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

(11) **EP 3 816 364 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
05.05.2021 Bulletin 2021/18

(51) Int Cl.:
E04F 13/08 *(2006.01)* ***E04F 13/12*** *(2006.01)*
E04F 13/14 *(2006.01)*

(21) Application number: **19205846.9**

(22) Date of filing: **29.10.2019**

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

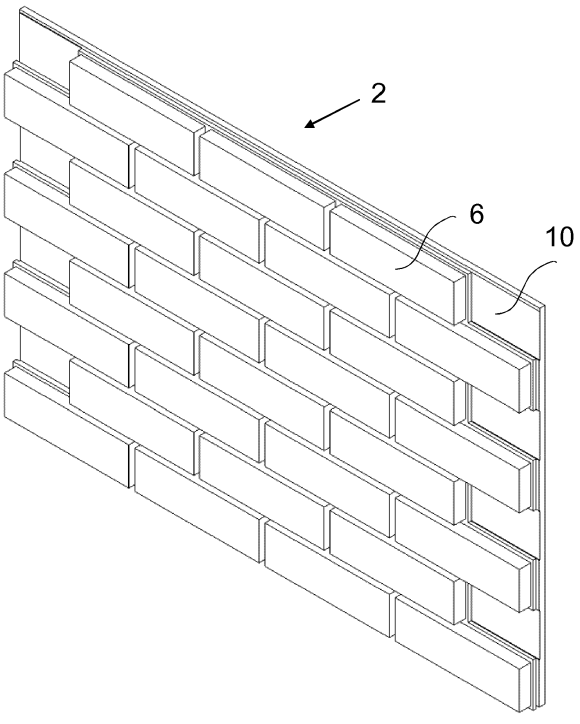
(71) Applicant: **Isosystems AG**
4770 Amel (Schoppen) (BE)

(72) Inventors:
- **COOL, Rainer**
  4731 EYNATTEN (BE)
- **FRECHES, Gregor**
  4780 St.-Vith (BE)

(74) Representative: **Pronovem**
Office Van Malderen
Parc d'affaires Zénobe Gramme- bâtiment K
Square des Conduites d'Eau 1-2
4020 Liège (BE)

(54) **FIRE RESISTANT MODULAR PREFABRICATED CLADDING PANEL**

(57) A substantially inorganic fire-resistant modular portable prefabricated cladding panel (2) adapted, in use, to be fastened to a building by fastening, said panel comprising one or more decorative cladding elements (6) embedded in a structural support element (10) of a mortar matrix, the structural support element comprising an openwork metal plate and dispersed particles, whose density is lower than the density of the mortar matrix of the structural support element (10).



(FIG 1)

EP 3 816 364 A1

Description

Technical field

[0001] The present invention relates to a fire-resistant modular prefabricated cladding panel and its manufacturing process, as well as a building comprising said panel.

Prior art

[0002] Cladding panels (also known as cladding systems) of the state of the art comprising a decorative part and a supporting part, generally elements of bricks or stones associated with thermosetting foams, have existed for years. These panels have been used in the construction of new buildings as well as in the renovation of old buildings. The panels encountered a commercial success because the thermosetting foams offered some insulation properties.

[0003] Documents BE 891963 and EP 2 392 741 A1 disclose such cladding panels.

[0004] In the meanwhile, new constructions present isolation solutions that are directly integrated in their structures. In this context, the additional insulation provided by said thermosetting foams is not anymore a key competitive advantage for these panels.

[0005] Cladding panels according to the state of the art use polymer-based foams, which are not fire resistant. However, after the Grenfell tower fire in London region in 2017, some countries change the construction regulations requiring that any construction element of a building, including the cladding plate, should be almost free of organic compound(s)(less than 5%, preferably less than 1%), for the 6^{th} floor and above.

Aims of the Invention

[0006] The invention aims to provide a solution to at least one drawback of the teaching provided by the prior art.

[0007] More specifically, the invention aims to provide a fire resistant panel with convenient rigidity.

Summary of the invention

[0008] For the above purpose, the invention is directed to a substantially inorganic fire-resistant modular prefabricated cladding panel adapted, in use, to be fastened to a building by fastening means, said panel comprising one or more decorative cladding elements embedded in a structural support element of a mortar matrix, an openwork metal plate and dispersed particles, whose density is lower than the density of the mortar matrix of the structural support element.

[0009] According to some embodiments of the invention, the device comprises one or more of the following technical features, taken alone or any combination thereof:

- the openwork metal plate is embedded in the mortar matrix, said matrix forming connections through the openings of said plate;
- the open area ratio of the openwork metal plate lies in the range from 30% to 70%, preferably from 35% to 60%, or more preferably from 35% to 49%;
- the density of the particles, whose density is lower than the density of the mortar matrix lies in a range from 0.01 to 0.95 kg/dm^3;
- the particles, whose density is lower than the density of the mortar matrix are at least one of the following elements: expanded glass granulates, expanded aluminosilicate glass granulates, mica exfoliated grains or vermiculites, or any combination thereof;
- the openwork metal plate has a thickness ranging from 0.3 mm to 5.0 mm, preferably from 0.3 mm to 3.0 mm, more preferably from 1.0 to 2.0 mm;
- the openwork metal plate is made of aluminum;
- the thickness of the cladding panel lies within an range from 13 to 35 mm;
- the structural support element comprises only one openwork metal plate;
- the openwork metal plate is profiled, ribbed and/or textured;
- the structural support element comprises at least one layer, wherein said layer comprises a cement-based adhesive, preferably with a weight ratio of organic compound less than 5%, in particular less than 3%, most preferably less than 1%;
- the panel comprises two layers: an adhesive layer embedding the decorative cladding element, preferably said layer being free of dispersed particles and a support layer comprising the dispersed particles;
- the structural support element comprises additional reinforcing particles, said particles being selected from the group consisting of: fibers, granules or platelet particles, or any combination thereof;
- the back face of the structural support element comprises a woven or unwoven reinforcing fabric;
- two directly neighboring elements of the decorative cladding elements are separated by a joint between said elements, said joint being coated with sand;

- the openwork metal plate is metallic perforated plate;
- the weight ratio between the particles, whose density is lower than the density of the mortar matrix, and the mortar matrix ranges between 0.2 and 5.0, preferably between 0.5 and 3.0, more preferably 0.7 and 2.0;
- the inradius of at least one of the openings of the metallic perforated plate is adapted in a form-fitting manner to the fastening means of the panel;
- the inradius of at least one or all openings ranges from 2 to 8 mm, preferably in a range from 2 to 3 mm;
- the openings are square-shaped, triangular, hexagonal, rectangular, elliptic and/or circular;
- the circular openings present a diameter ranging from 4 to 16 mm, preferably from 4 to 6 mm;
- the inradius of at least one or all openings is higher than the half of the major diameter of the fastening means, in particular a screw;
- the major diameter of the screw lies in a range from 3 to 16 mm, preferably in a range from 4 to 6 mm;
- the inradius of said openings is smaller than the half of the diameter of the head of said screw;
- the difference between the diameter of the head of the screw and the double of the inradius ranges from 1.0 mm to 6.0 mm, preferably the diameter of the head is not larger than the width of the gap between two adjacent of the one or more decorative cladding elements facing said head;
- the one or more decorative cladding elements comprise bricks, tiles, or artificial/natural stones;
- the weight of the panel is less than 60 kg, preferably less than 23 kg, more preferably less than 20 kg;
- the panel comprises a coupling structure arranged on at least one of two opposing side edges, said mechanism including recesses and tongues formed by some of the decorative cladding elements.

