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(54) THREE-DIMENSIONALLY CONFIGURABLE SHEET FOR MULTIPLE USES IN CONSTRUCTION AND BLANK AND PROCESS FOR ITS MANUFACTURE

(57) A three-dimensionally configurable sheet (1) for multiple uses in construction, the sheet (1) having a given thickness and defining a plane (P), comprises a plurality of folding segments (2) oriented on said plane (P) along at least two different directions, each folding segment (2) having a given height; and through holes (4) opened in folding segments (2) convergence areas along different directions; wherein the sheet thickness matches the greater height of the folding segments (2). The invention also relates to a blank which constitutes the forming base of the configurable sheet, and to the manufacturing process of the latter. The configurable sheet includes multiple applications, for example as inner or outer coating or as a mould for shipbuilding, and it could be used particularly in the construction field, namely in construction industry, shipbuilding, and aircraft construction but also in the automotive industry.

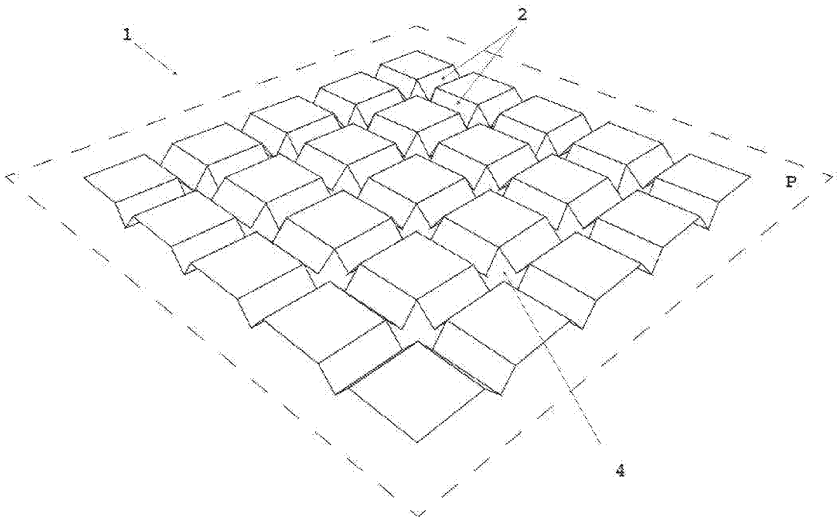

Fig. 1

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a three-dimensionally configurable sheet which can be used in multiple applications, particularly in the construction field, namely in construction industry, shipbuilding, and aircraft construction but also in the automotive industry and others. The invention also relates to a blank which constitutes the forming base of the configurable sheet, and to the manufacturing process of the latter. The configurable sheet includes a myriad of different applications, for example as inner or outer coating or as a mould for shipbuilding among many others.

BACKGROUND OF THE INVENTION

[0002] Both in construction field and in a wide range of areas where three-dimensional shapes are developed, there was always a need of a sheet able to be manipulated in order to be three-dimensionally configurable so as to overcome the limitations posed by sheets or similar members in the prior art that only allow changes along one or two spatial reference axes, that is, one- or two-dimensional variations.

[0003] In addition to the need for a three-dimensionally configurable sheet, those skilled in the art require that such sheets are susceptible to accommodate significant dimensional variations allowing them to be provided with a great versatility regarding the application intended.

[0004] The existing construction technologies available in the market to address these needs are very complex and imply complex, cost expensive and time consuming moulds or manufacturing processes.

[0005] For example, to obtain a bubble shape when building a hull of a ship, the same has to be shaped on thin sheets of wood, polyurethane or MDF, which then, after being combined into the desired shape are laminated and finished, which allows to obtain a shape having concave and convex volumes. To accomplish such shapes various MDF boards are arranged in a layered format and then sanded and grouted before painting.

[0006] In such a case, the provision of a three-dimensionally configurable sheet that further guarantees the necessary strength to subsequent working loads during construction of the hull itself would be extremely useful and productive since it would quickly allow to obtain the shape of the mould saving countless hours of process work.

[0007] Other examples, particularly in the technical field of coatings having more or less complex shapes, are representatives of the advantages of a three-dimensionally configurable sheet.

[0008] In the light of the foregoing, there is a needed in the art of a three-dimensionally configurable sheet whose configuration can be manually or mechanically obtained in a simple way, allowing to easily adapt the sheet to the desired object or shape.

