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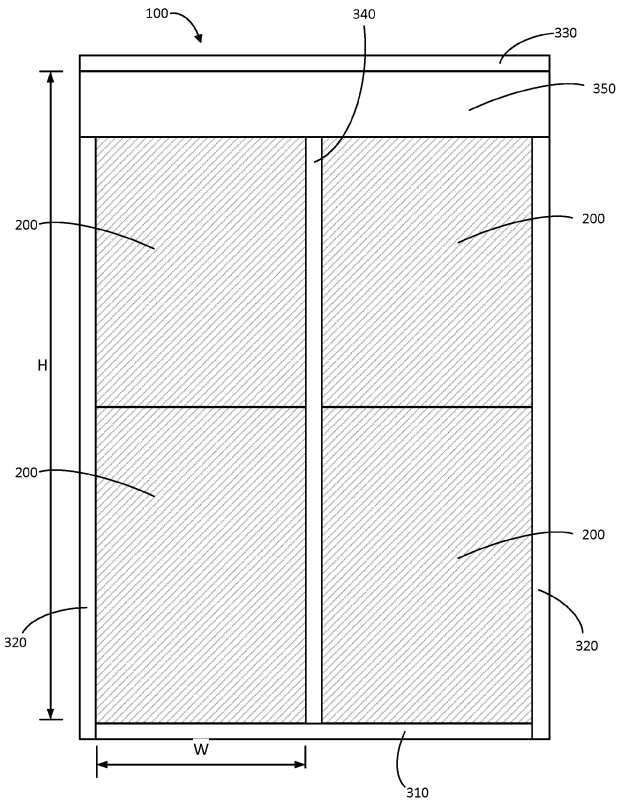
(54) **CONSTRUCTION MODULE USING CELLULAR GLASS**

(57) A construction module includes at least one rigid panel (200) made of cellular glass and at least one member (310, 320, 330, 340, 350; 410A, 410B, 410C; 510; 610; 710, 720; 840; 940) made of wood secured to and covering and protecting at least one face and/or or edge of each panel (200). The construction module can be delivered and installed as a unit.

FIG. 1



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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority of United States Provisional Patent Application No. 63/396,493, which was filed 8 August 2022.

TECHNICAL FIELD

[0002] This invention relates to materials for construction of flat surfaces such as walls..

BACKGROUND ART

[0003] Cellular glass, known in some places as "foam glass", has already proven itself as an excellent building material. Among its other advantageous qualities are that it is airtight, fire-proof, and resistant to insects and vermin. It also has an R-value per unit thickness that is on par with common insulation materials such as rigid plastic foam, while providing superior moisture resistance and compressive strength. It is also a superior material from the environmental perspective both in how it is manufactured, and also in that it is recyclable and exceptionally durable.

[0004] A leading manufacturer of cellular glass is the company Owens-Corning, which has a range of building solutions using cellular glass, which is refers to using its trademark FOAMGLAS®. See, for example, "Cellular Glass Insulation Guide, FOAMGLAS® for the Building Envelope" https://www.foamglas.com/- /media/project/foamglas/public/corporate/foamglas-com/files/brochures/building-envelope/foamglas-for-the-entire-building-envelope-int-en.pdf?la=en .

[0005] Generally, cellular glass is applied as a sheet, that is, a layer, on top of other insulating material or bearing members. WIPO Patent Application WO/2020/152287 A1, for example, discloses a "Facade Cladding Fixing System" illustrates these solutions. The German company Glapor provides another example of using cellular glass as a cladding layer that is glued onto a wooden frame: GLAPOR Schaumglasprodukten, https://www.glapor.de/anwendungen/flachdach/flachdach-ungenutzt/flachdach-ungenutzt-auf-holz-bituminoes-frei-bewittert/ and https://www.glapor.de/anwendungen/innendaemmung/innendaemmung-wand/innendaemmung-wand-mit-bitumenspachtelung/. The cellular glass sheets are then glued onto a load-bearing substrate so as to form a layer lying on it.

[0006] Cellular glass is sometimes also either crushed or manufactured in granular form so that it can be used as an aggregate, on its own or mixed with some other material, to make an insulating filler for stabilising soft soil, as a thermally insulating sub-slab for building foundations or for roofs. Examples of such uses can be seen on the website https://www.glavel.com/what-is-cellular-glass-insulation/#:~:text=Cellular%20glass%20insulation%20can%20also,produced%20for%20nea rly%2030%20years.

[0007] A disadvantage of known construction solutions using cellular glass is their complication, in particular, the need to mount and secure multiple layers of different materials, knowledge of proper gluing techniques for cellular glass, and extra care in the handling of the cellular glass sheets themselves so as to avoid chipping or cracking them. Another shortcoming is that the known solutions fail to take full advantage of another property of cellular glass, namely, its compressive strength.

SUMMARY OF THE INVENTION

[0008] The invention encompasses several different aspects and embodiments, as well as variations that will be within the skill of those skilled in the building trades given the description below. The invention is summarized by the accompanying claims.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

Figure 1 depicts one embodiment of a construction module that incorporates cellular glass panels.

Figure 2 illustrates the embodiment of Figure 1 in a side view.

Figure 3 illustrates the embodiment of Figure 1 with one of possibly two covering layers of cellular glass, which is integrated with the rest of the module.

Figure 4 illustrates use of several of the construction modules in a roof structure.

Figure 5 illustrates use of the use of several of the construction modules in a building foundation, as well as an alternate covering material.

Figure 6 depicts a non-rectangular construction module.

Figure 7 depicts a side view of a hybrid cellular-glass/"glulam" module.

Figures 8 and 9 depict embodiments of a construction modular in which cellular glass panels are "sandwiched" to make the module well-suited to building exterior walls. Figure 9 depicts

DESCRIPTION OF EMBODIMENTS

[0010] Embodiments of the invention are described below primarily in the context of providing a construction module for a wall. This is by way of example; the module may be used to create a construction module for any

substantially flat surface such as ceilings, floors, etc., and some such alternative embodiments are described and shown.

[0011] The construction modules provided by different embodiments of the invention may be installed in any desired orientation. The modules will typically have a height and width greater than their thickness. In Figures 1-3 and 7-9 the panels are shown standing, such that "vertical" is to be taken to mean "up/down" as viewed in the figures. The outer surfaces of the modules will be substantially planar and Figures 1-3 and 6 show the modules as viewed into this plane, that is, they show a face of the modules. Figures 7-9, however, show partially cross-sectional views from the "side" of a panel, that is, looking into an edge, such that "horizontal" refers to module or panel thickness, not the planar extension of its face.