[0010] The invention also relates to a method for producing the panel, comprising the following steps:

- providing a mold with an appropriate shape;
- arranging the one or more decorative cladding elements in the mold;
- filling the mold with mortar preferably mixed with at least the particles, whose density is lower than the density of the mortar matrix;
- placing the openwork metal plate in the mold;
- filling the mold with mortar mixed with said particles ;
- optionally covering the back face of the structural support element with the woven or unwoven reinforcing fabric;
- drying said mortar.

[0011] Preferably, the method comprises a step of filling the mold with sand after arranging the one or more decorative cladding elements of the panel in the mold and before the filing of the mold with mortar preferably mixed with at least the particles, whose density is lower than the density of the mortar matrix.

[0012] Advantageously, the method comprises a compression step of the structural support element, via a plate with a pressure ranging from 10 to 100 kPa, preferably from 30 to 70kPa exerted on said plate for a predetermined amount of time ranging for 0.5 to 100 seconds, said step taking place before the drying of said mortar and after the filling of the mold with mortar mixed with said particles.

[0013] The invention also relates to a building comprising the panel according to the invention.

[0014] The present invention is advantageous since the deformation resulting from temperature change or humidity are considerably diminished because of the use of a metallic insert, i.e. the openwork metal plate. The panel according to the invention is stable and is therefore easy to mount because it requires fewer "on-the-spot" adjustments to compensate changes in dimension.

[0015] The rigidity of the panel also depends on the selection of a suitable open area ratio. This ratio is a compromise between an improved adherence between the openwork metal plate (e.g. perforated metallic plate) and the substantially mineral binding composition (i.e. mortar), and an enhanced stiffness of the openwork metal plate. An excessively high open area ratio would increase the anchoring effect of the openwork metal plate within the mortar matrix while reducing the stiffness of the openwork metal plate. To the contrary, an excessively low ratio would reduce the anchoring effect of the openwork metal plate within the mortar matrix while increasing the rigidity of the openwork metal plate.

[0016] The introduction of particles, whose density is lower than the density of the mortar matrix, in the mortar matrix of the panel reduces the weight without a significant reduction of the rigidity and/or resistance of the panel. These particles are also known as low-density particles. It appears that the presence of low-density particles does not influence the anchoring effect providing that the open area ratio remains in a certain range. It has however been observed that when the low-density particles dispersed within the mortar matrix reach a certain concentration, the binding of the decorative cladding elements embedded in the surface of the cladding element is less effective. After several test, a stratified structure comprising at least two layers presented a surprising behavior. A first layer combining a coarse and lightweight binding

mixture in which the openwork metal plate is embedded. A second layer presenting a relatively denser and more spreadable binding mixture ensuring a secure adherence of the decorative cladding elements. An strong bounding between the two layers can be ensured by the use of the same mortar composition for both layers.

[0017] Furthermore, it has been observed that an openwork metal plate with a 3D structure (e.g. ribs, profile, and/or texture), such as a corragurated plate, synergistically interacts with the mortar matrix because the overall resistance of the structural support element goes beyond the contribution of the inherent enhanced stiffness of a profiled and/or ribbed plate, thanks to an improved anchoring effect. This allows increasing further the proportion of low-density particulates, without adverse effects on the overall resistance of the panel.

[0018] Synergistically, the openings can be used for the fastening of the panel on the building. Indeed, a fastening screw can pass through one of the openings. The more openings are present, the easier it is to select an optimized position of the fastening means (e.g. mechanical fixation such as screws), simplifying the tasks of the construction workers.

[0019] The selection of an aluminum plate allows that the panel can be trimmed without reducing the corrosion resistance of the plate. Aluminum presents a specific elastic modulus (i.e. ratio between Young modulus and density) similar to that of steel.

[0020] The present invention is highly customizable. Indeed, a joint-free brick wall or an apparent joint brick wall can be manufactured with several panels produced on the same production line. In the former case, it is foreseen that one or more decorative cladding elements are voluntarily not embedded in the panel in order to free one or more portions of the external surface of the panel, where openings for allowing the insertion of the fastening means (e.g. screw(s)) are formed. In the latter case, one or more fastening screw holes are arranged on one or more joints sandwiched between their respective adjacent decorative cladding elements (e.g. bricks).

[0021] In general, the preferred embodiments of each subject-matter of the invention are also applicable to the other subject-matters of the invention. As far as possible, each subject-matter of the invention is combinable with other subject-matters. The features of the invention are also combinable with the embodiments of the description, which in addition are combinable with each other.

Brief description of the figures

[0022] Aspects of the invention will now be described in more detail with reference to the appended drawings, wherein same reference numerals illustrate same features and wherein:

Figure 1 represents a perspective view of a panel according to the invention.

Figure 2 represents a perspective view of a facade made of a plurality of panels according to the invention.

Figure 3 represents a perspective view of a panel with form fitting opposing side edges according to the invention.

Figure 4 represents a perspective view of a facade made of a plurality of panels with form fitting opposing side edges according to the invention.

Figures 5a-5b represent two transversal sections of two panels according to the invention. Figure 5a discloses straight side edges. Figure 5b discloses side edges with at least one step.

Figure 6 represents a transversal section of a portion of a panel with an apparent joint according to the invention.

Figure 7 represents a transversal section of a portion of a panel without an apparent joint according to the invention.

Figure 8 represents a magnified transverse section of a panel according to the invention.

Figures 9A-9C represent usual formulas for assessing the opening ratio.

List of reference symbols

[0023]

2	(substantially inorganic) (fire resistant) (modular) (prefabricated) cladding panel
4	building
6	(decorative) cladding element
10	reinforcing support
12,14	(adhesive or support) layer(s)
16	mortar matrix
18	openwork metal plate or perforated metallic plate
20	openings
22	low-density particles or particles whose density is lower than the density of the mortar matrix
24	fastening means or screw
26	joint or grout
28	sand
30	reinforcing particles
32	(woven or unwoven) reinforcing fabric

Detailed description of the invention

[0024] Figure 1 shows a perspective view of a cladding panel according to the invention. The panel can comprise rows of decorative cladding elements, e.g. bricks. It can be noted that the bricks in figures 1 and 2 are staggered leaving empty footprints corresponding in shape to half of the reference pattern brick. The footprints are aimed at being filled with bridging bricks on site as shown in figure 2. The embodiment in figures 1-4 and 6 are described with bricks and apparent/appearing joints/grouts. However, the use of bricks and/or appearing grouts should not limit the scope of the invention, because oth-

er(s) decorative claddings element(s) such as tiles in combination with or without an appearing grout can be used.

[0025] By "appearing grout", we mean the panel surface sandwiched between the cladding elements. This term is also known as (apparent or appearing) joint. This sandwiched surface can be coated for instance with sand to bring a decorative aspect. For bricks, sand is generally used. When the gap between two decorative cladding elements is smaller than a value between 2 to 6 mm, the joint surface is not visible anymore because the gap is too narrow. In this case, it is considered that there is no significant apparent/appearing grout/joint.

[0026] The dimension of a panel is related to the production requirements and weight constrains. A construction panel should not exceeds 25 kg according to a European Union guidelines so that it can be easily handled by a worker (e.g. less than 20 or 23 kg, depending on work scenario). However, for certain applications where the work is automatized, it can be conceived that a portable untrimmed panel should not exceed 60 kg. Ideally, an untrimmed (rectangular or square) panel has a height from 50 to 90 cm, preferably from 60 cm to 70 cm and a length from 70 to 150 cm, preferably from 90 to 120 cm. If needed, a panel can be trimmed to the right size using for instance a suitable circular saw. The thickness of the panel ranges from 15 to 35mm.