SUMMARY OF THE INVENTION

[0009] The present invention relates to a three-dimensionally configurable sheet (1) for multiple uses in construction, the sheet (1) having a thickness (E) and defining a plane (P), and being characterized in that it comprises:

- a plurality of folding segments (2) oriented on said plane (P) along at least two different directions, each folding segment (2) having a height (A), and
- through holes (4) opened in convergence areas (3) of folding segments (2) along different directions,

wherein said sheet thickness (E) is given by the greater height (A) of folding segments (2).

[0010] Preferably, said height (A) of folding segments (2) is the same in all folding segments (2).

[0011] In one embodiment of the invention, said folding segments (2) are oriented on said plane (P) along two different directions. Preferably, said folding segments (2) which are oriented along two different directions form an angle of 90º in relation to one another.

[0012] In another embodiment of the invention, said folding segments (2) are oriented on said plane (P) along three different directions.

[0013] The three-dimensionally configurable sheet (1) is formed by a material without shape memory, preferably a metallic material, more preferably aluminium.

[0014] In one embodiment, the three-dimensionally configurable sheet (1) further comprises at least one recess (5) or at least one protrusion (6) or a combination of at least one recess (5) and at least one protrusion (6) arranged on at least one folding segment (2).

[0015] The present invention also relates to a blank (10) from which a three-dimensionally configurable sheet (1) as defined above can be built. The blank (10) is characterized in that it comprises:

folding lines (20) oriented along at least two different directions on a plane (P') defined by blank (10), and

through holes (40) that interrupt intercepting folding lines (20) at intercepting points (30), the through holes (40) including said intercepting points (30).

[0016] Preferably the shape of through holes (40) is selected from the group comprising a circular, a square, a rectangular, a triangular, a hexagonal, a rhomboid and a star shape.

[0017] The invention further relates to a manufacturing process of a three-dimensionally configurable sheet (1) such as characterized above. The manufacturing process of the sheet (1) is characterized in that it comprises the step of forming folding segments (2), each folding

segment (2) having a given height (A), wherein forming folding segments (2) is carried out from said folding lines (20) arranged on a blank (10) such as defined above.

[0018] In one embodiment of the process according to the invention, it additionally comprises a step of providing at least one of the folding segments (2) with at least one recess (5) or at least one protrusion (6) or a combination of at least one recess (5) and at least one protrusion (6). Such recesses (5) and protrusions (6) are designed to be fitted by engagement of the folding segments (2) of the sheet (1) into another independent member suitably configured for reception and fitting of said folding segments (2).

[0019] In one embodiment of the process according to the invention, the step of providing at least one of the folding segments (2) with at least one recess (5) or at least one protrusion (6) or a combination of at least a recess (5) and at least one protrusion (6) is performed before the step of forming folding segments (2) on blank (10).

[0020] In another embodiment of the process, the step of providing at least one of the folding segments (2) with at least one recess (5) or at least one protrusion (6) or a combination of at least one recess (5) and at least one protrusion (6) is performed after the step of forming folding segments (2) on blank (10).

[0021] The formation of folding segments (2) can be carried out by folding, bending, stamping, moulding or 3D impression.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The following is a description of the invention with reference to the accompanying drawings, in which:

Fig. 1 illustrates schematically the upper face of a first embodiment of the shape of the invention, in which folding segments oriented along two different directions and forming an angle of 90° in relation to one another are shown.

Fig. 2 shows a detail of the lower face of the sheet of Fig. 1, where the folding segments along different directions and their respective areas of convergence, in which through holes are opened, are visible.

Fig. 3 shows the sheet of Fig. 1 after it has been manually deformed so as to give a rounded shape to its central zone.

Fig. 4 illustrates a plan view of the sheet of Fig. 1.

Fig. 5 illustrates a plan view of a second embodiment of the sheet of the invention formed by folding segments arranged along three different directions.

Fig. 6 illustrates a plan view of a third embodiment of the sheet of the invention also formed by folding segments arranged along three different directions.

Fig. 7 illustrates a plan view of a fourth embodiment of the sheet of the invention formed by folding segments arranged along two different directions, forming angles which are different from the angles of the first embodiment.

Fig. 8 illustrates a blank suitable to form a sheet according to the first embodiment of the invention illustrated in Fig. 1.

DETAILED DESCRIPTION OF THE INVENTION

[0023] The present invention relates to a three-dimensionally configurable sheet which overcomes the prior art problems and meet the needs felt until now.

[0024] In the context of the present disclosure, the term "comprising" is to be understood as "including, among others". As such, the term should not be interpreted as "consisting only of" .

