 230 is also plastically, i.e. permanently, deformed.

[0033] The edges 206 and 208 of the panel 200 in Fig. 2a are shaped for a half lap scarf joint. The first edge 206 comprises a first tongue 210, and the first edge 206 limits a first groove 220. The second edge 208 comprises a second tongue 240, and the second edge 208 limits a second groove 250. In Fig. 2a the projection 230 is arranged in the first tongue 210. The shape of the second groove 250 is adapted to the shape of first tongue 210. However, when the panel is in use, the projection 230 may be completely deformed by compression. Therefore, the shape of the second groove 250 is adapted to the shape of first tongue 210, when the projection 230 is completely deformed. Under a complete deformation the projection is completely compressed. This issue will be describe in more detail below. The shape of the first groove 220 is adapted to the shape of second tongue 240. As with the first tongue, the shape of the first groove 220 is adapted to the shape of second tongue 240, when the projection 230 is completely deformed. Because of the tongues and the grooves (i.e. the half lap scarf joint) two panels can be easily adapted to each other, and because of the projection, a space 150 is left in between two such panels (cf. Fig. 3a).

[0034] In Fig. 2a, the panel comprises a second edge 208 opposite to the first edge 206 that comprises the projection 230. The second edge 208 comprises a supporting area 232 arranged to support the projection 230 of another similar panel. In Fig. 2a, the supporting area 232 is shown by the dotted circle around the supporting area 232.

[0035] The supporting area 232 is arranged on a distance d_{sa} from the first surface 202. At least a part of the

supporting area 232 is arranged on the same distance d_p as the projection 230. In Fig. 2b, the supporting area 232 is arranged on the same distance, d_{sa} , from the first surface 202 as the projection 230. Thereby these distances are equal, i.e. $d_p = d_{sa}$. Therefore, when two similar panels are arranged on a support such that their first surfaces 202 or second surfaces 204 are aligned on a same plane, the projection 230 of the first panel can be arranged in contact with the supporting area 232 of the second panel (cf. Fig. 3a).

[0036] Some typical measures for the panel will be given with reference to Fig. 2b. The measures are given only as an example. The thickness of the panel, T_{pa} , may be in the range from 5 mm to 60 mm, preferably about 12 mm. The length of the panel, L_{pa} , may be from 300 mm to 1800 mm, preferably from 500 mm to 620 mm. The panel may be arranged to be fixed to a supporting frame having supports at the intervals of 450 mm or 600 mm, whereby the additional 50 mm to 20 mm allows for the tongue-groove joint. The height of the projection, L_p , may be from 1 mm to 5 mm, preferably about 2 mm. The length of the first tongue 210, L_{t1} , (including the height of the projection 230) may be from 15 mm to 30 mm, preferably about 20 mm. The second groove 250 is adapted to receive the first tongue 210. The shape of the second groove 250 is adapted to the shape of first tongue 210, when the projection 230 is completely deformed. Therefore, the length of the second groove, which equals the length of the second tongue 240, L_{t2} , equals the length of the first tongue, excluding the height of the projection. Mathematically: $L_{t2} = L_{t1} - L_p$. In this way, the shape of the second groove 250 is adapted to the shape of first tongue 210, when the projection 230 is completely deformed. When the projection 230 is not deformed, a space 150 is left between panels (Fig. 3a).

[0037] The thickness of the projection 230, T_p , may be in the range from 0, 5 mm to 3 mm, preferably about 1, 5 mm. The thickness of the first tongue 210 (including the thickness of the projection 230), T_{t1} , may be e.g. about half of the thickness of the panel, T_{pa} , or, preferably slightly more, as will be discussed later. As the second groove 250 is adapted to receive the first tongue 210, the thicknesses of the first tongue 210 and the second tongue 240 total to the thickness of the panel, i.e. $T_p = T_{t1} + T_{t2}$.

[0038] The width of the panel, W_{pa} , (cf. Fig. 1) may be in the range from 300 mm to 3600 mm, preferably about 2440 mm. In Figs. 2a and 2b, the projection 230 is arranged on the longer edge on the panel. Alternatively, the projection could be arranged on the shorter edge. Moreover, the projection could be arranged on two edges, e.g. on a longer edge and on a shorter edge, or on two equally long edges on a square panel, to allow for swelling, expansion, and/or contraction two directions.

[0039] Figure 3a shows a structure comprising a substrate 310 and two plywood panels 200a and 200b. The substrate 310 may be e.g. a wall or a frame in a building. The panel 200a is attached to the substrate 310 using

attachment means 140a such as a nail or a screw. If the substrate is a metal frame, the attachment means is preferably a screw. When installing the panel 200b, the first tongue 210 of the panel 200b is arranged in the second groove of panel 200a, limited by the second tongue 240 of the panel 200a. Furthermore, when installing the panel 200b, the panel 200b is supported on the panel 200a. More precisely, the projection 230 of the panel 200b can be supported to the supporting area 232 of the panel 200a. When the panel 200b is in this way supported by the panel 200a, the panel 200b can be attached to the substrate 310 using attachment means 140b such as a nail or a screw. In Fig. 3a, at least the panel 200b is substantially dry. A space 150 is left between the panels. As is evident, the width of space 150 (in the direction of the height of the projection) corresponds to the height of the projection, L_p . This applies when installing the panels. If the panels swell, the width of the space 150 decreases. As is also evident from the above discussion, the space 150 does not extend from the first surface 202 to the second surface 240, as the panels are supported by the combination of the projection 230 and the supporting area 232.

[0040] Referring to Fig. 3b, when the panel 200b swells or expands, the attachment means 140a and 140b keep the respective locations of the panels fixed. Therefore the panel 200b swells or expands in such a way that the projection 230 is compressed towards panel 200a. Under compression, the projection 230 deforms and allows for swelling of the panel 200b.

[0041] Swelling or expansion of the panel 200b induces compressive stress in the panel 200b. Likewise, contraction of the substrate 310 induces compressive stress in the panel 200b. As is well known, the stress equals to force divided by the area the force affects. Given that the compressive stress in the panel 200b is σ , the corresponding force is $F = \sigma \times T_{pa} \times W_{pa}$. As this force is transmitted to panel 200a only through the projection 230, the compressive stress in the projection 230 equals $F / (T_p \times W_{pa})$. Therefore, the compressive stress in the projection 230 is (T_p / T_{pa}) times the compressive stress in the panel 200b. The compressive force is transmitted to panel 200a, specifically to the supporting area 232 of the panel 200a. As is known from mechanics, from the Boussinesq equation, the pressure (i.e. stress) under the supporting area 232 of the panel 200a spreads to the panel 200a within a short distance. Therefore, the compressive stress in the supporting area 232 decreases to the same compressive stress as in the panel 200b, i.e. σ , provided that the cross sectional areas of the panels 200a and 200b are the same. Therefore, the compressive stress is concentrated mainly in the projection 230, and only in a small volume near the supporting area 232.

[0042] It is known that materials, such as plywood, have a yield stress, where the material starts to yield. As described above, the yield stress may be related to a yield force, i.e. a compressive force, where the material starts to yield. As describe above, the projection 230 has

a first yield force, and the supporting area has a second yield force, wherein the second yield force is greater than the first yield force. This is because of the principle of the stress concentration, even if the plywood panels 200a and 200b have the same compressive yield stress. The compressive stress is thus concentrated into the projection 230. To enable the described stress concentration, the thickness of the projection 230, T_p , should be at most one third ($1/3$) of the thickness of the panel, T_{pa} . Preferably the thickness of the projection 230, T_p , is at most one fifth ($1/5$) of the thickness of the panel, T_{pa} . It is also possible to exploit the anisotropic properties of plywood, whereby even the yield stress of the projection 230 may be smaller than the yield stress of the rest of the panel 200. This issue will be described in more detail later.

[0043] Figs 4a-4f show embodiments of the invention in a side view. The invention relates to a panel, even if all these figures show two mutually similar panels. The projection 230 of a panel, and the corresponding supporting area 232 are shown in the figures.

[0044] The panel of Fig. 4a comprises a first edge that comprises the projection 230. The panel comprises a second edge. The second edge is planar and opposite to the first edge. The second edge comprises the supporting area 232.

[0045] The panel of Fig. 4b comprises a first edge that comprises a first tongue and a first groove. The projection 230 is arranged in the first groove. The panel comprises a second edge. The second edge comprises a second groove and a second tongue. The supporting area 232 is arranged in the second tongue. The depth of the first groove, excluding the projection 230, equals the length of the second tongue.

[0046] The panel of Fig. 4c comprises a first edge that comprises a first tongue and a first groove. A first projection 230a is arranged in the first groove and a first supporting area 232a is arranged in the first tongue. The panel comprises a second edge. The second edge comprises a second groove and a second tongue. A second projection 230b is arranged in the second groove and a second supporting area 232b is arranged in the second tongue. As can be noticed, the edges are symmetrical, and can be machined with same tools. The depth of the grooves, excluding the projections 230a and 230b, equals the length of the tongues. In this way the shape of the tongues are adapted to the shape of a grooves, when the projections 230a, 230b are completely deformed.