[0027] Figure 2 represents a perspective view of a facade comprising several decorative cladding panels. It should be noted that panels could be fixed on vertical beams and the bridging cladding elements (i.e. bricks) are mounted at vertically oriented junctions between panels. Generally, the bridging bricks can adhere with glue, mortar such as cement-based adhesive or any other suitable binding mineral material on the panels.

[0028] Figure 3 represents a perspective view of a panel with form fitting opposing edges according to the invention. This alternative design prevents the use of bridging bricks and simplifies the mounting. With this design, the panel comprises a coupling structure arranged in opposing side edges, said structure including recesses and tongues. The tongues are formed by some of the decorative cladding elements that are arranged on both edges. The recesses and tongues are alternatively arranged along respective side edges.

[0029] Figure 4 represents a perspective view of a facade made of a plurality of panels with form fitting opposing sides according to the invention. The vertical edges of two adjacent panels are arranged to fit together.

[0030] Figures 5a-5b represent two transversal sections of two (rectangular or square) panels according to the invention. Figure 5a discloses straight side edges. Figure 5b discloses side edges with a step. The step(s) positioned on the side(s) of the panel allow(s) an overlapping with the neighboring plate(s) once they are mounted on a building. The cladding panel can present bricks embedded in a structural support element comprising a mortar composition such as a cement-based adhesive. The structural support element further comprises an openwork metal frame such as a perforated metallic plate. The perforated plate is anchored within the structural support element in an intermediate section thereof.

[0031] Figure 6 represents a transversal section of a portion of a panel with an appearing grout according to the invention. Figure 6 shows that one of the openwork metal plate can be used for engaging with a fastening element such as a screw. To achieve this result, the dimensions of the thread/shank of the screw match those of the corresponding opening, in which the screw is fitted. Preferably, the fastening screw dimensions and the inradius of the opening(s) of the openwork metal plate can be selected such that the inradius of at least one or all openings is higher than the half of the major diameter of the fastening screw. Typically, the inradius lies in a range from 2 to 8 mm, preferably in a range from 2 to 3 mm. Moreover, the inradius of said opening(s) and the fastening screw can be configured so that the head of the screw can be tightened against the external surface of the panel without weakening said surface. For this purpose, the plate and the fastening means should be adapted in such a manner that traction stresses from the tightening of the screw and load are essentially borne by the metal perforated plate. For instance, a difference ranging from 0.5 mm to 3.0 mm between the half of the diameter of the head and the inradius of the corresponding opening ensures that the head securely rests on the external surface of the structural support element. It is meant by major diameter, the largest diameter of the screw thread or shank.

[0032] The inradius is by definition the radius of the largest circle that fits inside any given geometric shape, especially inside a regular polygon.

[0033] Figure 7 represents a transversal section of a panel without an appearing grout according to the invention. In this case, it should be noted that the opening engaging with a fastening screw is positioned directly underneath the corresponding decorative cladding. This decorative cladding element is mounted once the panel is fixed on the building.

[0034] Figure 7 shows an embodiment, in which the openwork plate (e.g. perforated plate) separates a region with low-density particles from a region free of low-density particles. This plate positioning with regard to the stratification of the low-density particles could be applied to any panel according to the invention with an appearing grout as for instance that in Figure 6.

[0035] Figures 6 and 7 represent a transversal section of a portion of a panel with dispersed low-density particles according to the invention. The use of dispersed low-density particles reduces the weight. It has been discovered that the overall rigidity of the panel is not or just slightly adversely influenced by the presence of low-density particles, which by nature introduces heterogeneity and weakens the structure. Synergistically, the combination of the openwork metal plate and the low-density

particles present an overall resistance of the panel that is higher than what would normally be expected. Equally, it is preferred to stratify the reinforcing structure and to concentrate the dispersed low-density particles in the region wrapping the openwork metal plate. This stratified structure can comprise a support layer with dispersed low-density particles and an adhesive layer free of dispersed low-density particles. The composition of the filling material (i.e. mortar composition) of both layers can be the same or different.

[0036] Figure 8 represents a magnified transverse section of a panel according to the invention. The structural support element can comprise additional reinforcing particles such as fibers, granules or platelet particles. The back face of the structural support element can comprise a woven or unwoven reinforcing fabric.

[0037] Figures 9A-9C represent usual formulas for assessing the open area ratio. These formulas are derived for the state in the art, for example a publication of the Industrial Perforators Association: Designers, Specifiers And Buyers Handbook For Perforated Metals, © 1993. The shapes of the perforated plate presented in figure 9A-9C should not be regarded as limiting the scope of the present invention. The open area ratio of an openwork metal plate is the ratio between the cumulative surface of all openings area of the plate divided by the area delimited by the plate. It has been found that when the open area ratio of the openwork metal plate lies in the range from 30% to 70%, from 35% to 60%, more preferably from 35% to 49%, the stability is increased.

[0038] A method (not shown) for producing a panel comprises the steps of providing a mold with an appropriate shape; arranging the cladding elements of the panel in the mold; filling the mold with mortar, preferably mixed with at least the particles, whose density is lower than the density of the mortar matrix; placing the openwork metal plate in the mold; filling the mold with mortar mixed with said particles; optionally covering the back face of the structural support element with the woven or unwoven reinforcing fabric; and drying said mortar.

[0039] Preferably, the openwork metal plate is displaced vertically in the mold to be positioned at a predefined height within the thickness of the support structure element. The mold can therefore comprise one or more abutment surfaces to maintain in place the plate at the predefined height within the mold. The plate can be pressed within the mold to reach its rest position on the abutment surface(s). The displacement of the plate also ensures that the hydrated mortar passes though the openings of the openwork metal plate so as to optimize the anchoring effect and that the contact surface between the mortar and the openwork metal plate is maximized. This step also favors that air bubbles imprisoned in the mortar are released.

[0040] Furthermore, a step during, which the mold is filled with a coating element such as calibrated sand of the appearing joint/grout, can be foreseen before the filling of the mold with the mortar, preferably mixed with low-density particles and after arranging the one or more decorative cladding elements of the panel in the mold.

[0041] Moreover, the manufacturing process can comprise a step, during which a mortar composition free of low-density particles is filled in the mold before the step of the filling the mold with mortar mixed with low-density particles and prior to the placing of the plate. This step takes place after the filling of the mold with sand if applicable.

[0042] A woven or unwoven fabric can be applied on the uppermost layer of mortar (i.e. the back face of the panel) before the drying. The use of the woven or unwoven fabric will increase the handling and stability during transport.

[0043] The complete layered preparation will be put under a complete surface pressure. This step place before the drying. This will increase the binding between the different layers and link all component together.

[0044] The mold is filled with (hydrated) binding mixtures (e.g. mortar mixed with low-density particles) that are poured or injected. Each binding mixture can be a ready-to-use material or the result of a mix of several constituents, for instance a combination of at least a cement-based adhesive powder, water and optionally dispersed low-density particles.

[0045] By "substantially inorganic" element is meant that the amount of mineral components represents at least 90%, more preferably 95%, in particular 99% in weight of the element.