[0012] As Figure 1 illustrates, a construction module 100 includes a frame, which comprises a bottom (viewed as in the figure) member 310, side members 320, and a top member 330. The members 310, 320, 330 may be made of any conventional material such as boards made of wood (including solid, laminated, composite, etc.), or even of any known synthetic material, of any standard or preferred dimension. In the embodiment shown Figure 1, the module is also divided into two lateral portions by a central reinforcing member 340, which also improves the module's ability to bear the loads that normally arise when installed in windows and doors, and also helps maintain the module's shape during lifting and mounting. It would also be possible to include a horizontal (viewed as in Figure 1) reinforcing member between the adjacent panels. Because of the rigidity of cellular glass, this may not be necessary over the shorter horizontal dimension (assuming for the moment that the panel is not square, which it of course may be), especially if the panel edges are securely glued to each other, and such a wood member may even reduce the thermal efficiency of the panel (wood will allow more heat leakage), but such an extra reinforcing member may be preferred if there is a need to protect the panel edges, for example if there may be a risk of shearing force and grinding.

[0013] Together, the members 310, 200, 330, 340 form a frame around the periphery of the cellular glass panel(s) that can bear various conventional internal and external coverings used for walls, roofs and ceilings, decks, floors and foundations, etc. This frame also protects the edges of the cellular glass during transport and installation. In some uses, one or more or the frame members may be deleted, especially if the thereby exposed edge of the cellular glass panel(s) will be installed abutting some other surface.

[0014] Panels 200 of cellular glass are preferably positioned within the frame so as to "fill" the interior, that is, to lie flush against the inner surfaces of the members 310, 320, 330, and 340. In other words, the width W of a cellular glass panel is preferably the same as the lateral distance between the members 320, 340. Because of the rigid, essentially incompressible nature of cellular glass, the panels are preferably be manufactured or cut to size.

[0015] In Figure 1, there are four cellular glass panels, two on either side of the central member 340. This is just one example. The number and arrangement of the panels 320 may be changed according to the needs of a particular installation. In some implementations, there may thus be no need for the central member 340, or there may be a need for more than one, with more than two panels per "row". One advantage of cellular glass is that it is relative easy to manufacture panels of any preferred thickness. It would also be possible, however, to increase the thickness of the module as needed by layering (preferably through gluing) more than one panel on top of another. Because cellular glass can be cut precisely, the module can be fabricated such that adjacent edges substantially mate, without significant gaps between adjacent panels, or between the panels and the frame members. Sealing will be improved even further by the glue holding these elements together.

[0016] Panels 200 preferably also "fill" the interior of the frame not only horizontally (other than the central member(s) 340, but also vertically, such that their combined height H is the same as the distance between the top and bottom members 310, 330. Having substantially the whole of the interior of the module within the outer members 310-330 comprise cellular glass leads to exceptional strength, in addition to the other advantages of the material.

[0017] The width (as shown in Figure 1, the dimension extending perpendicular to the plane of the figure) of the frame members is preferably equal to or great than the thickness of the chosen cellular glass panel(s) they enclose. If equal, then the construction module as a whole will be totally flat, that is, flush, on both sides and will also avoid an air gap upon installation. If the frame is thicker than the cellular glass panels 200, however, then at least the edges and corners of the panels will be protected during transport and installation, and in some cases an air gap may actually be desired.

[0018] The panels may be simply placed within the frame, but are preferably glued to the inner surface of the wooden members to which they are adjacent, but also to each other where they abut. This not only improves the air-tightness of the module, but also increases its stiffness.

[0019] A top piece 350 may optionally also be included and positioned to extend laterally across the module to increase the module's load-bearing ability when used, for example, in door and window openings in external walls; it also helps maintain the module's form (in particular, rectangularity) when being lifted, for example, by a crane. As Figure 2 depicts, to ensure that the entire front face of the module is flat, the top piece 350 is preferably mounted within a cut-out 355 of the side members 320; the central member 340 may also be cut out to receive the top piece 350. The upper edge of the cellular glass panels may then be cut away to receive the top piece

350 so that the entire module 100 forms a compact unit with little or no empty interior spaces.

[0020] Figure 3 illustrates another optional but advantageous embodiment of the construction module according to the invention: The entire rear and/or front surface of the module 100 may be covered by either a single layer 250, of cellular glass or by panels of cellular glass that, together, cover the surface(s), preferably without gap. This layer 250 is preferably glued not only to the frame members, but also to the cellular glass panels 200 positioned within them. This increases not only the insulating properties of the module, but also its structural rigidity and strength. In many implementations, the covering layer 250 will be included on only the surface of the module facing the exterior of the construction in which the module is included, which leaves the interior-facing surface and wooden frame members (310-350) exposed, which in turn makes it easier to install conventional coverings such as drywall, particle board, etc., over the module. A covering layer like layer 250 may be applied (for example, glued) even on interior surface of the module, however, for example, in constructions in which it is important to reduce the thermal conductivity (λ-value) even further. Moreover, as is described below in connection with Figure 5, either or both of the covering layers 250 could be made of a material such as wood, for example, a laminate such as plywood.

[0021] One advantage of the invention can be seen from the figures: The module 100 may be manufactured either in standard dimensions (including thickness), but also customized to fit openings as needed. The module may then be delivered as a unit, ready to install, with all of the advantageous properties of cellular glass "ready to go". This avoids on-site complications such as multilayer cutting and gluing. Because the frame members 310, 320, 330 are preferably made of wood, standard techniques such as nailing, screwing, bracketing, etc., through or into the members may be used for installation, with no need to risk damaging the cellular glass panels.

[0022] Figure 4 depicts a cross section of a corner of a roof structure 400, which shows conventional elements such as a rafter 405, a ceiling joist 406 and a perlin 407, as well as several construction modules fabricated similar to the module 100 described above. in Figure 4, panels of cellular glass are shown cross-hatched and numbered 200. Members 410A, 410B, 410C shown form parts of the respective modules' frames, as with the module 100. Using the modules according to this embodiment provides not only superior strength to the construction, but also superior insulating and fire-resistance properties.

[0023] Figure 5 depicts, in cross section, an embodiment in which modules similar to those shown in Figure 1, may be used in house or other building foundations 500 in which there is direct contact with the underlying surface 505, such as gravel, a slab, etc., or even compact soil (cellular glass does not rot and is impervious to insects). In a similar embodiment, the foundation structure may be supported on blocks or plinths. As in Figure 4, cellular glass blocks/sheets 200A-200D are shown hatched. Member 510 forms part of the frame for the module that includes cellular glass sheet 200A. Sheets 550 of some material such as any type of wood, such as plywood or other laminate, are preferably glued to the faces of the cellular sheet 200A. This embodiment thus illustrates not only a use case for a building foundation, but also that other materials such as wood may be used instead of more cellular glass as the layer 250. For completeness, Figure 5 shows external sheathing 560, as well as a barrier layer (for example, against radon) 570.