[0047] As for the terminology, the tongue-groove joint of Fig. 4d comprises two opposing half lap scarf joints (Figs. 2a, 2b, 4a and 4b). As the terms "tongue" and "groove" are used in connection with half lap scarf joints, the joint of Fig. 4d comprises elements of such joints. Therefore, the panel of Fig. 4d comprises a first edge that comprises a first tongue between two grooves. The projection 230 is arranged in the first tongue. The panel comprises a second edge. The second edge comprises a second groove between two tongues. The supporting area 232 is arranged in the second groove.

[0048] The panel of Fig. 4e comprises a first edge that comprises a first tongue between two grooves. The supporting area 232 is arranged in the first tongue. The panel comprises a second edge. The second edge comprises a second groove between two tongues. The projection 230 is arranged in the second groove. The walls of the groove, i.e. the two tongues of the second edge, protect the projection 230.

[0049] The panel of Fig. 4f comprises a first edge that comprises a tongue in between two first grooves. A first supporting area 232 is arranged on one of the first grooves, and a second supporting area 232 is arranged on the other first groove. The panel comprises a second edge. The second edge comprises a groove between two second tongues. The projections are arranged on the second tongues; a first projection 230 on the first second tongue and a second projection 230 on the second second tongue. In Fig. 4f, the projections comprise a part of the surface plywood layer of the panel.

[0050] It is evident, that projections could be alternatively arranged on the first grooves (not shown). The supporting areas could be arranged respectively on second tongues (not shown). It is also evident, that a first projection could be arranged on a first groove, and a second projection could be arranged on a second tongue (not shown). The a first supporting area could be arranged respectively on a second tongue and a second supporting area could be arranged on a first groove (not shown).

[0051] Figure 5 shows installing the panels of Fig. 4f to a floor structure. The process starts by arranging the projection 230 of a first panel 200a in contact with a supporting area of the wall structure 510. Specifically, the panel 200a is moved, e.g. on the substrate 310, such that the projection 230 of the panel is in contact with the supporting area, as depicted in the figure. The first panel 200a may be fixed to the substrate 310. As the panel 200a is a floor panel, the panel may be kept in its place by gravitational force, i.e. without the fixing means 140a. The substrate 310 is not necessarily a solid substrate, and may be for example a frame, grid or a mesh. After placing, and possible fixing the first panel 200a, a second panel 200b may be installed in a similar manner. The projection 230 of the second panel 200b is arranged in contact with the supporting area 232 of first panel 200a. The second panel may be fixed to the substrate 310 by fixing means 140b or by gravitational forces. As the panels of Fig 4f are used, wherein projections 230 comprise a part of the surface plywood layer of the panel 200a, 200b, the surface of the floor thus formed by the panels is free of the spaces 150. The space 150 is formed only in the interior of the joint.

[0052] Figs. 6a- 6c and 7a- 7c show, in a side view, using the panel of Fig. 2a (and Fig. 9a and 10a) in a wall structure, and a method for installing such a structure. The difference between Figs. 6 and 7 is that in the figures 6, the second surface of the panel is facing the inner wall 310 (substrate), while in the figure 7, the first surface of the panel is facing the inner wall 310. The inner wall may

comprise a metal frame. Installing the wall structure starts by fixing the first panel to the inner wall 310 to a proper height. Comparing Figs. 6a and 7a, in Fig. 6a a spacer may be used to form the first space 150 while fixing the panel 200a to the inner wall. In Fig. 7a, the space is formed by supporting the projection 230 to the floor 520, whereby part of the floor acts as a supporting area for the projection. The panel 200 is preferably installed such that a groove that opens upwards is also facing towards to substrate 310. Referring to Fig. 6a the groove may be the first groove 220. Referring to Fig. 7a the groove may be the second groove 250. Thereby the upward-opening groove 220, 250 can be used to install the second panel 200b (Figs. 6b, 7b). Specifically, a tongue of the second panel 200b can be installed to the upward-opening groove 220, 250.

[0053] The first panel 200a can be fixed to the wall with the fixing means 140 such as a nail or a screw. In Fig. 7a the projection 230 of the panel 200a is in contact with an essentially planar part of the floor 520. The panel 200a is moved, e.g. from a storage, such that essentially the whole projection 230 of the panel is in contact with the floor 520. The floor 520 may comprise a panel. The first panel 200a is in contact with the floor (or a panel of the floor), wherein the first panel is essentially perpendicular to the floor.

[0054] In Fig. 6b, the second panel 200b is installed such that the supporting area 232 of the second panel 200b is facing the projection 230 of first panel 200a. Thus, the projection 230 (of the first panel 200a) supports the second panel 200b. In a corresponding way, in Fig. 7b, the second panel 200b is installed such that the projection 230 of the second panel 200b is facing the supporting area 232 of first panel 200a. Thus, the projection 230 (of the second panel 200b) supports the second panel 200b. In both Figs 6b and 7b, the combination of the projection 230 and the supporting area 232 form the support for the second panel 200b, and provides the space 150. In Figs. 6b and 7b the projection 230 of a panel 200 is in contact with an essentially planar part of another similar panel 200. The essentially planar part is the supporting area 232. The second panel 200b is moved in such a way that essentially the whole projection 230 is in contact with the supporting area 232. Moreover, the second panel 200b is essentially parallel to the first panel 200a.

[0055] Referring to Figs 6c and 7c, after installing the plywood panels 200, an overlying layer 610 is installed on the plywood panels. In Figs 6c and 7c, the overlying layer 610 comprises a gypsum board. The overlying layer 610 is fixed to at least one plywood panel 200 using the fixing means 620 such as nails or screws. The fixing means 620 may be located substantially at the same height as the fixing means 140, provided that they are horizontally at different locations. As a gypsum board is known to be brittle, the gypsum board does not withstand warping. Therefore, the space 150 allowing for uneven expansion, contraction or swelling of the different layers, is needed in the panel system of Figs. 6a-6c and 7a-7c.

In the embodiment, the space 150 is formed using the projection 230 and the respective supporting area 232.

[0056] Of the figures 6a-6c and 7a-7c, the embodiment shown in Figs. 7a-7c is preferred, because

- no spacer is needed, when installing the first panel 200a.
- in Figs. 7, the second tongue of the first panel 200a (i.e. the tongue without the projection, and facing upwards) limits the second groove of the first panel 200a, into which the second panel 200b is installed. When installing the second panel 200b into the second groove, the second panel 200b easily hits the second tongue limiting the groove. Thus, if the second tongue limiting the second groove comprised a projection, as in Fig. 6c, the projection could easily break. These parts could fall into the space 150 thereby excessively supporting the second panel 200b. However, in Fig. 7c the second tongue limiting the second groove does not comprise a projection, and is therefore stronger the corresponding tongue of Fig. 6c.

[0057] The panel system of Figs. 6 and 7 may form a part of a wall structure. A wall structure is essentially vertical. Therefore the panels 200a and 200b in a wall structure are essentially vertical. Each of the panels 200a, 200b of Figs. 6 and 7 comprise a projection 230, a first tongue 210 and first groove 220, wherein the projection 230 of each panel is arranged in the first tongue 210 of the panel. In the preferred embodiment of Figs. 7a-7c, the projections 230 protrude essentially downwards.

[0058] The panel 200 has first thermo-hygro-mechanical properties, such as EMC, CME, HCE, and CTE, as discussed above. In the embodiment shown in Figs. 6c and 7c, the substrate 310 (i.e. the inner wall 310) comprises metal. The inner wall may comprise a metal panel. The substrate 310 (inner wall) may comprise a metal frame, to which the panels are attached. The substrate 310 (inner wall) may comprise a metal frame made of metal bars. The substrate has second thermo-hygro-mechanical properties. As motivated above at least one first thermo-hygro-mechanical property is different from the corresponding second thermo-hygro-mechanical property. The equilibrium moisture content (EMC) of the panel is different from the equilibrium moisture content of the substrate. As another example, the coefficient of moisture expansion (CME) of the panel is different from the coefficient of moisture expansion of the substrate. Alternatively, the substrate 310 could be a gypsum board.

[0059] Referring to Figs 6c and 7c, the wall structure (i.e. a panel system) further comprises an overlying layer 610. In the embodiment shown in Figs. 6c and 7c, the overlying layer 610 comprises a gypsum board. The overlying layer has third thermo-hygro-mechanical properties. At least one first thermo-hygro-mechanical property (of the panel) may be different from the corresponding third thermo-hygro-mechanical property (of the overlying

layer 610). The overlaying layer 610 could, alternatively, comprise a metal panel. The panel system comprises the gypsum board as the overlaying layer 610 to increase fire resistance of the structure. The panel system comprises the plywood panel 200 to increase the strength of the wall structure. In particular, the plywood panel enables fixing of objects to the wall structure with standard nails and/or screws. In addition, the plywood panels form a continuous supportive layer (as opposed to a discontinuous frame), whereby objects can be fixed to the wall structure to arbitrary locations. Still further, the plywood layer enhances the sound insulation of the wall structure. The panel system comprises the substrate (wall comprising metal, such as metal panel or metal frame). The substrate may comprise a metal panel to increase the weather resistance of the wall structure.