Claims

1. A substantially inorganic fire-resistant modular prefabricated cladding panel (2) adapted, in use, to be fastened to a building (4) by fastening means (24), said panel comprising one or more decorative cladding elements (6) embedded in a structural support element (10) of a mortar matrix (16), an openwork metal plate (18) and dispersed particles (22), whose density is lower than the density of the mortar matrix (16) of the structural support element (10).

2. The panel (2) according to Claim 1, wherein the openwork metal plate (18) is embedded in the mortar matrix (16), said matrix (16) forming connections through the openings (20) of said plate (18).

3. The panel (2) according to any of the preceding claims, wherein the open area ratio of the openwork metal plate (18) lies in the range from 30% to 70%, preferably from 35% to 60%, or more preferably from 35% to 49%.

4. The panel (2) according to any of the preceding claims, wherein the density of the particles (22), whose density is lower than the density of the mortar matrix (16) lies in a range from 0.01 to 0.95 kg/dm^3.

5. The panel (2) according to any of the preceding claims, wherein the openwork metal plate (18) has a thickness ranging from 0.3 mm to 5.0 mm, preferably from 0.3 mm to 3.0 mm, more preferably from 1.0 to 2.0 mm, said plate (18) being preferably made of aluminum.

6. The panel (2) according to any of the preceding claims, wherein the inradius of at least one of the openings (20) is adapted in a form-fitting manner to the fastening means (24) of the panel (2).

7. The panel (2) according to any of the preceding claims, wherein the structural support element (10) comprises only one openwork metal plate (18), preferably the openwork metal plate (18) being profiled, ribbed and/or textured.

8. The panel (2) according to any of the preceding claims, wherein the structural support element (10) comprises at least one layer (12,14), wherein said layer (12, 14) comprises a cement-based adhesive, preferably with a weight ratio of organic compound less than 5%, in particular less than 3%, most preferably less than 1%.

9. The panel (2) according to any of the preceding claims, wherein the panel (2) comprises two layers (14): an adhesive layer (14) embedding the decorative cladding element (6), preferably said layer (14) being free of dispersed particles (22) and a support layer (12) comprising the dispersed particles (22).

10. The panel (2) according to any of the preceding claims, wherein the structural support element (10) comprises additional reinforcing particles (30), said particles (30) being selected from the group consisting of: fibers, granules or platelet particles, or any combination thereof.

11. The panel (2) according to any of the preceding claims, wherein the back face of the structural support element (10) comprises a woven or unwoven reinforcing fabric (32).

12. The panel (2) according to any of the preceding claims, wherein two directly neighboring elements (6) of the decorative cladding elements (6) are separated by a joint (26) between said elements (6), said joint being coated with sand (28).

13. The panel (2) according to any of the preceding claims, comprising a coupling structure arranged on at least one of two opposing side edges, said structure including recesses and tongues formed by some of the decorative cladding elements.

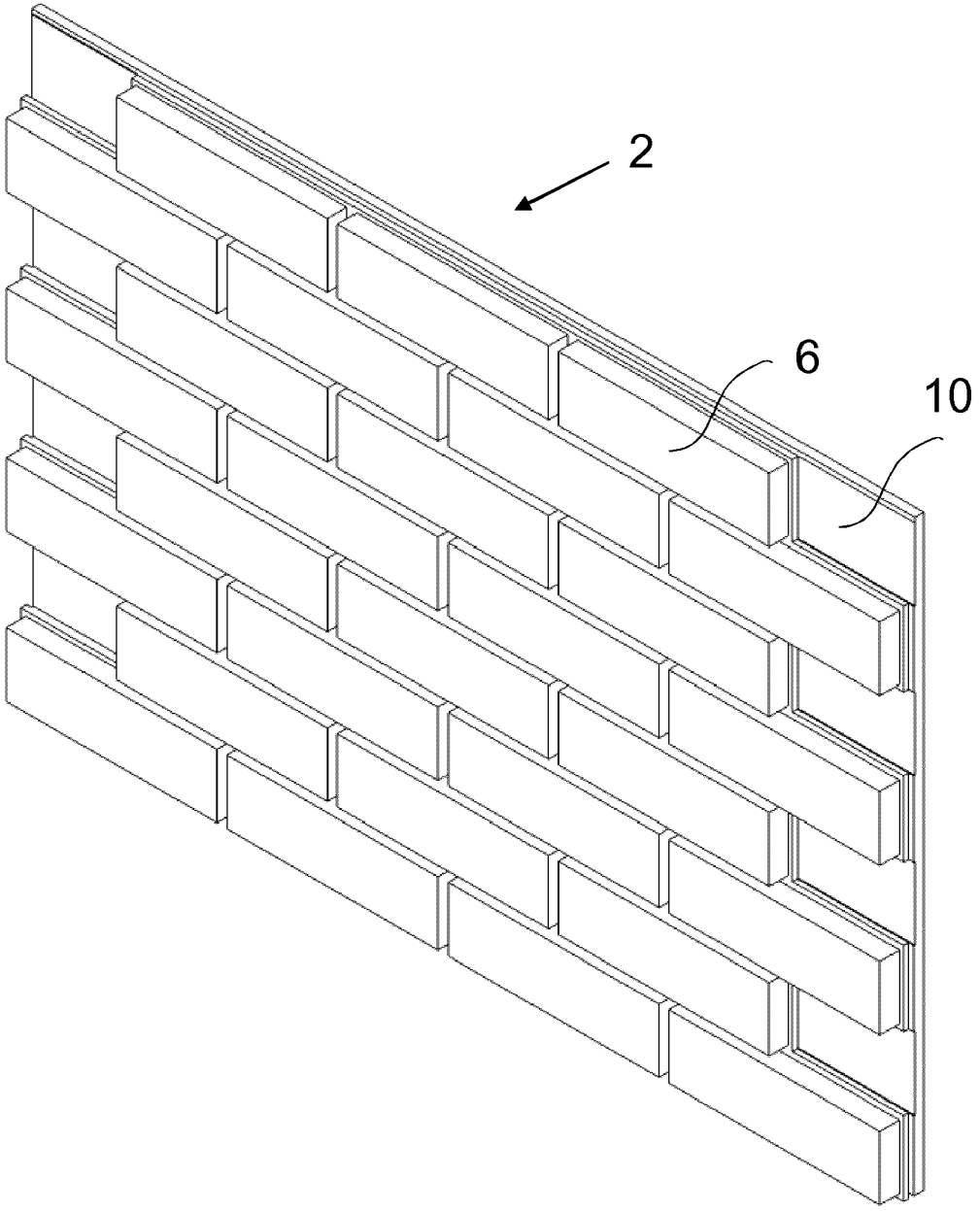
14. A building (4) comprising at least one panel (2) according to any of the preceding claims 1-13.