[0024] In the embodiments described and shown above, the cellular glass construction module, including frame members, is rectangular. This is likely to be the most commonly needed shape, but the invention is advantageous even in other situations where a module of a different shape is needed. As Figure 6 illustrates, a construction module 600 may also be made to be round, or indeed, have any other shape for which a fully or partially enclosing frame 610, comprising any number of sections, around the enclosed cellular glass panel 200 can be made.

[0025] See Figure 7. Glued laminated timber (sometimes referred to as "glulam") is a structural engineered wood product in which layers of dimensional lumber are bonded by adhesive so that all of the wood grain runs parallel to the longitudinal axis of the glulam member. Besides being environmentally friendly, glulam typically has a higher strength-to-weight ratio than even concrete or steel, typically with less tendency to buckle than steel as well. In the "hybrid" embodiment depicted in Figure 7, cellular glass panels 200 (in this example, four of them) are sandwiched between two sheets 710 of wood, such as plywood. Between the upper and lower pairs of cellular glass panels at least one glulam board 720 (or series of glulam beams) is fixed, preferably using construction adhesive, as well as, laterally, to the inner surface of the sheets 710, such that the glulam member 720 is itself "sandwiched" vertically between the cellular glass sheets 200.

[0026] One of the advantages of including the glulam member 720 is that it provides a suitable surface into which nails or screw can be driven through the sheets 710 if needed for mounting of the module itself, or of some covering or other element to be attached to the module. Another advantage is that, in modules in which there is more than one cellular glass panel "on top of" the other (vertically, as shown in Figure 7), these are preferably glued to the member 720, which eliminates any air leakage that might arise between the adjacent panel surfaces, and also prevents any "grinding" of these somewhat rough and brittle surfaces against each other. Note that glulam is a preferred material for the member 720 because of the general advantages of glulam, but this material is not a requirement for fabricating a module according to this or any other embodiment; rather, any other wood or synthetic material could be used as long

as it performs the same functions.

[0027] Figure 7 shows thicknesses; the different elements 200, 710, 720 extend for any desired length in the direction normal to ("into" and "out of") the plane of the drawing; moreover, more than one glulam member could be included vertically (viewed as in Figure 7) between additional pairs of cellular glass panels, preferably with any standard joist separation, such as 60 cm.

[0028] The construction 700 depicted in Figure 7, as with other embodiments, may be prefabricated to any desired dimensions and delivered as a unit, substantially ready to install. In one prototype, the plywood sheets 710 had a thickness in the range of 12-20 mm, the cellular glass panels together were 200 mm thick, and the glulam member 720 was 45 thick (vertical distance viewed as in the figure and 200 mm wide (to match the combined thickness of the cellular glass panels.

[0029] In Figure 7, the module is two cellular glass panels thick (viewed in the horizontal direction as shown in the figure). This is not a requirement for the module, but rather will depend on the needs of a given installation. More or fewer cellular glass panels may be used in the module to achieve a desired minimum degree of thermal insulation. This is true even for other multi-panel embodiments such as those shown in Figure 8 and Figure 9.

[0030] The hybrid module embodiment 700 depicted in Figure 7 may, for example, replace the common cross-laminated timber (CLT) panels. In comparison, the hybrid module greatly reduces the amount of wood needed, can be manufactured substantially climate-neutral, delivering greater energy efficiency and, in most cases, superior rigidity. The hybrid module is much more moisture- and fire-resistant, has a longer expected service life, and does not suffer from problems of drying.

[0031] Figure 8 illustrates another embodiment 800 that is suitable for use in constructing an exterior wall. Note that Figure 8 is a cross-sectional "side" view, such that the various elements will extend into and/or out of the plane of the figure. The planar faces of the module will therefore be the surfaces one would view in the plane of the figure, from the left and right. Viewed as in the figure, from left (the exterior of the structure) to right (the interior), a typical construction might include:

- 810: Exterior paneling or cladding
- 820: Exterior wall studs onto which the paneling or cladding is fastened
- 830: At least one spacer stud to form an air gap and drainage plane; alternatively, 830 could be a synthetic material such as polyurethane filler
- 200L: A panel of cellular glass
- 840: A wood panel separating cellular glass panel 200L from a second cellular glass panel 200R. Although any type of wood construction may be used to make the panel 840, for strength and dimensional stability it is preferably made of a laminate, such as glulam (see above), laminated veneer lumber (LVL) or the like
- 850: A spacer stud
- 860: At least one interior stud to nail or screw into
- 870: A wood panel to bear an interior wall covering 880

[0032] Note that the cellular glass panels 200L, 200R and the panel 840, as well as, optionally, other members such as the spacing studs 830, 850, may be prefabricated and delivered as a unit, as with the other illustrated embodiments.

[0033] Figure 9 illustrates yet another embodiment 900 that is suitable for use in constructing an exterior wall. As with Figure 8, Figure 9 is a cross-sectional "side" view, such that the various elements will extend into and/or out of the plane of the figure. In Figure 9, several members are shown as together forming an exterior weather barrier 910 and an interior structure 920 for mounting any conventional covering. As with the embodiments shown in Figures 7 and 8, the various layers and members have their greatest extension in the direction perpendicular to the plane of the drawings, that is, the drawings show each respective structure from the side. The embodiments shown in Figures 7-9 may and preferably are also be provided with frame members, such as shown in Figure 1, that extend around and protect at least one edge of the cellular glass panels and also form a structure that can secured to other structures by nailing or screwing.

[0034] The barrier 910 and structure 920 may have the same or similar members as the embodiment shown in Figure 8. Of relevance in Figure 9 is that two cellular glass panels 200M, 200R are glued to each other to increase thickness, and a third cellular glass panel 200L may be included, with a sheet 940 of wood, such as a glulam or plywood in between and glued to the faces of both 200L and 200M. Figure 9 illustrates how multiple cellular glass panels may be included in the module to increase the overall cellular glass thickness of the module, for example to achieve a minimum required degree of thermal insulation.

[0035] As an option, even the module illustrated in Figure 9 could be fabricated with a horizontally (viewed as in the figure) extending glulam or other member such as the member 720 shown in Figure 7. This may be desired especially if more than one cellular glass panel is included vertically, for the reasons stated above.

[0036] An exterior-facing sheet of wood 930 is preferably glued to the face of the outermost cellular glass panel 200L to avoid the glass surface being directly exposed to the exterior. This embodiment therefore illustrates that the "sandwich" construction of the module, like the other embodiments described above, can be pre-fabricated and delivered and conveniently installed as a unit.