[0060] Fig. 8a shows, in a side view, a plywood panel 800 with three plywood layers 810, 820 and 830. As is evident to a person skilled in the art, a plywood panel may comprise several plywood layers. Typically the number of plywood layers is odd (i.e. $2 \times N + 1$, wherein N is an integer at least one). The number may be even. Typically a plywood panel 800 comprises from 3 to 30, preferably from 4 to 15, and most preferably from 5 to 10 plywood layers. The plywood layers are attached to each other using suitable adhesive. Fig. 8b shows, in a perspective exploded view, the plywood panel of Fig. 8a; in particular the plywood layers.

[0061] Referring to Fig. 8c, each plywood layer, e.g. the lowest plywood layer 830, comprises at least one veneer 831, 832, 833. The plywood layer 830 of Fig. 8c comprises three veneers 831, 832 and 833. The veneers are attached onto a plywood layer, e.g. onto the plywood layer 820, using suitable adhesive. The term veneer refers to thin slice of wood. A veneer is usually thinner than 3 mm. Veneer is usually produced from wood by turning. Fig. 8d shows, in a perspective view, an example of a veneer 834 and its grain direction 843. The veneer 834 could be used as the veneer 831, 832 or 833, or, as the plywood layer 810, 820 or 830. As the veneer 834 is turned from wood, the veneer comprises wood grains. As the veneer is a thin slice, it may be considered to be planar. The term grain refers to the alternating regions of relatively darker and lighter wood resulting from the differing growth parameters occurring in different seasons. Typically the different grains of a veneer are more or less parallel.

[0062] The grains define a grain direction for the veneer. The grain direction represents an average direction of the individual grains of the veneer. The grain direction is parallel with a direction of the plane of the veneer. The grain direction of the veneer 834 is shown with the arrow 843 in Fig. 8d. The grain direction may be referred to as the fibre direction, since the wood fibres are aligned more or less parallel to the grain direction.

[0063] A plywood layer may consist of one veneer. More typically, a plywood layer may comprise at least two veneers. As illustrated in Fig. 8c, the veneers of a

plywood layer are so aligned that the grain directions of different veneers in the plywood layer are parallel. Therefore, each plywood layer has a grain direction. The grain direction is parallel to a direction of the plane of the plywood layer, and therefore also parallel to a direction in the surface of the plywood panel 800. Referring to Fig. 8b, a plywood panel is formed in such a way that the grain direction of each plywood layer is essentially perpendicular the grain direction of an adjacent plywood layer. For example, the grain direction 842 of the second plywood layer 820 is essentially perpendicular to the grain direction 841 of the first plywood layer 810 and to the grain direction 843 of the third plywood layer 830. Therefore, the grain directions of every second plywood layers are essentially parallel. For example, the grain direction 841 of the first plywood layer 810 is parallel to the grain direction 843 of the third plywood layer 830. Referring to Fig. 8a, the grain direction of the plywood layers are shown with the arrows 841 and 843, when the grain direction is in the plane of the figure. When the grain direction is perpendicular to the plane of the figure, e.g. the grain direction 842, the direction is shown with the cross-mark.

[0064] A plywood layer has anisotropic hygro-thermo-mechanical properties, meaning that these properties are different in the grain direction and in the direction perpendicular to the grain direction. Such properties include:

- Elastic modulus. The stress needed for a given deformation is greater when the deformation is to be made in the grain direction than when the deformation is to be made perpendicularly to the grain direction. In some woods at the 12 % moisture content, the ratio of the elastic modulus in the grain direction ("longitudinal elastic modulus") is about 10 to 70 times higher than the elastic modulus in the direction perpendicular to the grain direction and the ratio of the log ("tangential elastic modulus").
- Swelling. When plywood layers wet, they tend to swell more in a direction perpendicular to the grain direction than in the grain direction. Naturally, since the layers are bonded together in a panel, the alternating grain directional prevent anisotropic swelling of a plywood panel.
- Strength under compression. The strength (stress needed for rupture or yield) in the grain direction is higher than in the direction perpendicular to the grain direction. In some woods at the 12 % moisture content, the ratio of these strengths is between 6 and 11.

[0065] These anisotropic properties may be used to optimize the structure of the panel. As has been discussed, the projection 230, is arranged to deform under compression. Because of the above-mentioned anisotropic hygro-thermo-mechanical properties, the projection 230 can be oriented in such a way that the projection 230 is easily deformed under compression. i.e. the elastic

modulus and the strength in the direction of compression (i.e. the direction into which the projection 230 protrudes) should be small.

[0066] Fig. 9a shows, in a side view, a plywood panel 200 according to an embodiment of the invention. The plywood layers 810, 820, 830, 840, and 850 of the panel are shown in the figure. The grain directions of the plywood layers are shown using the same convention as in Figs. 8a-8d. A preferred embodiment of the panel comprises five plywood layer, as shown in the figure 9a. The panel according to the preferred embodiment is 12 mm thick, whereby the thickness of the plywood layers is in the average 2.4 mm. In general, the thickness of a plywood layer may be between 1.5 mm and 4.0 mm, preferably between 1.5 mm and 3.2 mm. In Fig. 9a, the projection 230 comprises part of one plywood layer 830. The plywood layer 830 has a grain direction perpendicular to the plane of the figure 9a, as indicated by the cross marks. The projection 230 protrudes in a direction that is parallel to a direction in the plane of the panel 200, and that is parallel to the direction of the length of the first tongue 210. Therefore, the projection 230 protrudes in a direction essentially perpendicular the grain direction of the plywood layer 830, wherein part of the plywood layer 830 is comprised by the projection 230. As the plywood layer 830 protrudes from the panel, the plywood layer 830 may be referred to as a protruding plywood layer.

[0067] It is noted, that in case the panel 200 does not comprise a tongue (Fig. 4a), the projection 230 protrudes in a direction that is parallel to a direction in the plane of the panel 200, and that is perpendicular to the edge (206, 208, cf. Figs. 2a and 4a) comprising the projection 230. Also in this case the projection 230 may protrude in a direction essentially perpendicular the grain direction of the plywood layer, part of which plywood layer is comprised by the projection 230.

[0068] It is also possible to include a part of an adjacent plywood layer in the projection 230. The projection 230 of Fig. 9b comprises a part of the plywood layer 830 (having the above mentioned preferred grain orientation). The projection 230 further comprises a part of the adjacent plywood layer 840, wherein the layer 840 has the unfavourable grain orientation. Therefore, the thickness of the projection 230, T_p , exceeds the thickness of one plywood layer 830, T_{pl} . The ratio of these thicknesses, T_p/T_{pl} , may be from 0.25 to 1.4, preferably from 0.3 to 0.95, and most preferably from 0.4 to 0.9. As also the plywood layer 840 protrudes from the panel, the plywood layer 840 may also be referred to as a protruding plywood layer. The panel 200 of Fig. 9b comprises two protruding plywood layers 830, 840, each having a grain direction, and the projection 230 comprises at least part of each of the said at least one protruding plywood layer.

[0069] In Fig. 9b, the ratio of material having the preferred grain direction (i.e. thickness of layer 830 comprised in the projection 230) to total amount of material in the projection (i.e. total thickness of the projection) is greater than 55 %. As an example, in Fig. 9b, the thick-

ness of layer 830 comprised in the projection 230 equals the thickness of the layer 830, and thickness of layer 840 comprised in the projection 230 equals approximately half the thickness of the layer 840. Thereby, the above mentioned ratio is about 2/3. Preferably the ratio is at least 65 %, and more preferably the ratio is at least 75 %. Referring to Fig. 9a, the ratio may also be 100 %, whereby all the material in the projection has the preferred grain direction. The ratio may be selected by selecting the thickness of the projection 230, and by orienting the panel 200, i.e. selecting which edge comprises the projection 230, such that the projection 230 protrudes in such a direction that at least at least the given percentage of material in the projection 230 has a preferred grain orientation, wherein the preferred grain orientation is perpendicular to the direction into which the projection 230 protrudes.

[0070] It is also noted that another type of mainly wooden boards is known in the art, the oriented standard board (OSB). An oriented strand board is manufactured in wide mats from cross-oriented layers of thin, rectangular wooden strips compressed and bonded together with wax and resin adhesives (95% wood, 5% wax and resin). These layers are referred to as oriented standard board layers. The layers are created by shredding the wood into strips, which are sifted and then oriented on a belt or wire cauls. The mat is made in a forming line, the layers are built up with the external layers aligned in the panel's strength axis with internal layers cross-oriented. The number of layers placed is determined partly by the thickness of the panel but is limited by the equipment installed at the manufacturing site. However individual layers can also vary in thickness to give different finished panel thicknesses (typically, a 15 cm layer will produce a 15 mm panel thickness). The mat is placed in a thermal press to compress the flakes and bond them by heat activation and curing of the resin that has been coated on the flakes. Since an OSB board has similar properties, and also the layers of compressed wooden strips are oriented in a grain direction, and the grain direction of individual layers are cross-oriented, the invention is equally applicable to oriented standard boards.