15. A method for producing the panel (2) according to any one of claims 1-13, comprising the following steps:

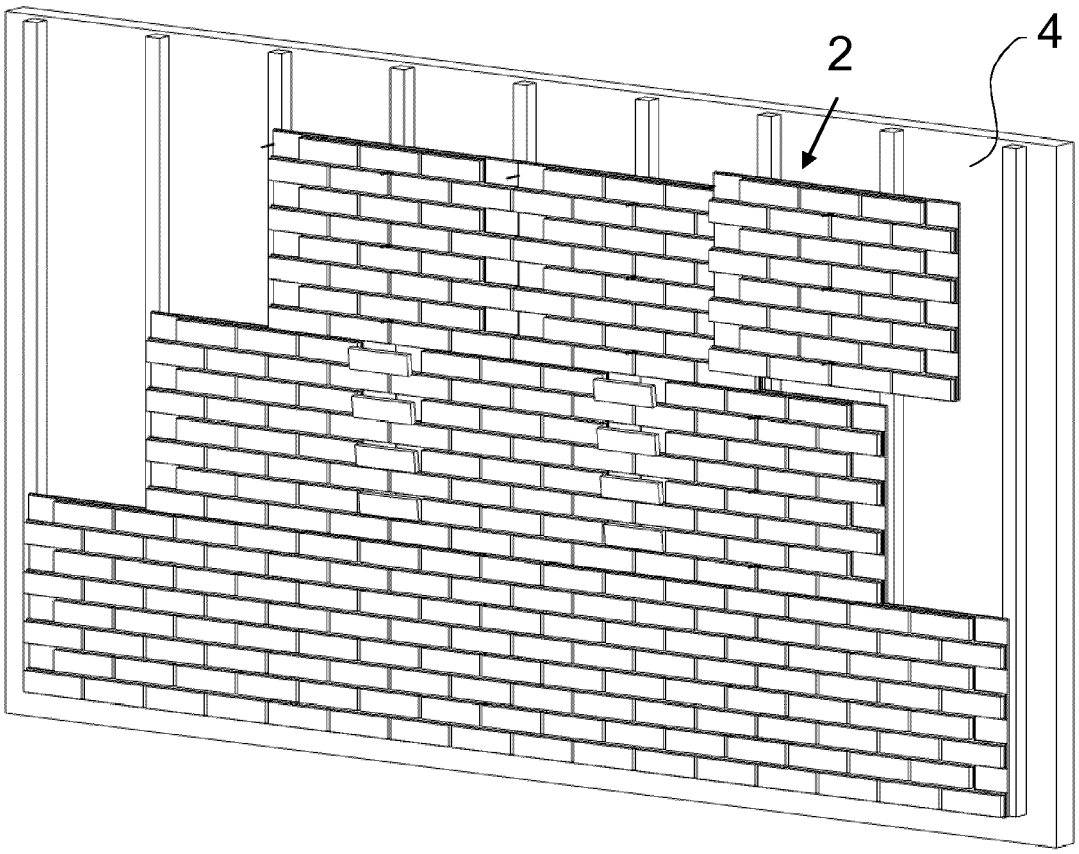
- providing a mold with an appropriate shape;
- arranging the one or more decorative cladding elements (6) in the mold;
- filling the mold with mortar (16) preferably mixed with at least the particles (22), whose density is lower than the density of the mortar matrix (16);
- placing the openwork metal plate (18) in the mold;
- filling the mold with mortar (16) mixed with said particles (22); and
- optionally covering the back face of the structural support element with the woven or unwoven reinforcing fabric (32);
- drying said mortar.

16. A method for producing the panel (2) according to the preceding claim, further comprising a step of filling the mold with sand (28) after arranging the one or more decorative cladding elements (6) of the panel (2) in the mold and before the filing of the mold with mortar preferably mixed with the particles, whose density is lower than the density of the mortar matrix (16).

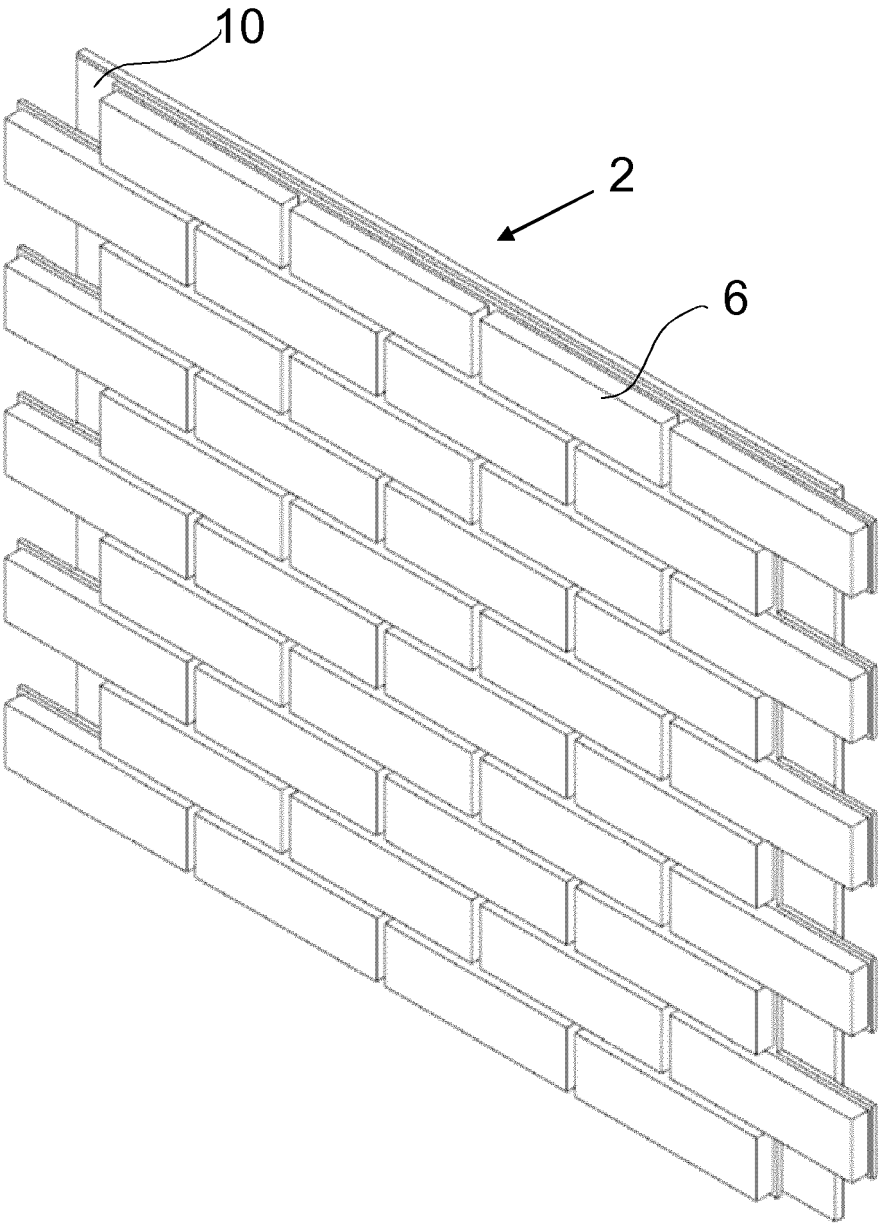
17. A method for producing the panel (2) according to claim 15 or 16, comprising a compression step of the structural support element (10), via a plate with a pressure ranging from 10 to 100 kPa, preferably from 30 to 70 kPa exerted on said plate for a predetermined amount of time ranging for 0.5 to 100 seconds, said step taking place before the drying of said mortar (16) and after the filling of the mold with mortar (16) mixed with said particles (22).