[0025] Note that regardless of the explicit presentation of the quantitative expression "about X", any X value presented in the course of the present disclosure is to be interpreted as an approximate value of the actual X value, since such approximation to the actual value would reasonably be expected by the one skilled in the art due to experimental and/or measurement conditions that introduce deviations to the actual value.

[0026] In the context of the present application, the use of the expression "and/or" is intended to mean that both conditions occur or only one of them occurs. For example, the expression "recesses and/or protrusions" means "recesses and protrusions or recesses or protrusions".

[0027] The sheet of the invention can be used in multiple applications, especially in the field of construction, namely in construction industry, shipbuilding and aircraft construction but also in the automotive industry and others including the solar energy device industry.

[0028] With reference to Figs. 1 to 8, three-dimensionally configurable sheet (1) has a thickness (E) and defines a plane (P), and comprises:

- a plurality of folding segments (2) oriented on said plane (P) according to at least two different directions, each folding segment (2) having a height (A), and
- through holes (4) opened in convergence areas (3) of folding segments (2) along different directions,

wherein said sheet thickness (E) is given by the greater height (A) of folding segments (2).

[0029] In the purely exemplary case of the embodiment of Figs. 1 and 2, in which Fig. 1 illustrates what would be called hereinafter as the upper face of the sheet and Fig. 2 illustrates a portion of the other face, hereinafter called

lower face, it is found that it has two distinct sets of folding segments (2). Each set has in itself a plurality of folding segments (2) parallel to one other. The relative orientation among folding segments belonging to different sets takes two different directions by adopting in this case an angle of about 90º among segments (2) of different sets.

[0030] Thus, the sheet has a plurality of folding segments (2) oriented along several different directions, for example three, four or five different directions.

[0031] By following different directions on the same plane (P), respective segments (2) having different angles in relation to one another are eventually intercepted in certain areas (3) of convergence, better shown in Fig. 8. There are no restrictions relating the selection of said angles between folding segments (2) oriented along different directions. The selection of the value of these angles will provide sheets (1) having different visual appearances.

[0032] As can be seen in Fig. 1, the selection of orientation of folding segments (2) along two different directions at an angle of approximately 90° to one another produces a configurable sheet (1) with a "chocolate tablet" appearance having squares separated by the folding segments (2). In the case of Fig. 7, although also oriented along two different directions, folding segments (2) form angles different from those of Fig. 1, which gives it the appearance of rhomboids (see Fig. 7) separated by the folding segments (2) on its upper face. In the embodiments of Figs. 5 and 6, folding segments (2) are oriented along three different directions but taking different angles in both cases, which gives it a tablet-like appearance with triangles in the embodiment of Fig. 5 and an appearance of hexagons in the one of Fig. 6.

[0033] Naturally, depending on the dimensions desired for the configurable sheet (1), the number of folding segments (2) must be accounted for accordingly.

[0034] With reference to Fig. 8, in relation to said convergence areas (3) among folding segments (2) along different directions, such areas (3) correspond to the zones in which the segments would converge if said through holes (4) didn't exist. Such confluence or interception between segments (2) would produce an accumulation of material in the convergence areas (3), which would introduce, on one hand, a local increase in stresses, and, in other hand, a stiffness which would reveal contrary to the conformability required for the sheet (1) of the invention, which would provide rigid and brittle sheets.

[0035] Thus, the provision of through holes (4) opened in said convergence areas (3) of folding segments (2) along different directions allows to make the sheet (1) three-dimensionally configurable by means of its combination with the folding segments (2). Each folding segment (2) has two overlapping portions which allow a relative movement with respect to each other (by application of stresses caused by its manual or machine configuration), providing in a certain extent the opening or closing of the folding segment (2). This dimensional variation of folding segments (2) allows adapting or adjusting the sheet (1) to the desired shape as it provides a general effect of stretching or compression to the sheet.

[0036] Through holes (4) further have an additional advantage of contributing to lightening the sheet (1), which in the case of large sheets (1) constitutes a considerable added value, since it allows to considerably reduce its weight without in practice affecting its mechanical strength.

[0037] It is found that the greater the number of intercepting folding segments (2) and respective through holes (4), the greater is the conformability of the sheet (1) of the invention.

[0038] In order to achieve the objects of the invention, it is further required to use materials without shape memory, that is, the sheet (1) should be made of a material or materials which maintain the shape which results from the shaping applied to the same in use. This way, appropriate metallic materials, such as aluminium, or even non-metallic materials or composite materials that meet this feature of not having shape memory can be used.