Claims

1. A construction module **CHARACTERISED BY**:

at least one rigid panel (200) made of cellular glass;
at least one member (310, 320, 330, 340, 350; 410A, 410B, 410C; 510; 610; 710, 720; 840; 940) made of wood secured to and covering and protecting at least one face and/or edge of each panel (200);
whereby the construction module can be delivered and installed as a unit.

2. The construction module of claim 1, in which the at least one member made of wood is at least one frame member (310, 320, 330, 340, 350; 410A, 410B, 410C; 510; 610) secured to at least one respective edge of the at least one panel, said at least one frame member thereby at least partially enclosing the at least one panel;

3. The construction module of claim 2, in which the at least one frame member encloses the entire periphery of the at least one panel.

4. The construction module of and of claims 1-3, in which the at least one frame member is secured to a respective edge of the at least one panel by gluing.

5. The construction module of any preceding claim, in which the thickness of the panels and of the frame members is such that the frame members are flush with the panels.

6. The construction module of any preceding claim, further including a layer of cellular glass covering and secured by gluing to both the panels and the frame members on at least one face of the module.

7. The construction module of any preceding claim, in which the module as a whole, and each of the panels, is rectangular.

8. The construction module of any preceding claim, in which:

a plurality of the panels is enclosed by the frame members;
panels positioned adjacent to each other are shaped to have abutting common edges;
the panels are secured to each other at their abutting common edges with glue, whereby no air gaps are present between adjacent panels.

9. The construction module of any of claims 1-6, in which the at least one panel is non-rectangular.

10. The construction module of any of claim 1, including at least one separating member (720) is located between adjacent edges of at least one pair of vertically separated ones of the cellular glass panels (200), said separating member being glued to the respective adjacent edges, thereby eliminating any air gap between the panels.

11. The construction module of claim 1, in which the separating member (720) is made of glued laminate timber.

12. The construction module of any of claim 1, 10 or 11, in which the construction module is formed as a sandwiched structure having at least two cellular glass panels that are planar parallel and in which at least one laminated wooden sheet (840) is attached between and to at least one pair of the cellular glass panels (200).