[0071] However, the hygro-metric coefficient of expansion (HCE), of an OSB panel is much larger than the HCE of a plywood panel. Therefore, plywood panels are better suited for structures comprising material with different hygro-thermo-mechanical properties. Furthermore, the OSB panel comprise more adhesive material than plywood panels. Therefore, the properties of the cross-oriented wooden layers are not as heavily dependent on grain direction in OSC than in plywood. Thus, the anisotropic properties of the plywood layers enable more orientation-specific properties of the projection 230 than the anisotropic properties of the cross-oriented wooden layers in OSB. In particular, if the projection 230 comprises a part of only one projecting plywood layer, the projection is essentially free from adhesives. Even if the projection 230 comprises a part of more than one pro-

jecting plywood layers, the projection comprises less adhesives than a corresponding projection in an OSB panel. Typically, the adhesive material in either plywood or OSB is isotropic, while wood is anisotropic.

[0072] A plywood panel may comprise an odd number of plywood layers (i.e. $2 \times N + 1$ plywood layers, wherein N is an integer at least one; in the preferred embodiment the plywood panel comprises five layers and N equals 2). The plywood panel of Figs. 2a and 9a comprises a first tongue 210 arranged in the first edge 206, and a second tongue 240 arranged in the second edge 208. To ensure the mechanical strength of both tongues, the thickness of the first tongue 210, T_{t1} , may be approximately the same as the thickness of the second tongue 240, T_{t2} . These thicknesses are approximately the same, when $2/3 \leq T_{t1}/T_{t2} \leq 3/2$. An example of such a panel is shown in Fig. 9a, wherein $T_{t1} = 3 \times T_{pl}$ and $T_{t2} = 2 \times T_{pl}$, wherein T_{pl} is the thickness of one plywood layer.

[0073] When the plywood panel shown in Fig. 9a wets, the first plywood layer 810 tends to swell in the horizontal direction 910 more than the second plywood layer 820. Therefore, the second tongue 240 warps, as indicated by the arrow 920. This happens, if the tongue has an even number ($2 \times N$, wherein N is an integer at least 1) of plywood layers. Warping may be diminished by adjusting the thickness of the tongue.

[0074] Fig. 10a shows, in a side view, a preferred embodiment of the plywood panel 200. Fig. 10a also shows the five plywood layers 810, 820, 830, 840, and 850 of the panel 200, and the grain directions of the plywood layers. To prevent the warping, as discussed in relation to Fig. 9a, the second tongue 240 comprises part of the third plywood layer 830. The third plywood layer 830, as well as the first plywood layer 810, tends to swell in the horizontal direction 910 more than the second plywood layer 820. Therefore the slice of the third plywood layer 830 comprised by the second tongue 240 prevents the second tongue 240 from warping.

[0075] Denoting the thicknesses of the plywood layers 810, 820, 830, 840, and 850 by T_{pl1} , T_{pl2} , T_{pl3} , T_{pl4} , and T_{pl5} , respectively, it is evident from the figure 10b that the thickness of the first tongue 210 is $p \times T_{pl3} + T_{pl4} + T_{pl5}$, and the thickness of the second tongue 240 is $(1 - p) \times T_{pl3} + T_{pl4} + T_{pl5}$, wherein p is a number greater than zero and less than 1. As is evident from the figures 10a and 10b, the thickness of the projection 230 is $p \times T_{pl3}$. Therefore, the panel 200 of figure 10a comprises an edge, wherein the edges comprises a tongue and a groove. The projection 230 is arranged in the tongue 210. The thickness of the tongue 210 is

- from the thickness of a number of plywood layers ($T_{pl4} + T_{pl5}$)
- to the thickness of a number of plywood layers, added by at most the thickness of the subsequent plywood layer ($T_{pl3} + T_{pl4} + T_{pl5}$).

[0076] As both the first tongue and the second tongue

comprise the same number (two in Figs. 10a and 10b) of whole plywood layers, the tongues have approximately equal strengths.

[0077] Preferably p is from 0.25 to 0.9. Also preferably, the panel 200 comprises an odd number of the plywood layers, wherein the odd number is $2 \times N + 1$, and N is an integer at least 1 (N equals two in the preferred embodiment of Fig. 10a). In the preferred embodiment, the projection 230 comprises part of the middle plywood layer 830. All the plywood layers have essentially the same thickness, whereby the thickness of the plywood layers is essentially equal to the thickness of a first plywood layer. The thickness of the plywood layers may be denoted by T_{pl} . Therefore, if p is in the preferred range, the thickness of the projection, T_p (Fig 2a), is from $0.25 \times T_{pl}$ to $0.90 \times T_{pl}$. Moreover, the thickness of the first tongue 210 comprising the projection 230 equals the thickness of the projection 230, T_p , added by the thickness of the other plywood layers in the tongue, $N \times T_{pl}$. Thus, the thickness of the first tongue is $T_{t1} = T_p + N \times T_{pl}$. In addition, the panel 200 of Figs. 9a- 10b comprises only one projection 230. The projection 230 is arranged in the first tongue 210. In the preferred embodiment, the thickness of a plywood layer is about 2.4 mm, whereby the thickness of the first tongue 210, T_{t1} , (the one comprising the projection) is from about 4.9 mm to about 7.1 mm (for $p=0.95$). As the panel comprises 5 plywood layers, the thickness of the panel 200, T_{pa} , is 12 mm. As the second tongue limits the second groove, and the second groove is adapted to the first tongue, it is evident that the total thickness of the first and the second tongues equals to the thickness of the panel, i.e. $T_{t1} + T_{t2} = T_{pa}$. Conversely, the thickness of the second tongue is $T_{t2} = T_{pa} - T_{t1}$.

[0078] The panels shown in the figures 2, 4, 9 and 10 can be used in a floor, a roof, or a wall structure of a building or a vehicle. In particular, the panel of Fig. 10 can be used in the wall structure of Fig. 7.

Claims

1. A panel comprising

- a first planar surface,
- a second opposite planar surface, the second surface being parallel to the first surface,
- plywood or oriented standard board layers arranged between the first surface and the second surface, wherein the layers are parallel to the first surface,
- a first edge extending from the boundary of the first surface to the boundary of the second surface, and
- a second edge extending from the boundary of the first surface to the boundary of the second surface, wherein the second edge is opposite to the first edge, wherein
- the first edge comprises a projection,

- the projection protrudes from the first edge and extends in a direction of the first edge,
 - the projection is made of the same material as the panel, and
 - the projection is an integral part of the panel; and wherein
 - the second edge comprises a supporting area; whereby the projection and the supporting area, in combination, are arranged to leave a space in between the panel and a similar other panel, when the projection of the panel is in contact with the supporting area of the other similar panel.
2. The panel of claim 1, wherein
- the thickness of the projection, T_p , is at most one third ($1/3$) of the thickness of the panel, T_{pa} ; whereby compressive stress in the panel is arranged to concentrate into the projection.
3. The panel of claim 1 or 2, wherein
- the first edge comprises at least one of a first tongue and a first groove, and
 - the second edge comprises at least one of a second groove and a second tongue, respectively,
 - the projection is arranged in at least one of the tongue and the groove, and
 - the shape of a tongue is adapted to the shape of a groove when the projection is completely deformed; whereby two panels can be easily adapted to each other such that a space is left in between the panels.
4. The panel of any of the claims 1 - 3, wherein
- the panel comprises plywood layers arranged between the first surface and the second surface, wherein the layers are parallel to the first surface,
 - each plywood layer comprises at least one wooden veneer, the veneer being turned from wood having grains,
 - a part of the grains in each plywood layer are oriented in a grain direction of the plywood layer, the grain direction being parallel to a direction in the first surface,
 - the grain direction of each plywood layer is essentially perpendicular the grain direction of an adjacent plywood layer,
 - the panel comprises at least one protruding plywood layer each having a grain direction,
 - the projection comprises at least part of each of the said at least one protruding plywood layer,
 - the projection protrudes in such a direction that at least at least 55 % of material in the projection

has a preferred grain direction, wherein the preferred grain direction is perpendicular to the direction into which the projection protrudes and parallel to the plane of the panel; to enable easy deformation of the projection under compression.

5. The panel of claim 4, wherein

- the first edge comprises a first tongue and first groove, and
- the second edge comprises a second tongue and a second groove,
- the projection is arranged in the first tongue, and
- the panel comprises only one protruding plywood layer.

6. The panel of claim 5, wherein

- the panel comprises an odd number of plywood layers, wherein the odd number is $2 \times N + 1$, and N is an integer at least 1, and
- the thickness of each plywood layer is essentially equal to the thickness of a first plywood layer, the thickness of the first plywood layer being T_{pl} , whereby the thickness of the panel is $T_{pa} = (2 \times N + 1) \times T_{pl}$,
- the thickness of the first tongue, T_{t1} , is at least $N \times T_{pl}$ and thickness of the second tongue, T_{t2} , is at least $N \times T_{pl}$; to ensure the mechanical strength of both the first tongue and the second tongue,
- the thickness of the projection, T_p , is from $0.25 \times T_{pl}$ to $0.90 \times T_{pl}$; to diminish warping of a tongue,
- the thickness of the first tongue is the thickness of the projection, T_p , added by the thickness of the other plywood layers in the tongue, $N \times T_{pl}$, and
- the total thickness of the first and the second tongues equals to the thickness of the panel, $T_{t2} = T_{pa} - T_{t1}$.