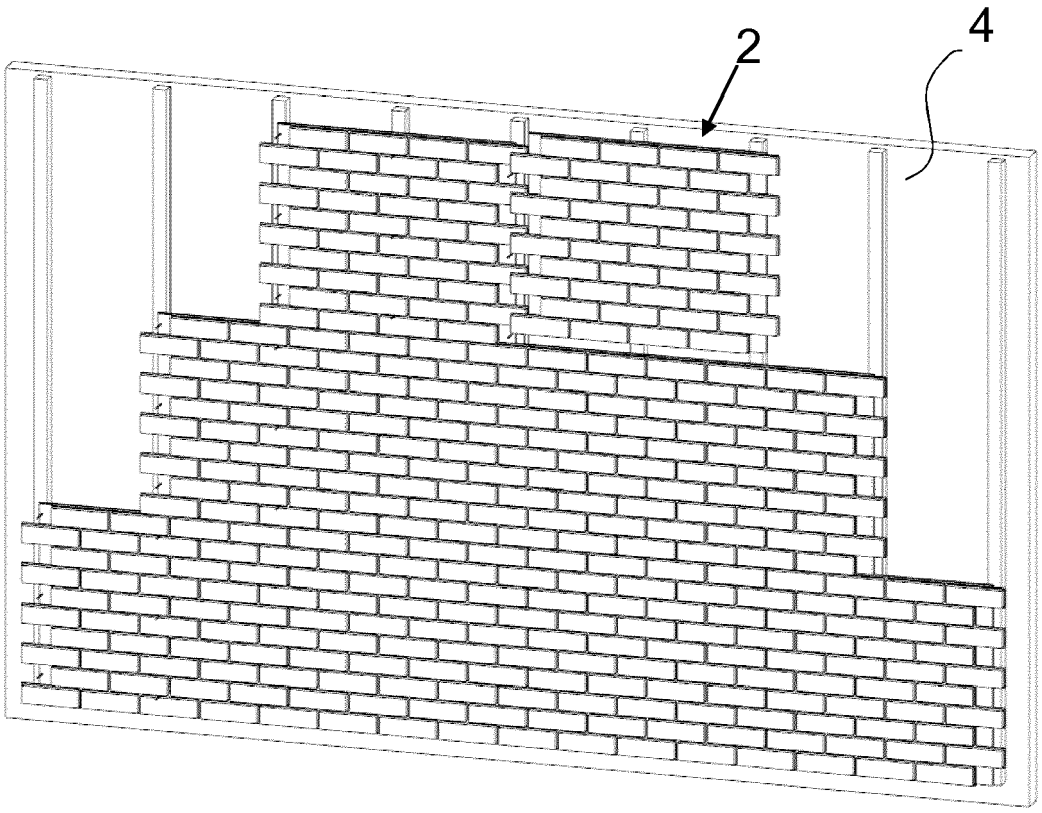
(FIG 1)



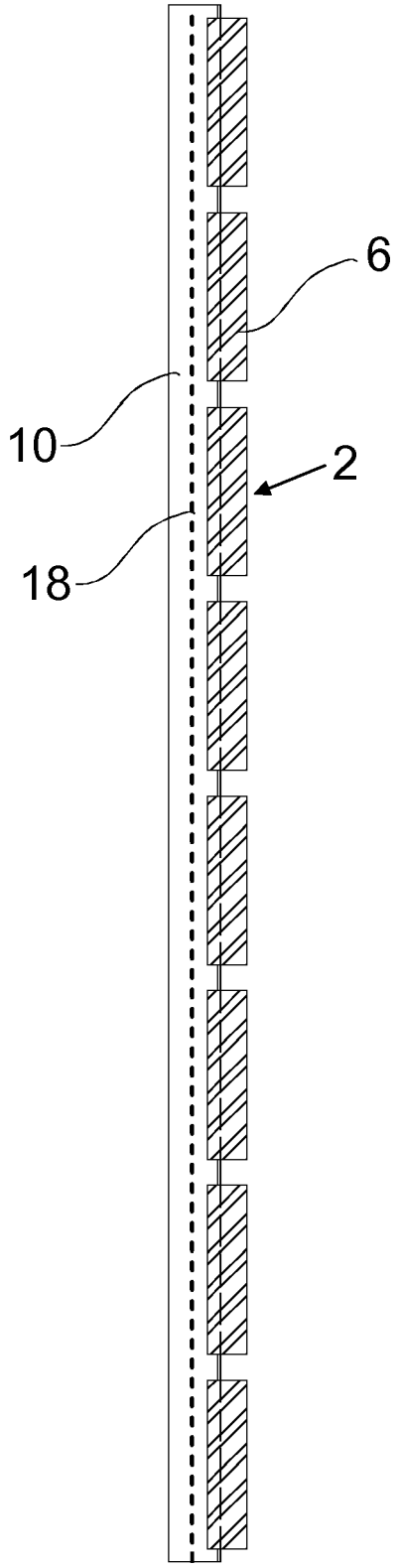
(FIG 2)



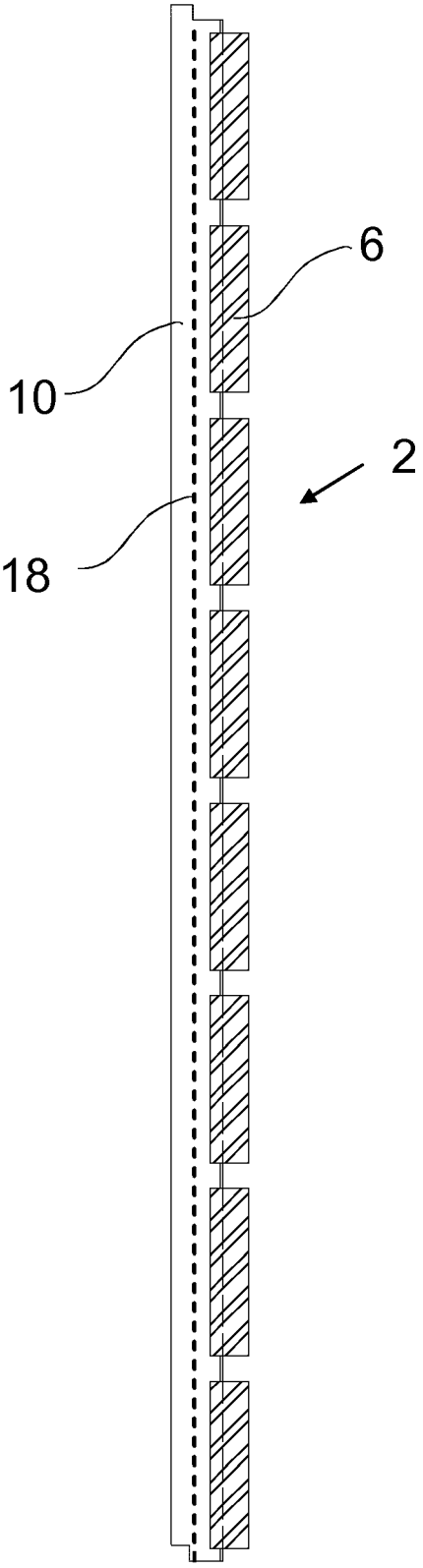
(FIG 3)