[0039] In Fig. 2 folding segments (2) having a given height (A) are illustrated. Height (A) is more easily measured on the underside of sheet (1). Naturally, said height (A) can vary between different folding segments (2). In the context of the present invention, it is considered that said thickness (E) of sheet (1) is defined by the greater of heights (A) of the folding segments (2). In case all folding segments (2) have the same height (A), this will correspond to the thickness (E) of the sheet.

[0040] It is noted that thickness (E) of sheet (1) can vary depending on the shaping operation that is carried out by the user when it applies tension on the sheet (1) for moulding it to the desired shape. Thus, thickness (E) of the sheet after user operation may be different from that which was provided to the sheet when it is outputted. This is due to the aforementioned opening (or closing) of folding segments (2), which naturally causes variations in the initial height (A) of such folding segments (2).

[0041] In a preferred embodiment of the invention, all of the folding segments (2) have the same height (A).

[0042] With reference to Fig. 2, in a particular embodiment of the invention, the folding segments (2) of sheet (1) are provided with recesses (5) and/or protrusions (6) for removable fitting and attachment into another independent member of the complementarily configured sheet (1) for such removable connection. More details of this option are disclosed below in association with the manufacturing process of a sheet (1).

[0043] The present invention also relates to a blank (10) from which the three-dimensionally configurable sheet (1) of the invention can be built.

[0044] Thus, referring to Fig. 8, the blank (10) of the invention comprises:

folding lines (20) oriented along at least two different directions on a plane (P') defined by blank (10), and

through holes (40) that interrupt intercepting folding lines (20) at intercepting points (30), the through holes (40) including said intercepting points (30).

[0045] The shape of said through holes (40) is selected from the group comprising a circular, a square, a rectangular, a triangular, a hexagonal, a rhomboid and a star shape and combinations thereof.

[0046] The blank (10) consists of materials without shape memory, as mentioned above. The preferred material is aluminium, although many others may also be selected according to the established criterion. One skilled in the art will carry out such selection, so additional teachings will be omitted.

[0047] The present invention also relates to the manufacturing process of the three-dimensionally configurable sheet (1) as described above.

[0048] The manufacturing process comprises a step of forming folding segments (2) having a height (A) from said folding lines (20) arranged on a blank (10) such as described above.

[0049] Thus, still with reference to Fig. 8, the process of formation of a sheet (1) of the invention comprises the steps of:

marking on a blank (10) made of no shape memory material a plurality of folding lines (20) orientated along at least two different directions on a plane (P') defined by said blank (10), whose folding lines (20) intercept each other at interception points (30),

opening up through holes (40) on the blank (10), the holes (40) including said interception points (30),

folding the sheet (10) from said folding lines (20) having a height (A), thereby forming folding segments (2).

[0050] In one embodiment of the process of the invention, it further comprises a step of providing at least one of the folding segments (2) with at least one recess (5) or at least one protrusion (6) or a combination of at least one recess (5) and at least one protrusion (6).

[0051] These recesses (5) and protrusions (6) will serve to attach sheet (1) from either its upper or lower side into a further independent fitting member of sheet (1) that is properly configured for cooperation with said folding segments (2) of sheet (1) of the invention.

[0052] In another embodiment, different sheets (1) of the present invention can also be fitted and attached into one another by means of such fitting and attachment members (5, 6).

[0053] Such fitting and attachment are advantageous in that they are detachable, since the folding segments (2) enable opening and closing dimensional variations, as mentioned above, which allows for engagement/disengagement between recesses (5) and openings (6), providing the connection/disconnection of the sheet (1) to the other cooperating member.

[0054] In one embodiment, the step of providing at least one of the folding segments (2) with at least one recess (5) or at least one protrusion (6) or a combination of at least one recess (5) and at least one protrusion (6) is performed before the step of forming folding segments (2) on blank (10).

[0055] In another embodiment, the step of providing at least one of the folding segments (2) with at least one recess (5) or at least one protrusion (6) or a combination of at least one recess (5) and the at least one protrusion (6) is performed after the step of forming folding segments (2) on blank (10).

[0056] Preferably, the step of forming folding segments (2) is carried out by folding, bending, stamping, moulding, 3D impression or a combination thereof.

[0057] Using the sheet of the invention the desired shape is easily achieved by applying a manual pressure or using mechanical devices. The sheet is thus configurable to obtain the desired shape and, after the latter is obtained, it is possible to add other materials and apply treatments in view of establishing the more or less rigid final configuration, for example by applying polyurethane, which is treated superficially and grouted to give the desired stiffness.