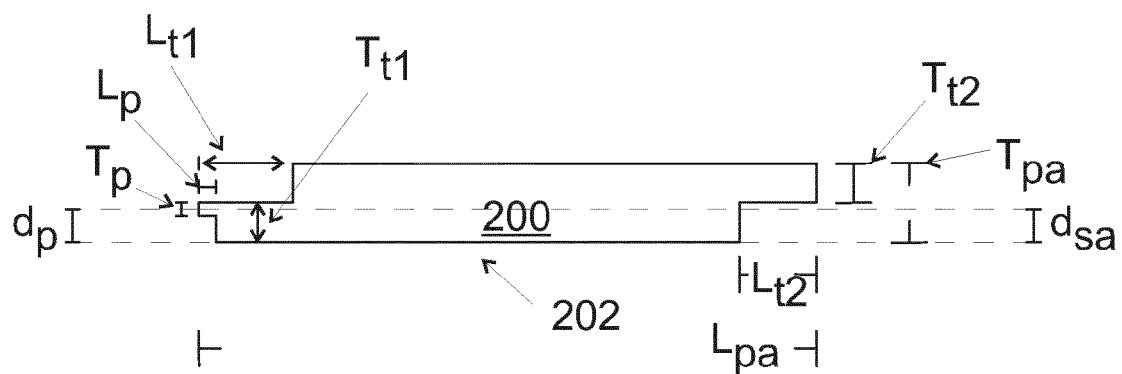
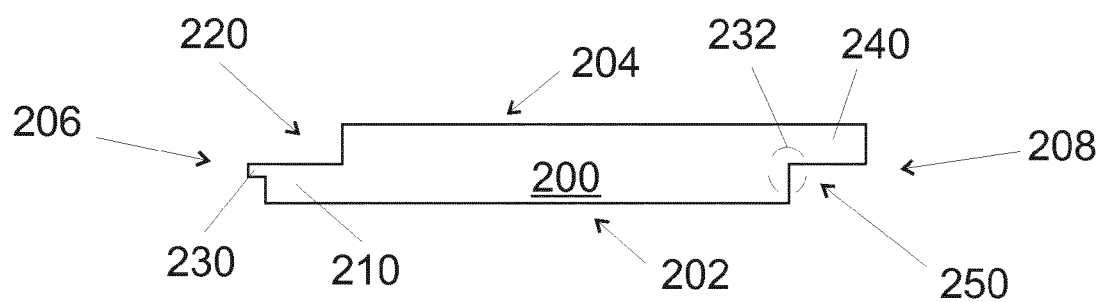
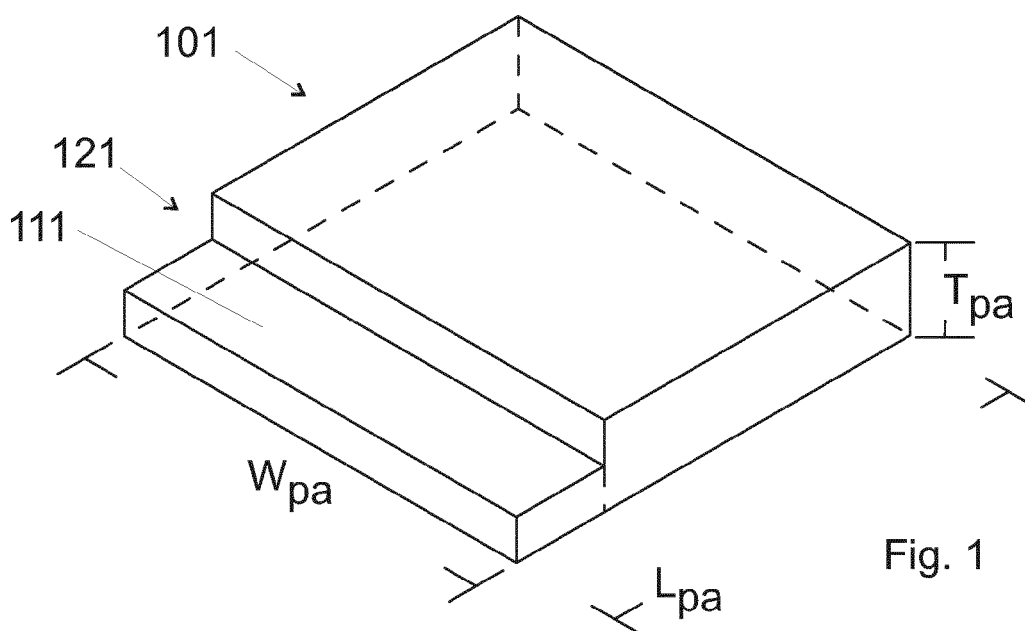
7. A panel system comprising

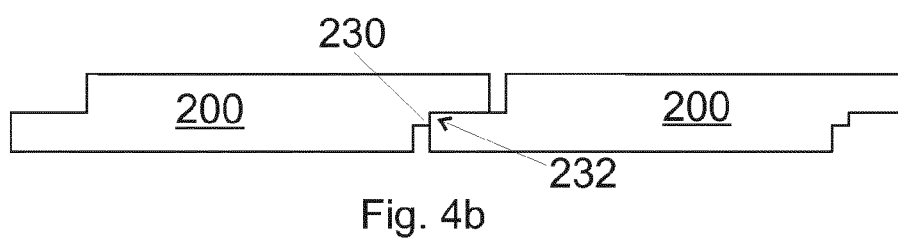
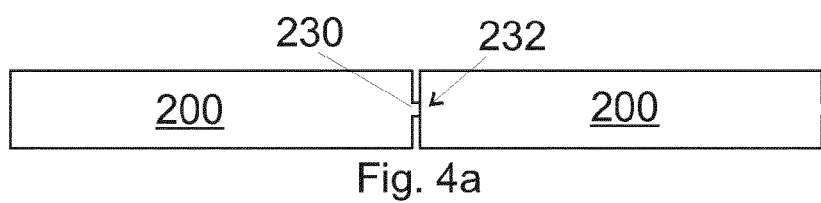
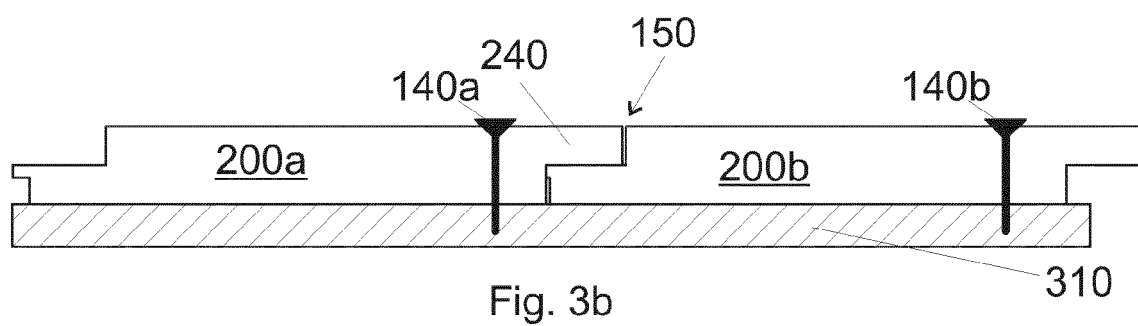
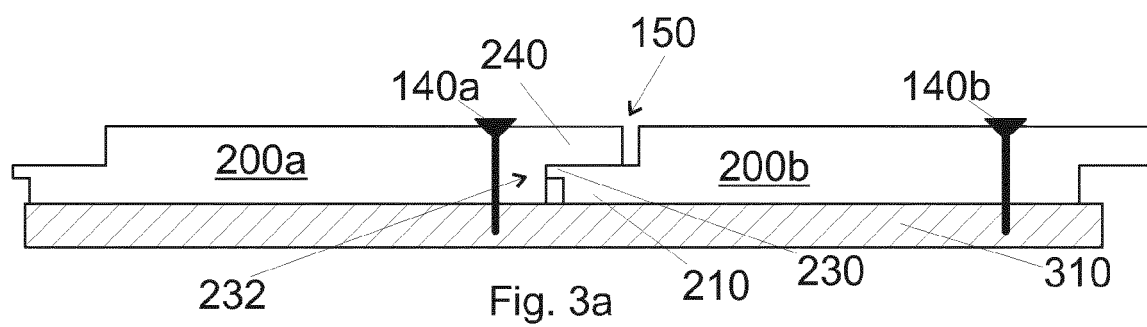
- a first panel and a second panel of any of the claims 1 to 6, the panels having first thermo-hygro-mechanical properties,
- an substrate having second thermo-hygro-mechanical properties, wherein at least one first thermo-hygro-mechanical property is different from the corresponding second thermo-hygro-mechanical property, wherein
- the first panel is attached to the substrate, and
- the second panel is attached to the substrate such that a projection of the first or the second panel is in contact with a supporting area of the

second or the first panel, respectively; whereby a space is arranged in between the first panel and a second panel.