FIG. 1

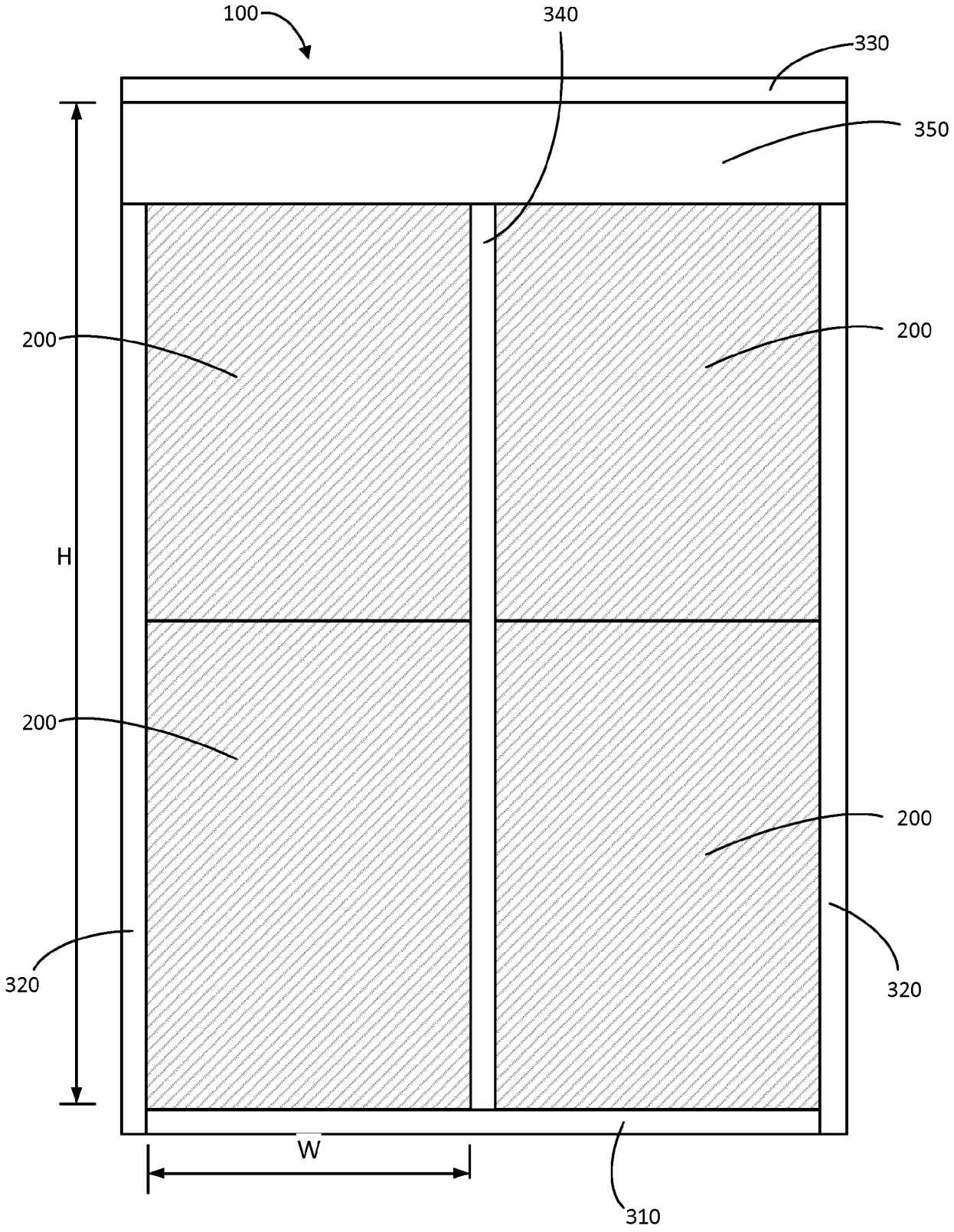


FIG. 2

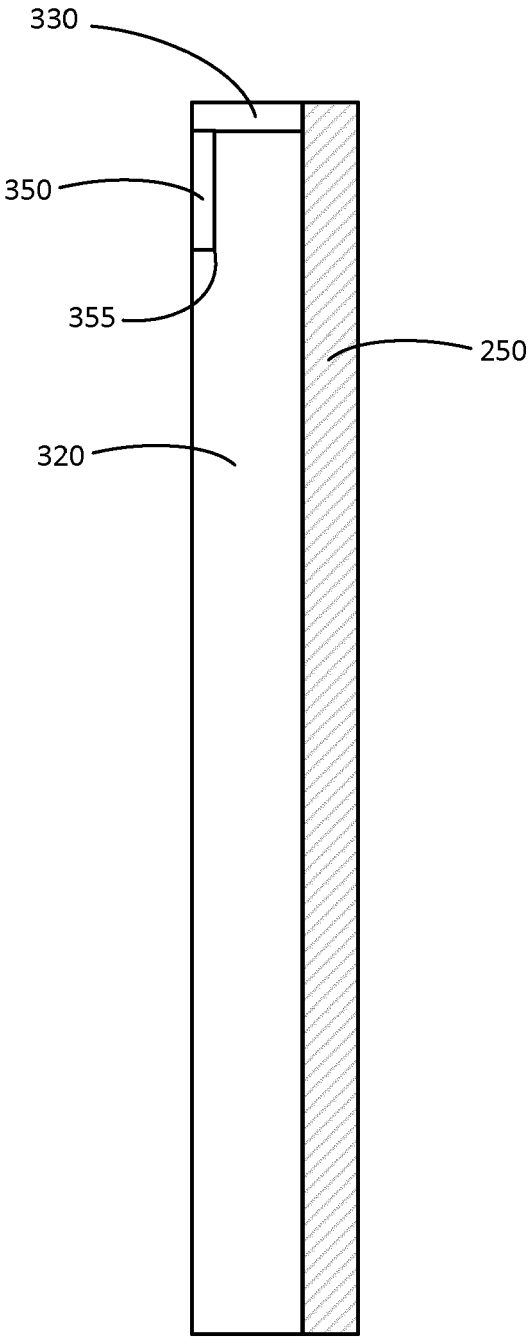


FIG. 3

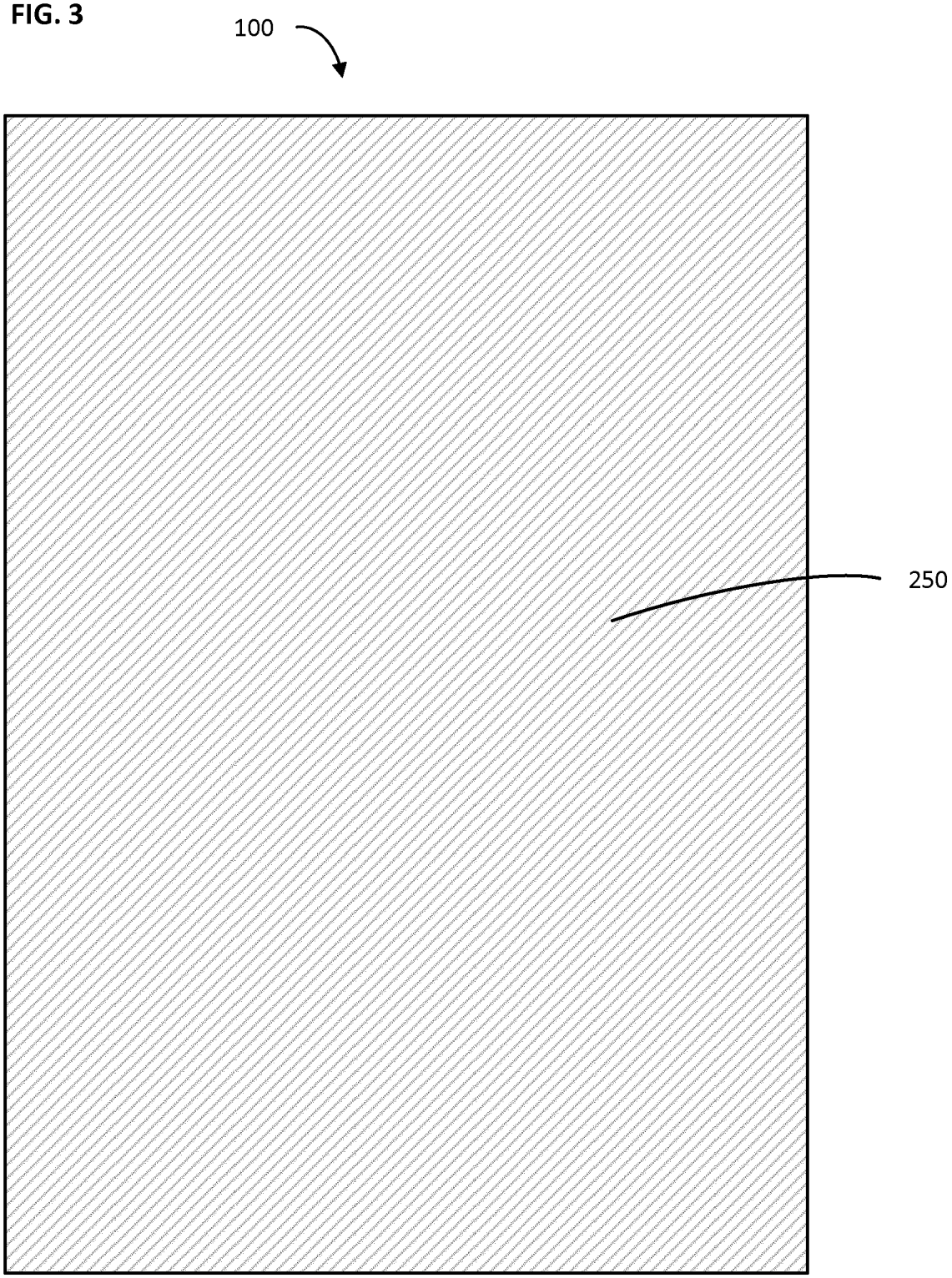


FIG. 4

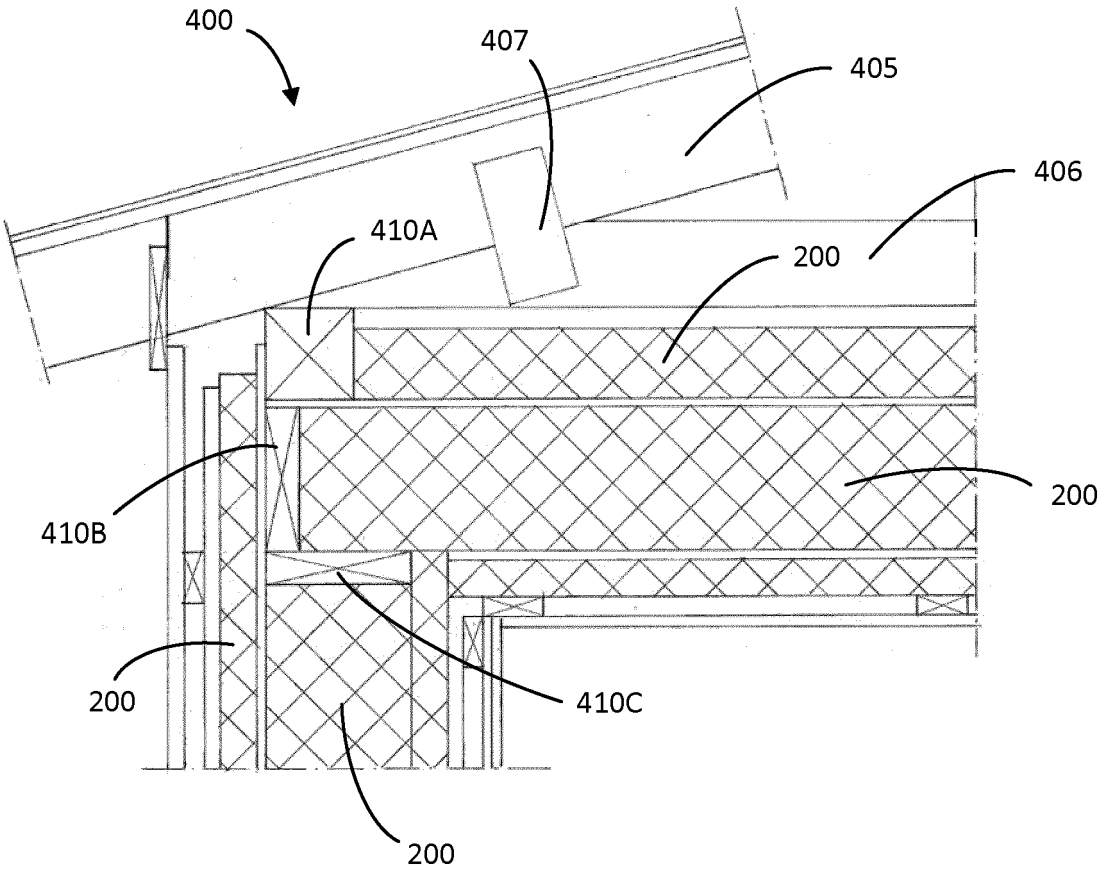


FIG. 5

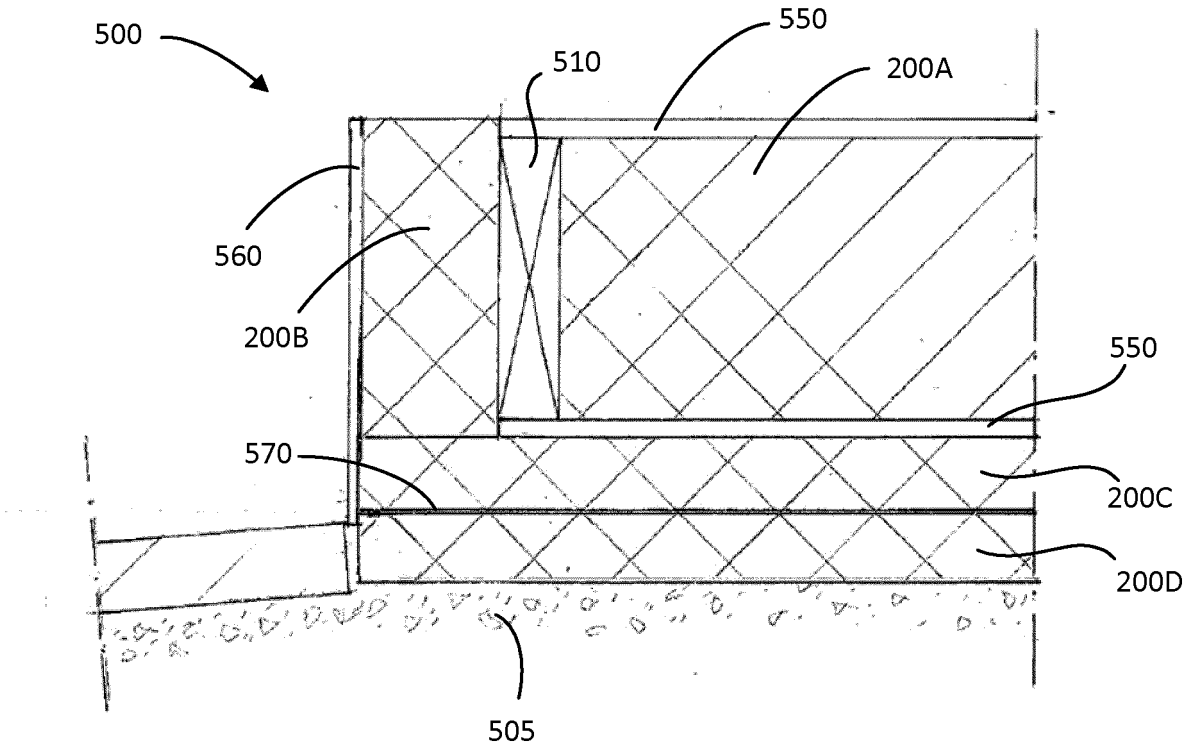


FIG. 6

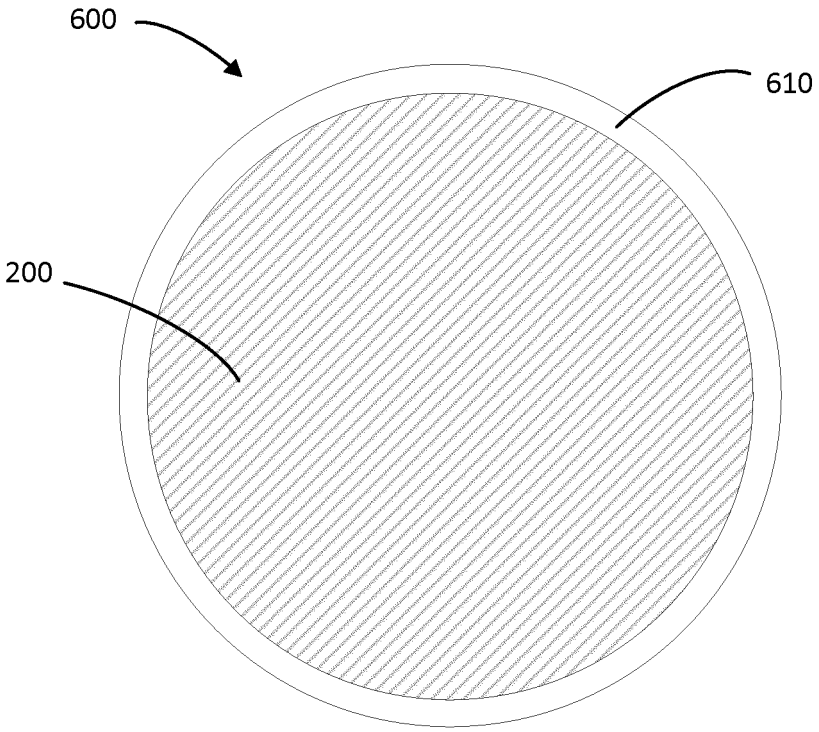


FIG. 7

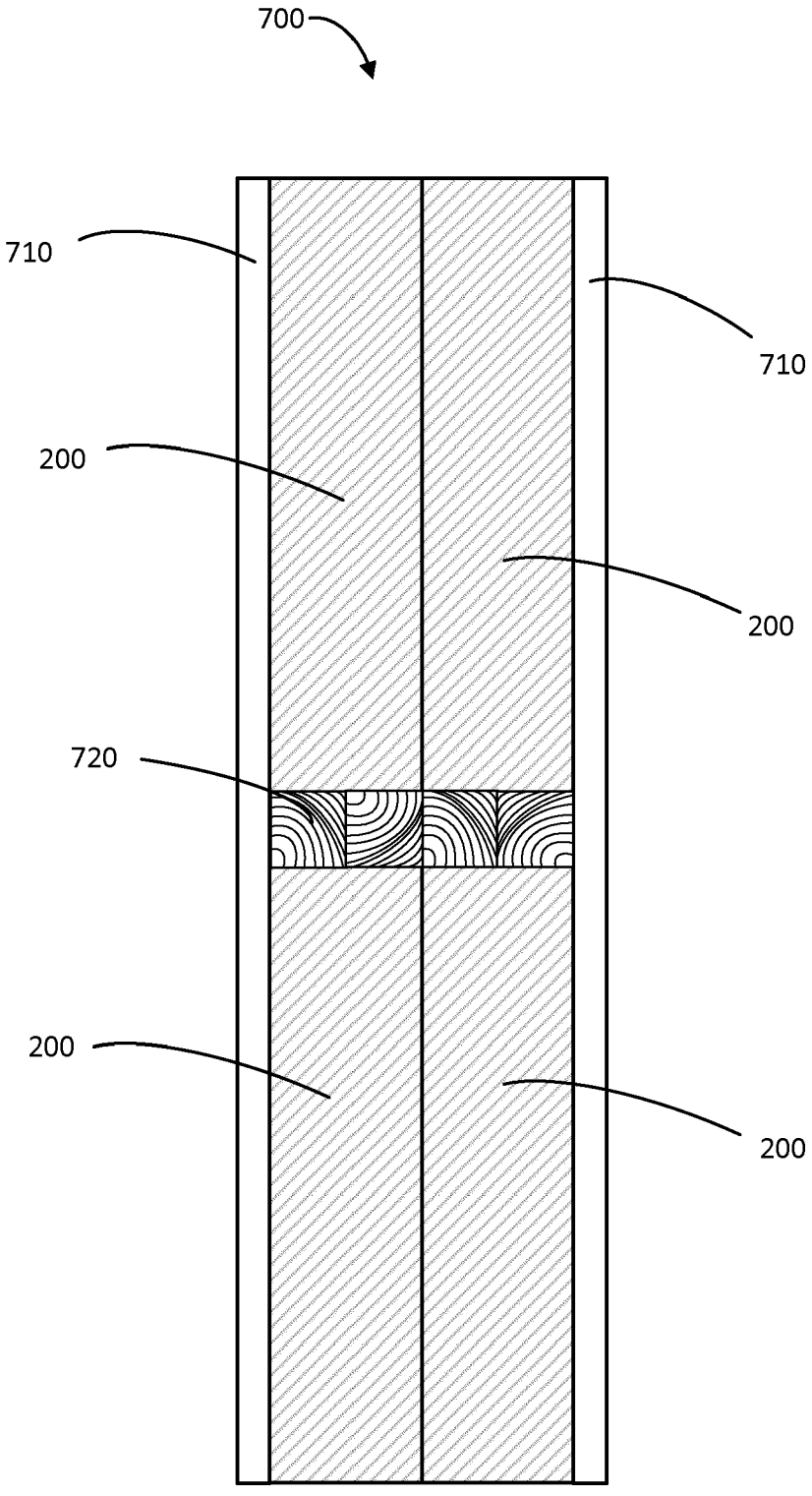


FIG. 8

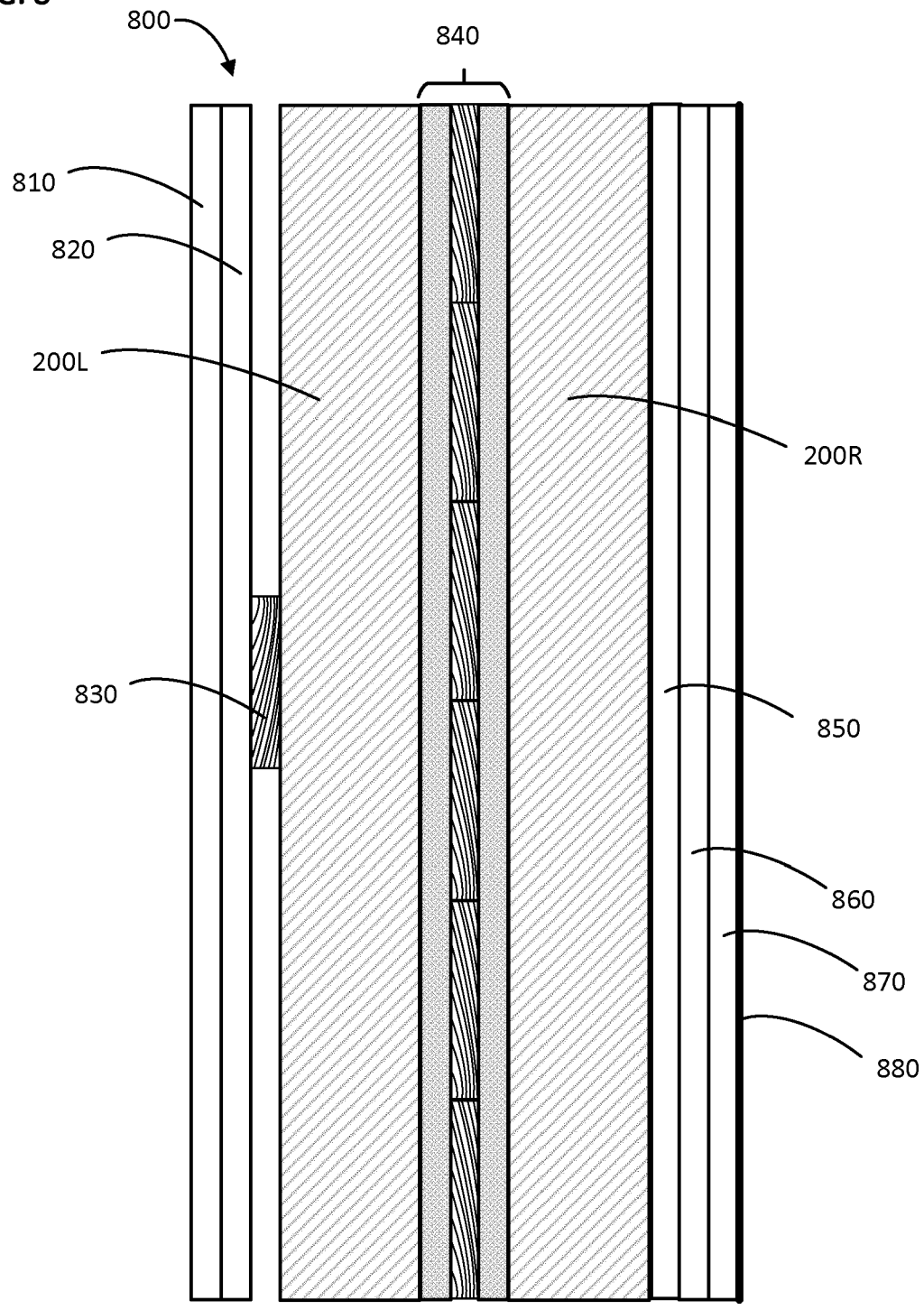