[0058] However, if the sheet is composed only of aluminium or another suitable material without shape memory, nothing prevents its use without any treatments or additional materials, its natural shape provided with folding segments and the geometry that they form being able to be used as decoration of the part. In the latter cases, a lamination on the lower face may be required to give the part a possibly required stiffness.

[0059] In one example, the sheet (1) of the invention further comprises high-density polyurethane bonded to the laminated sheet using a resin and glass fibre.

Examples of application

[0060] The sheet of the present invention can be used in construction industry as an outer or inner coating. The desired shape and volume are executed on an aluminium sheet using manual shaping and, then, the latter is fixed to the base structure by its lower face, the upper face of the same having, for example, a "chocolate tablet" appearance with the squares exposed without any other finishing.

[0061] The sheet of the invention can be applied in shipbuilding, in developing a mould for building a hull of a ship, avoiding the building of the usual male mould. The shape of the mould is imparted directly to the sheet, which is then subjected to a finishing work inside by lamination and filler application until the inside of the mould thus formed has the desired type of surface.

[0062] Another example is the creation of a degustation countertop provided with volumetric shapes. To this end, the structure with a tubular shape is created, and then it is coated with the sheet of the present invention,

which can be subjected to a finishing work or not. If a smooth finish is desired, it is sufficient to apply filler and then painting.

[0063] The disclosure herein should be understood as exemplary and not limiting the scope of the present invention, which is defined in the appended claims.

Claims

1. A three-dimensionally configurable sheet (1) for multiple uses in construction, the sheet (1) having a thickness (E) and defining a plane (P), **characterized in that** it comprises:

   • a plurality of folding segments (2) oriented on said plane (P) along at least two different directions, each folding segment (2) having a height (A), and
   • through holes (4) opened in convergence areas (3) of folding segments (2) along different directions,

   wherein said sheet thickness (E) is given by the greater height (A) of the folding segments (2).

2. The three-dimensionally configurable sheet (1) according to claim 1, **characterized in that** said folding segments (2) are oriented on said plane (P) along two different directions.

3. The three-dimensionally configurable sheet (1) according to claim 2, **characterized in that** said folding segments (2) which are oriented along two different directions form an angle of 90º in relation to one another.

4. The three-dimensionally configurable sheet (1) according to claim 1, **characterized in that** said folding segments (2) are oriented on said plane (P) along three different directions.

5. The three-dimensionally configurable sheet (1) according to any of the preceding claims, **characterized in that** said height (A) is the same in all folding segments (2).

6. The three-dimensionally configurable sheet (1) according to any of the of preceding claims, **characterized in that** it is formed by a material without shape memory.

7. The three-dimensionally configurable sheet (1) according to claim 6, **characterized in that** said material without shape memory is aluminium.

8. The three-dimensionally configurable sheet (1) according to any of the of preceding claims, **characterized in that** it further comprises at least one recess (5) or at least one protrusion (6) or a combination of at least one recess (5) and at least one protrusion (6) arranged on at least one folding segment (2).

9. A blank (10) for manufacturing a three-dimensionally configurable sheet (1) claimed in used to build claims 1 to 8, the blank (10) being **characterized in that** it comprises:

   folding lines (20) oriented along at least two different directions on a plane (P') defined by blank (10), and
   through holes (40) that interrupt intercepting folding lines (20) at intercepting points (30), the through holes (40) including said intercepting points (30).

10. The blank (10) according to claim 9, **characterized in that** the shape of through holes (40) is selected from the group consisting of a circular, a square, a rectangular, a triangular, a hexagonal, a rhomboid and a star shape.

11. A manufacturing process of a three-dimensionally configurable sheet (1) claimed in any of the claims 1 to 8, **characterized in that** it comprises the step of forming folding segments (2) having a height (A) on a blank (10) as claimed in claim 9 or 10 from said folding lines (20) arranged on the blank (10).

12. The process according to claim 11, **characterized in that** it further comprises a step of providing at least one of the folding segments (2) with at least one recess (5) or at least one protrusion (6) or a combination of at least one recess (5) and at least one protrusion (6).

13. The process according to claim 12, **characterized in that** the step of providing at least one of the folding segments (2) with at least one recess (5) or at least one protrusion (6) or a combination of at least a recess (5) and at least one protrusion (6) is performed before the step of forming folding segments (2) on the blank (10).

14. The process according to claim 12, **characterized in that** the step of providing at least one of the folding segments (2) with at least one recess (5) or at least one protrusion (6) or a combination of at least one recess (5) and at least one protrusion (6) is performed after the step of forming folding segments (2) on the blank (10).