15. Use of the panel of any of the claims 1 - 6 in a vehicle.

8. The panel system of claim 7, wherein 5
- the panel system comprises an overlying layer, wherein the first panel and the second panel are arranged in between the substrate and the overlying layer, 10
 - the substrate comprises metal, and
 - the overlying layer comprises gypsum.
9. A wall structure comprising 15
- the panel system of claim 8, wherein
 - the wall structure is essentially vertical, whereby the panels are essentially vertical,
 - each of the panels comprise a projection, a first tongue and first groove, wherein the projection of each panel is arranged in the first tongue of the panel, and 20
 - the projections protrude essentially downwards. 25
10. A method for forming a space in between a panel and an object, the object having an essentially planar part, comprising
- obtaining a first panel of any of the claims 1 - 6, 30
 - forming the space by moving the first panel such that the projection of the first panel contacts the essentially planar part of the object, and
 - fixing the first panel to the object or a second object. 35
11. The method of claim 10, wherein
- the object is a second panel, wherein the second panel is essentially parallel to the first panel, 40
 - the panel is fixed to a second object, and
 - the second object is a substrate comprising metal or gypsum.
12. The method of claim 10, wherein 45
- the object is a second panel, wherein the second panel is essentially perpendicular to the first panel,
 - the panel is fixed to a second object, and 50
 - the second object is a substrate comprising metal or gypsum.
13. Use of the panel of any of the claims 1 - 6 in a building. 55
14. Use of the panel of any of the claims 1 - 6 in a wall of a building.