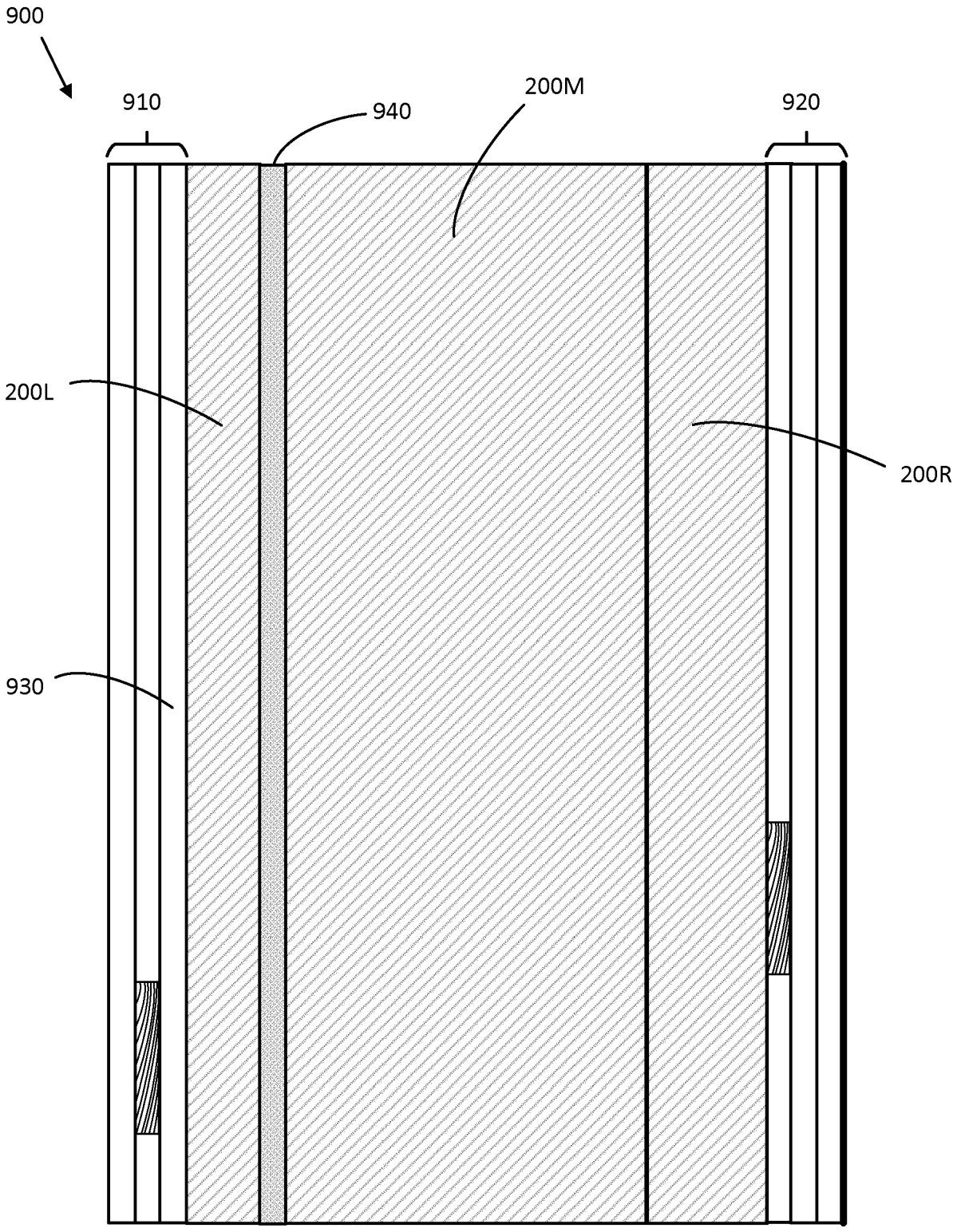


FIG. 9



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EUROPEAN SEARCH REPORT

Application Number
EP 23 19 0394

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 1 437 450 A1 (KAISER PETER A [DE]) 14 July 2004 (2004-07-14) * the whole document *	1,2,4,5, 7-9,12	INV. E04C2/38 E04B2/00 E04B1/80
X	DE 10 2012 110225 A1 (BECK BERND [DE]; BECK MICHAEL [DE]; BECK VOLKER [DE]) 30 April 2014 (2014-04-30) * paragraph [0023] - paragraph [0024] * * paragraph [0031] - paragraph [0034]; figures 1A-2B *	1-3,5,7, 9	
X	EP 3 366 862 A1 (OY FCR FINLAND LTD [FI]) 29 August 2018 (2018-08-29) * paragraph [0016] * * paragraph [0024] - paragraph [0025] * * paragraph [0033]; figure 1 *	1-3,5-7, 9-11	
A	FR 2 505 385 A1 (BOCHE PATRICIA [FR]) 12 November 1982 (1982-11-12) * figures 1-5 *	1-12	
A	CA 2 081 740 A1 (SCHUSTER MICHAEL G [CA]) 30 April 1994 (1994-04-30) * the whole document *	1-12	TECHNICAL FIELDS SEARCHED (IPC) E04C E04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	24 October 2023	Giannakou, Evangelia

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 19 0394

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24-10-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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