15. The process according to any of the claims 11 to 14, **characterized in that** said formation of folding segments (2) is carried out by folding, bending, stamp-

ing, moulding or 3D impression.

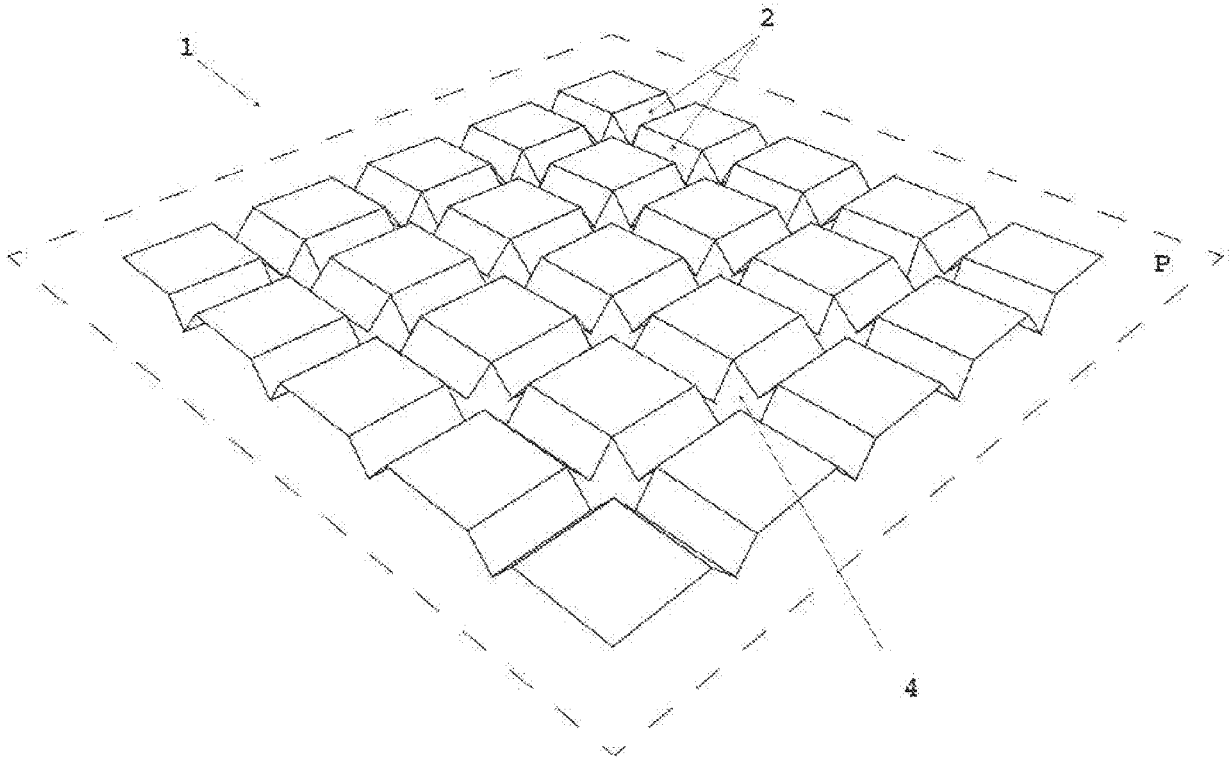

Fig. 1

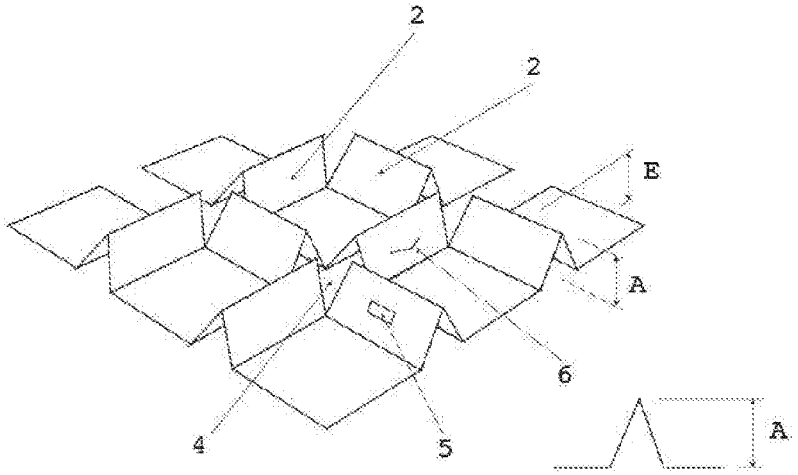

Fig. 2

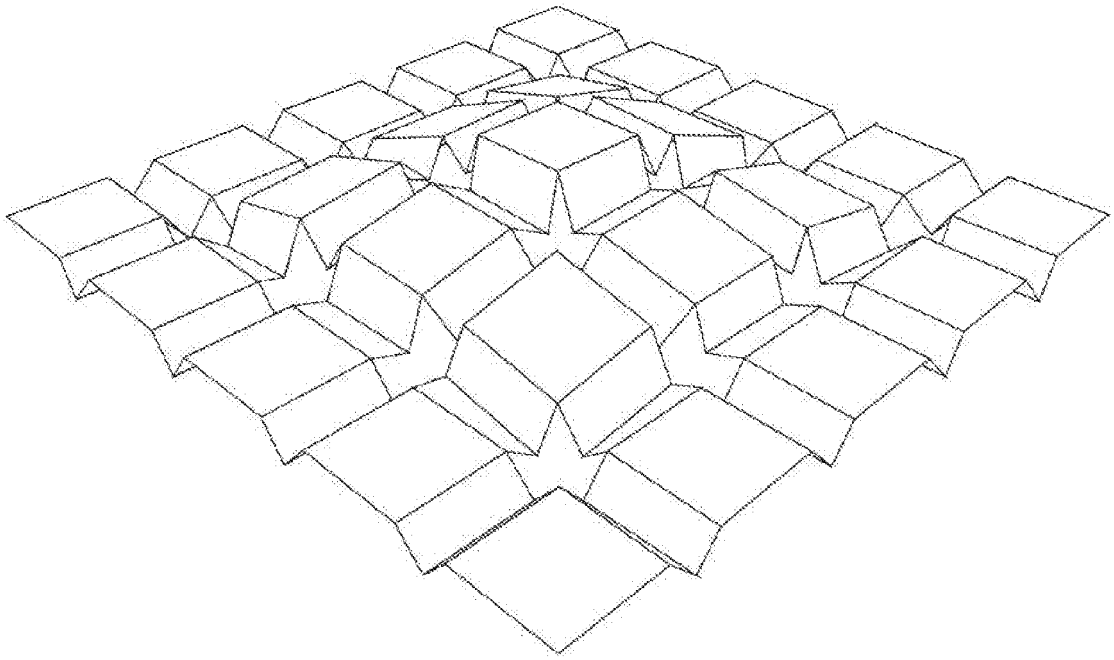