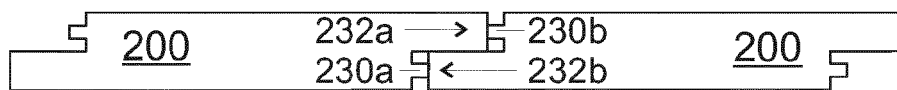


Fig. 4c

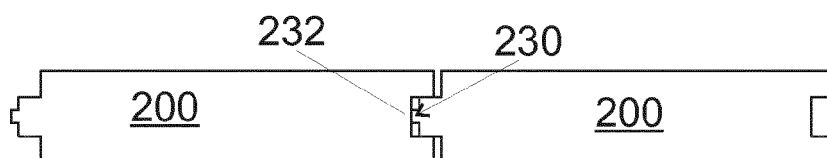


Fig. 4d

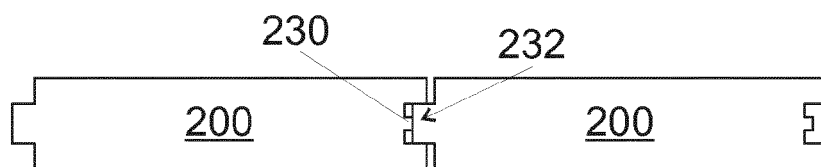


Fig. 4e

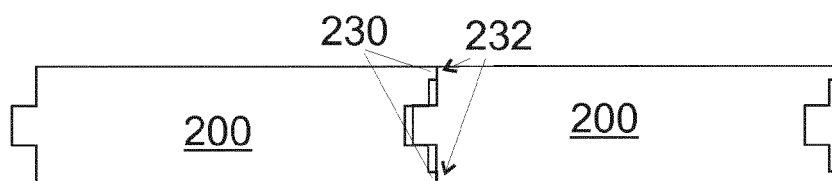


Fig. 4f

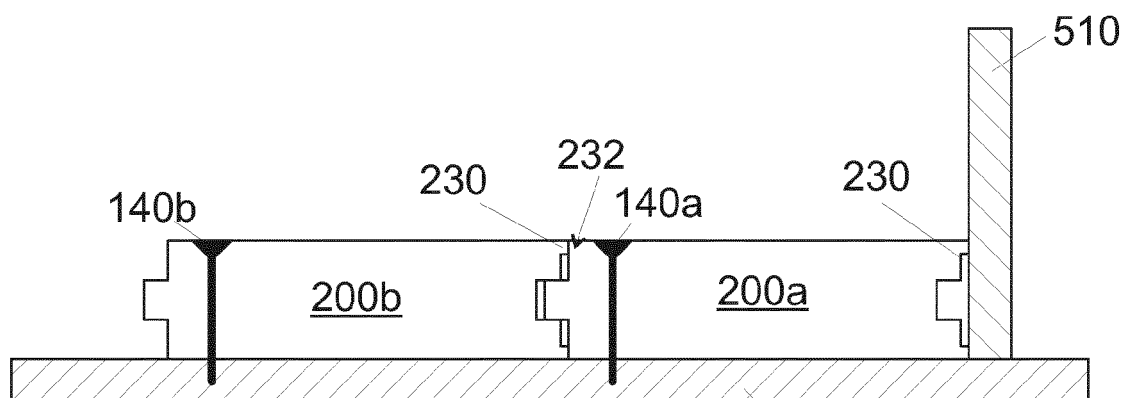


Fig. 5

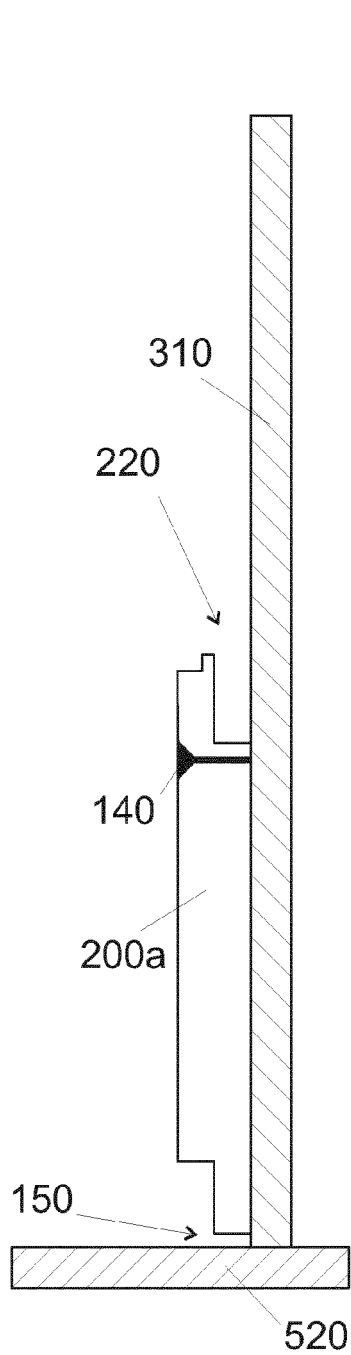


Fig. 6a

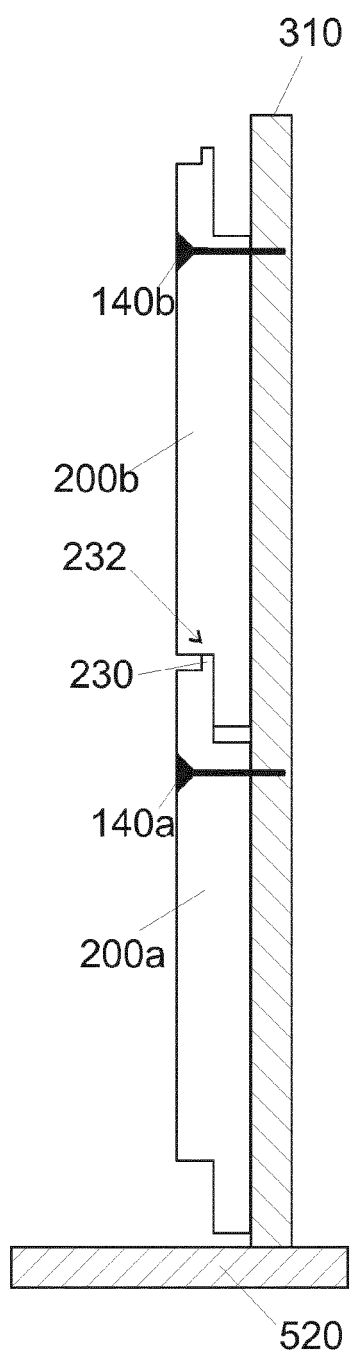


Fig. 6b

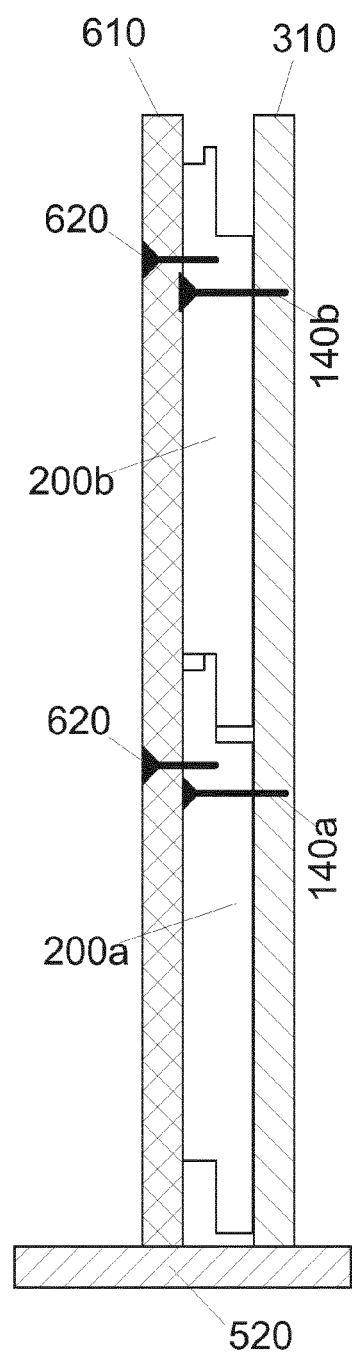


Fig. 6c

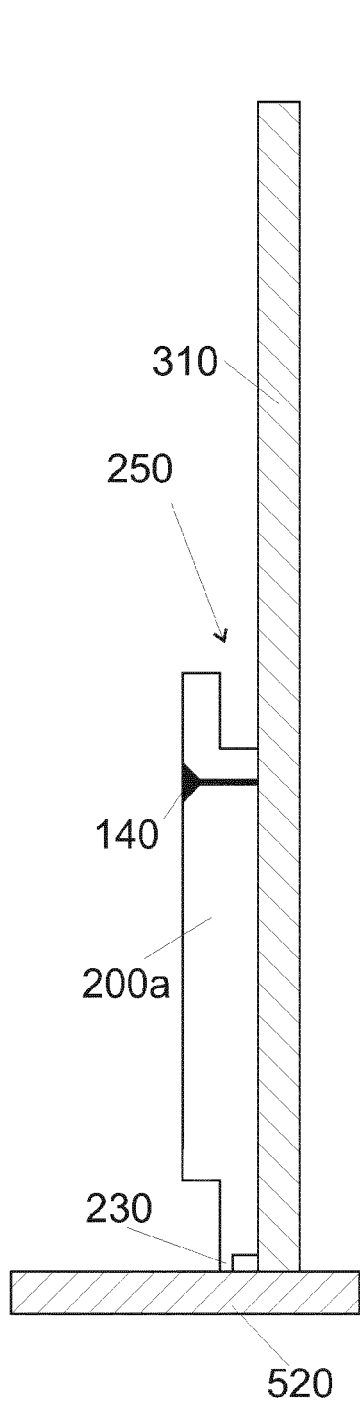


Fig. 7a

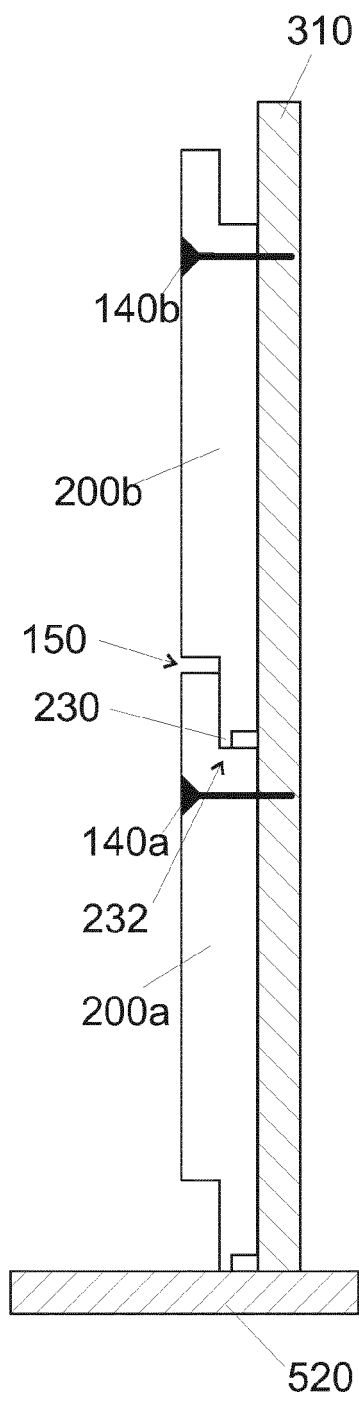


Fig. 7b

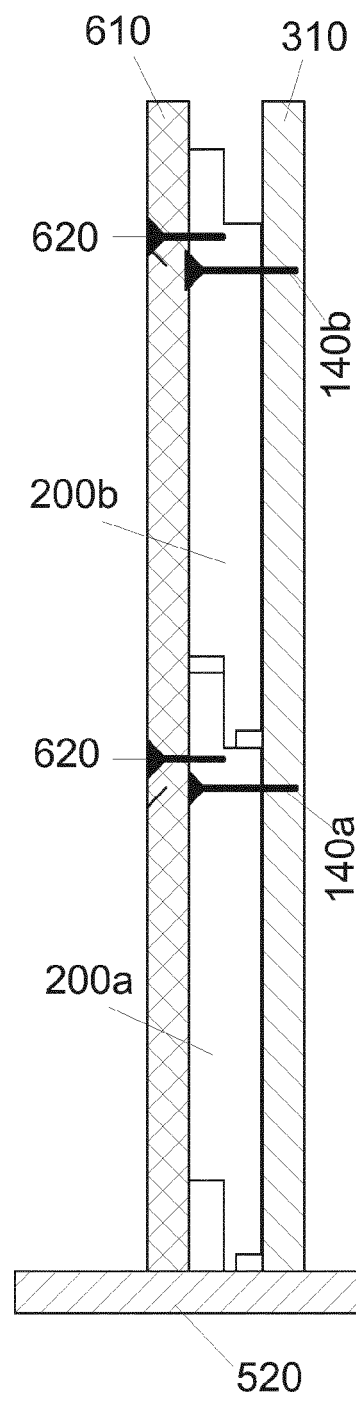
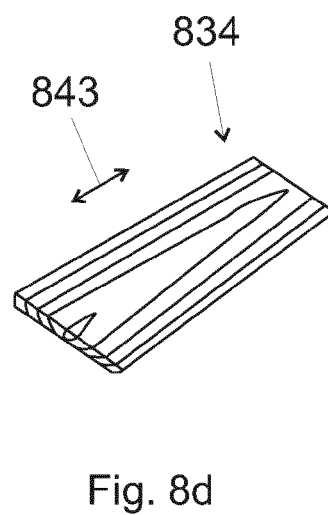
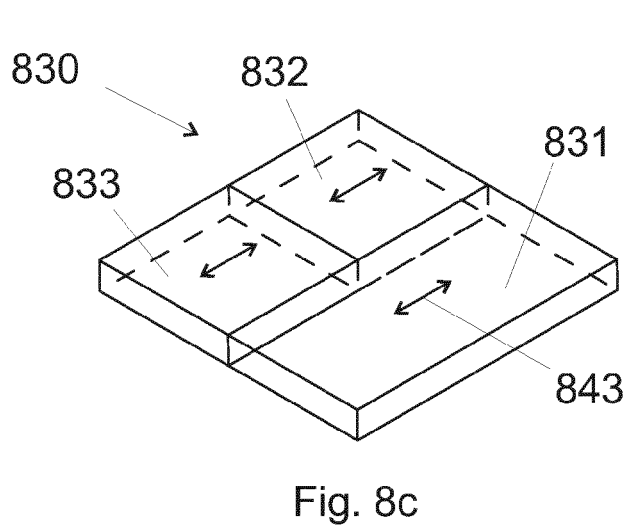
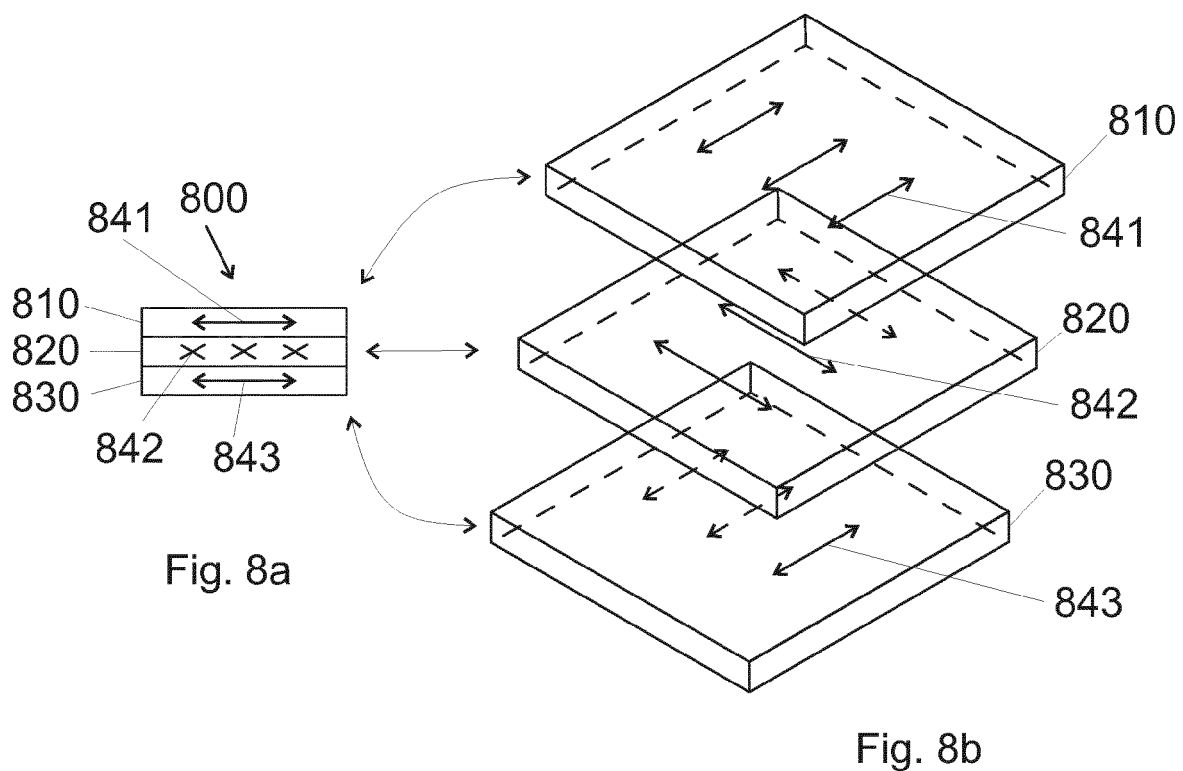
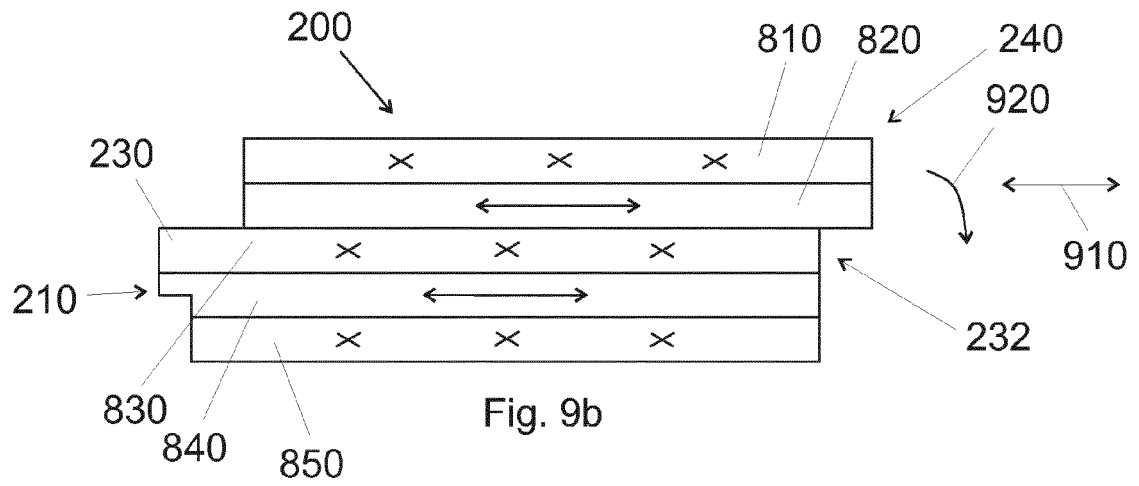