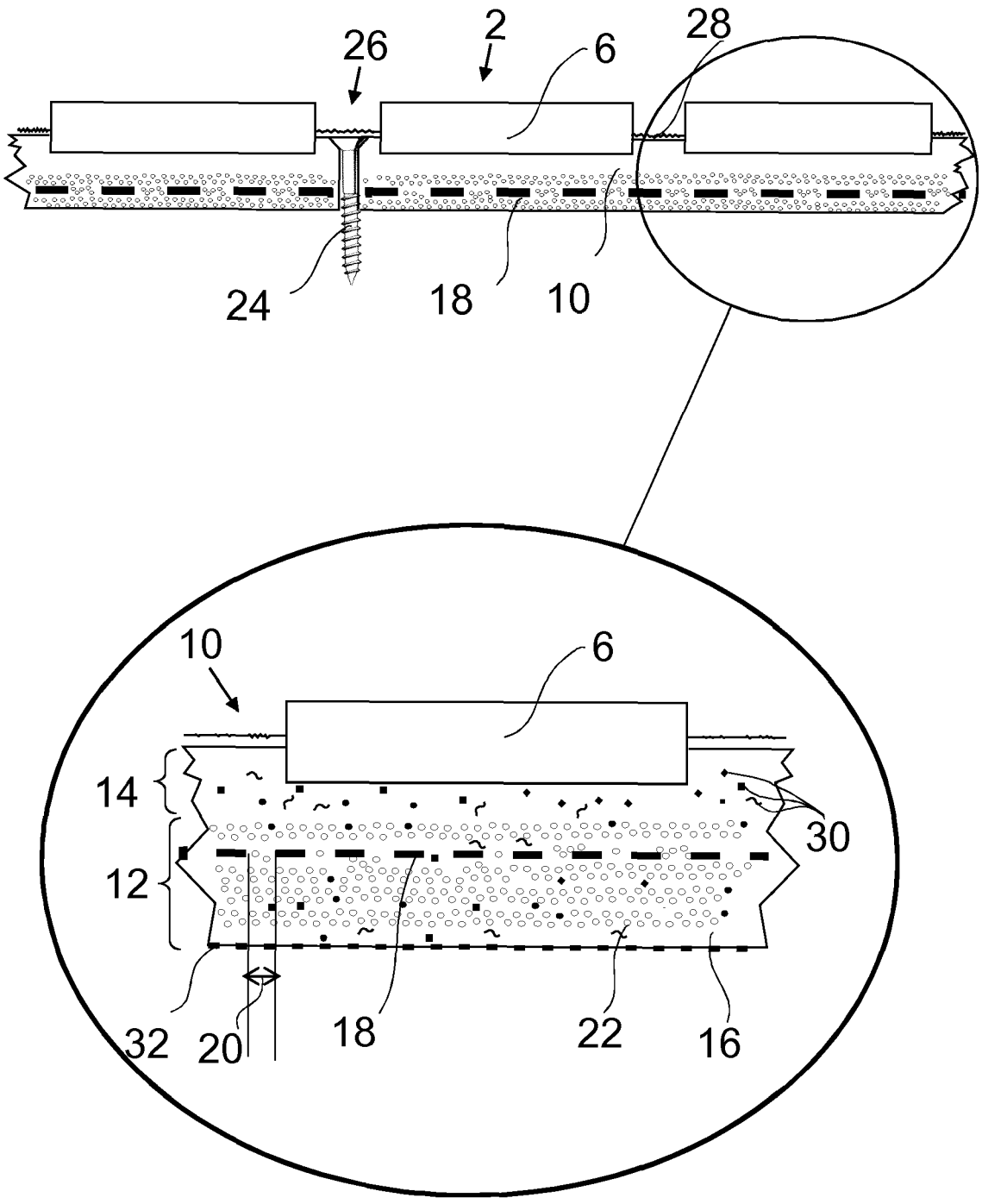
(FIG 4)



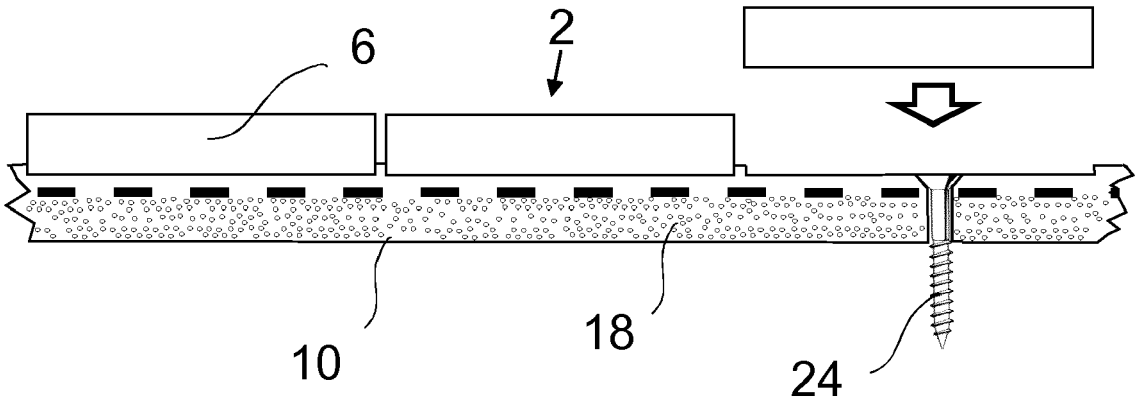
(FIG 5a)



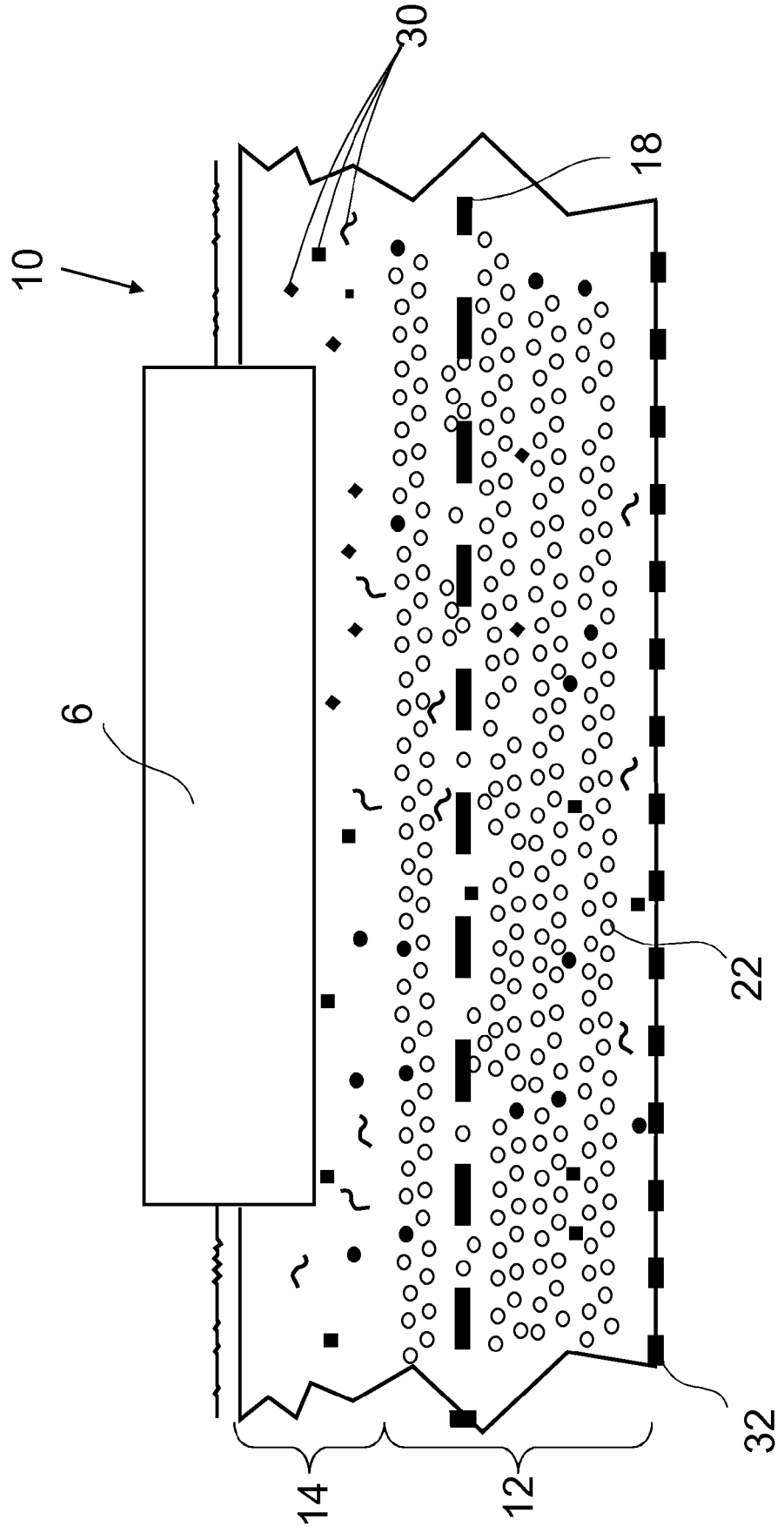
(FIG 5b)