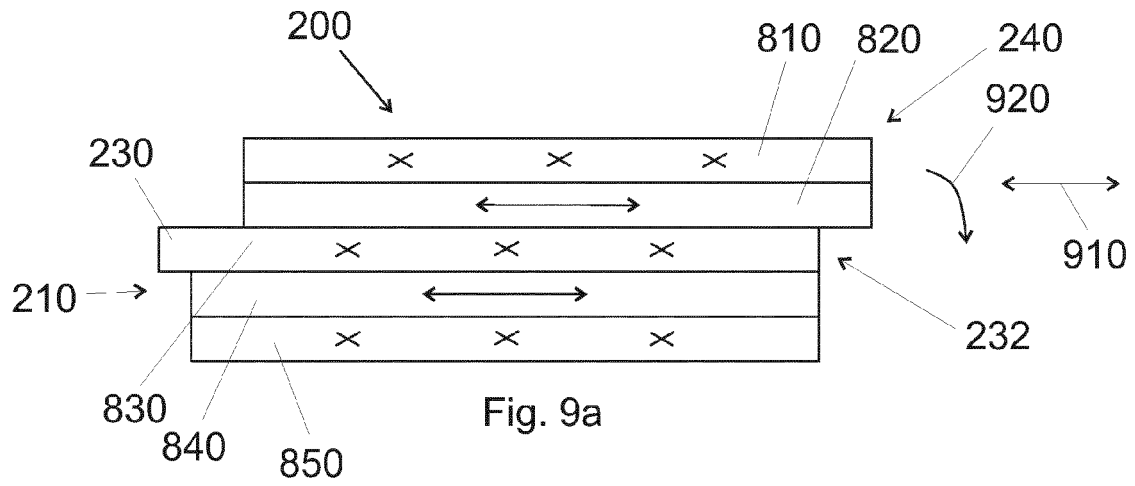
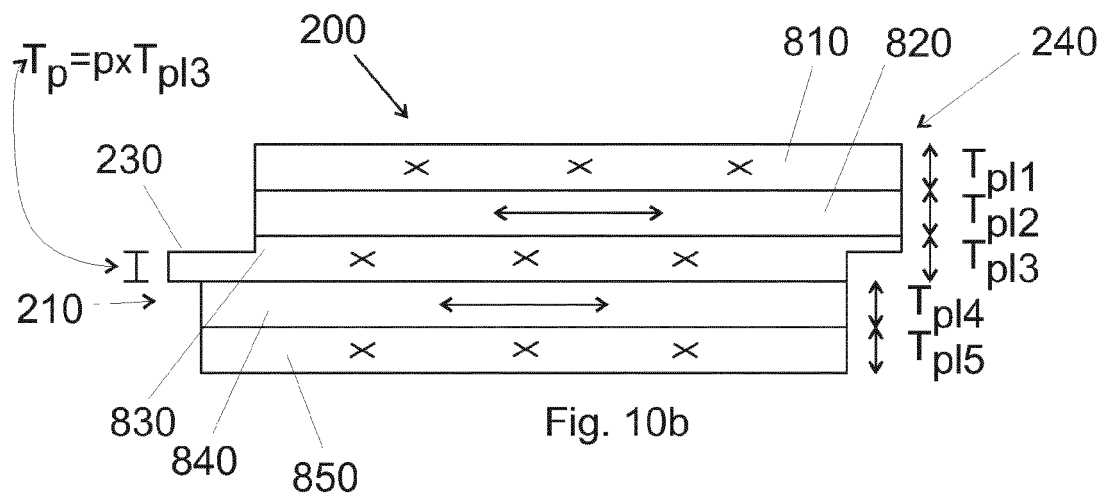
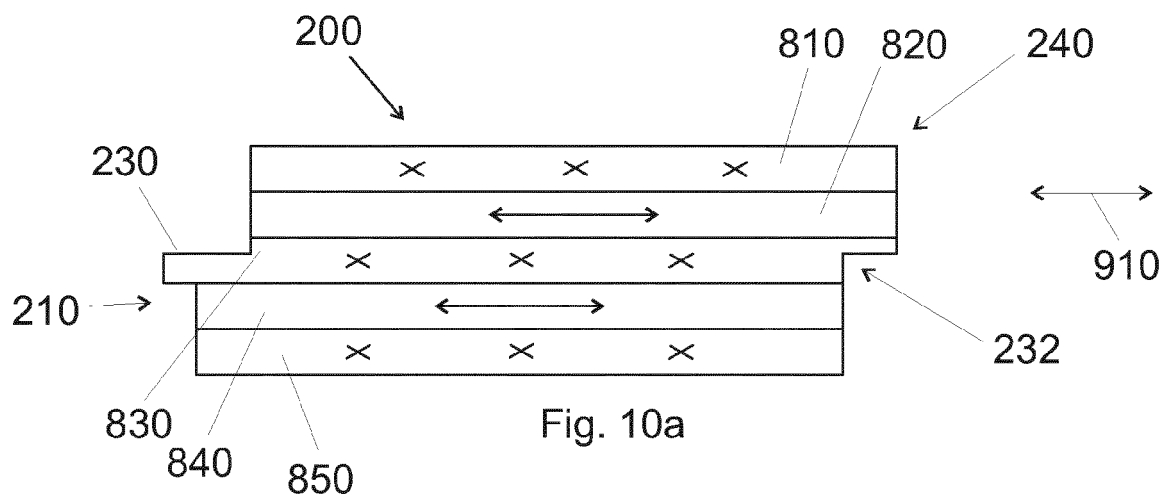


Fig. 7c









EUROPEAN SEARCH REPORT

Application Number
EP 12 39 7510

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Y	* paragraph [0002] * * paragraph [0010] * * paragraph [0032] - paragraph [0033]; figures 1-8d *	5, 6, 8	E04F13/10 E04F15/02 E04F15/04 E04B2/32 E04B2/70
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 25 October 2012	Examiner Giannakou, Evangelia
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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The members are as contained in the European Patent Office EDP file on
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