(FIG 6)

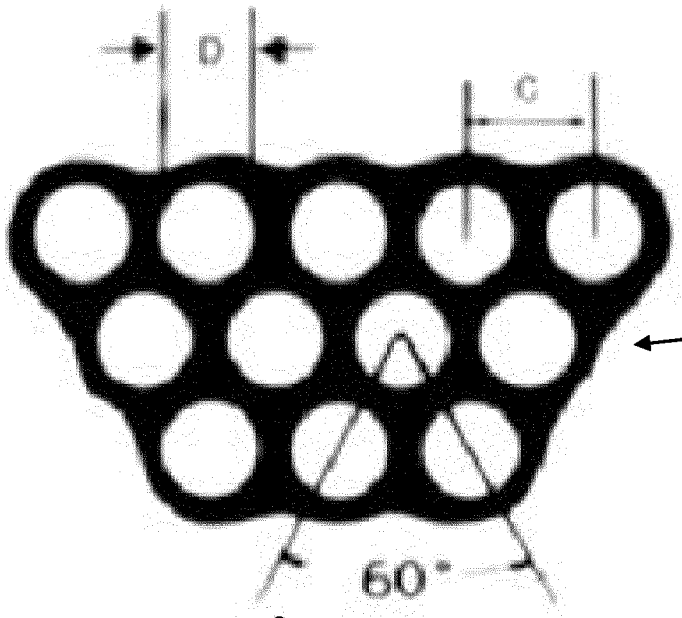


(Fig. 7)



(FIG 8)

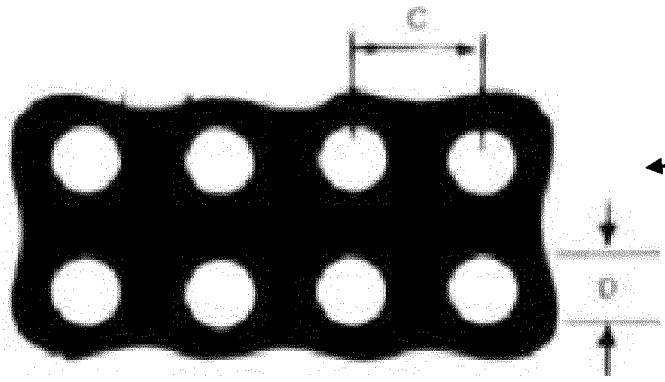
Staggered Round Holes



$$\frac{D^2 \times 90.69}{C^2} = \%$$

(Fig. 9A)

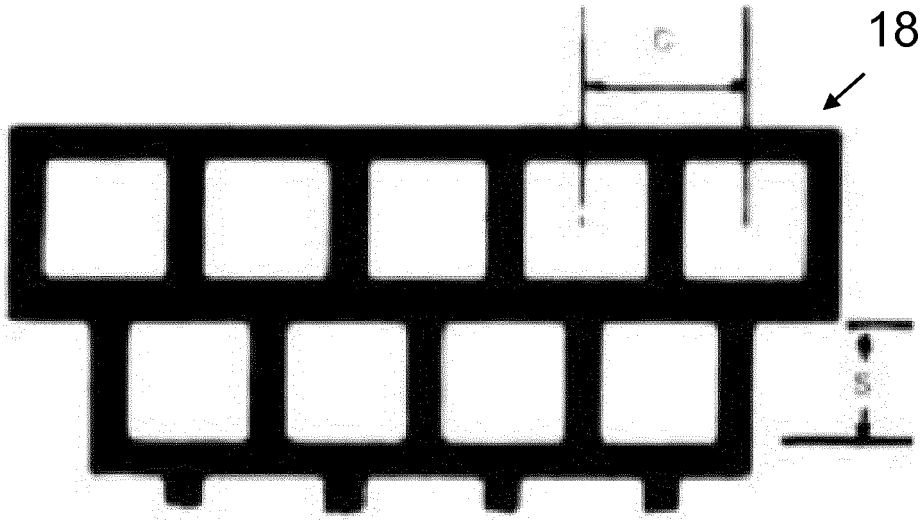
Straight Round Holes



$$\frac{D^2 \times 78.54}{C^2} = \%$$

(Fig. 9B)

Squared Holes (Straight or Staggered)



$$\frac{S^2 \times 100}{C^2} = \%$$

(Fig. 9C)

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 19 20 5846

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	FR 2 706 174 A1 (PIC CONSEIL [FR]) 16 December 1994 (1994-12-16) * figures 1-2 * * page 1, line 25 - line 28 * * page 2, line 4 - page 3, line 1 * * page 3, line 15 - line 20 * * page 4, line 2 - line 4 *	1-17	INV. E04F13/08 E04F13/12 E04F13/14
Y	US 2014/083033 A1 (MCINTOSH ROBERT GORDON [CA] ET AL) 27 March 2014 (2014-03-27) * figures 1-2 * * paragraph [0094] - paragraph [0100] *	1-17	
Y	US 2014/057075 A1 (WANG CHAO-LANG [TW]) 27 February 2014 (2014-02-27) * figures 2-3 * * paragraph [0015] *	3,5	
Y	US 2010/107531 A1 (HUNSAKER GARRICK [US]) 6 May 2010 (2010-05-06) * figure 1 * * paragraph [0050] *	6	TECHNICAL FIELDS SEARCHED (IPC) E04F
Y	CA 3 010 868 A1 (MAX LIFE LLC [US]) 27 April 2017 (2017-04-27) * figure 1 * * paragraph [0003] *	10,12,16	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	23 April 2020	Estorgues, Marlène

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

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 20 5846

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

23-04-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR 2706174 A1	16-12-1994	NONE	
US 2014083033 A1	27-03-2014	CA 2834614 A1	08-11-2012
		US 2014083033 A1	27-03-2014
		WO 2012149630 A1	08-11-2012
US 2014057075 A1	27-02-2014	CN 103625039 A	12-03-2014
		JP 2014040763 A	06-03-2014
		TW 201408490 A	01-03-2014
		US 2014057075 A1	27-02-2014
US 2010107531 A1	06-05-2010	US 2010107531 A1	06-05-2010
		WO 2010054106 A2	14-05-2010
CA 3010868 A1	27-04-2017	AU 2016342075 A1	26-04-2018
		CA 3010868 A1	27-04-2017
		EP 3365511 A1	29-08-2018
		WO 2017069802 A1	27-04-2017

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- BE 891963 **[0003]**
- EP 2392741 A1 **[0003]**