Fig. 3

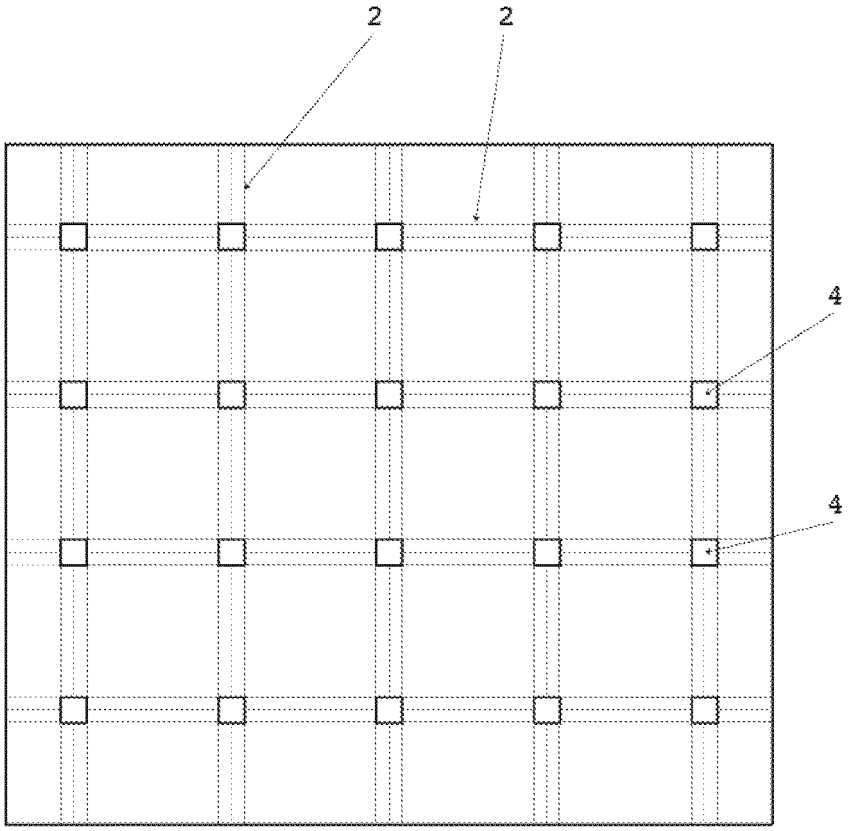

Fig. 4

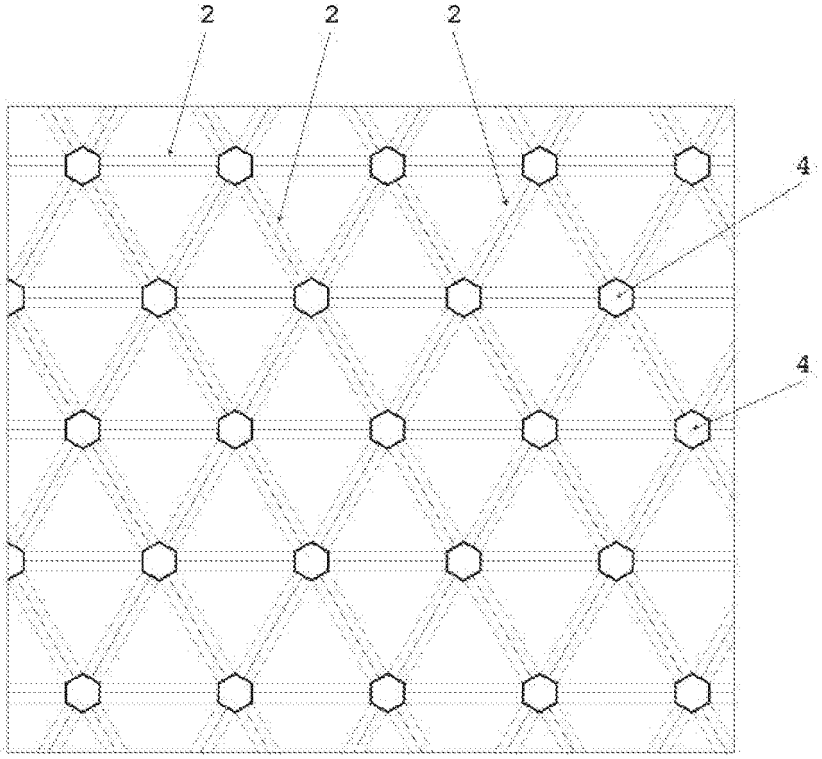

Fig. 5

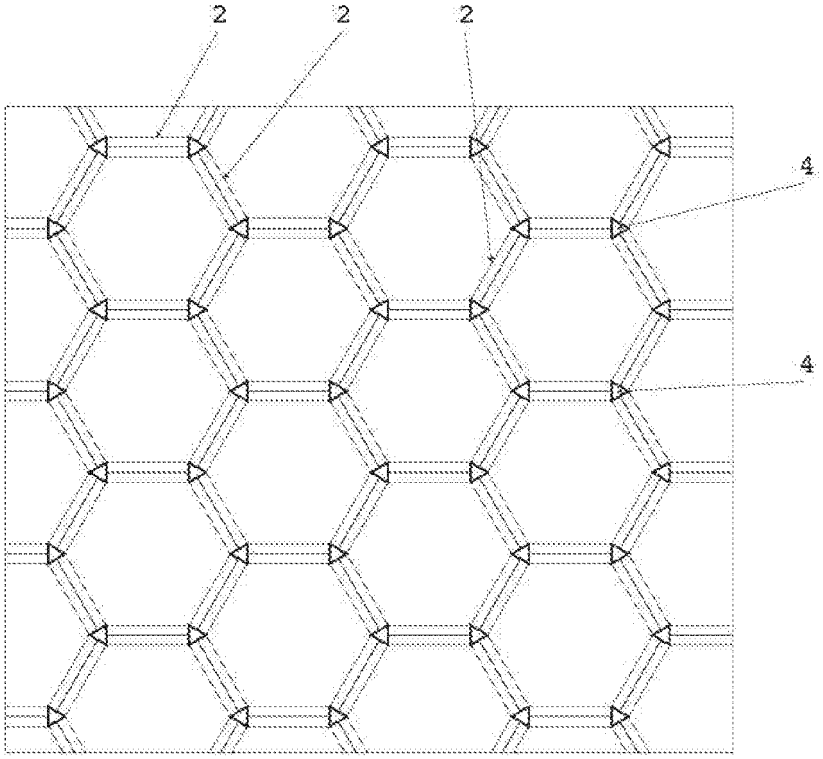

Fig. 6

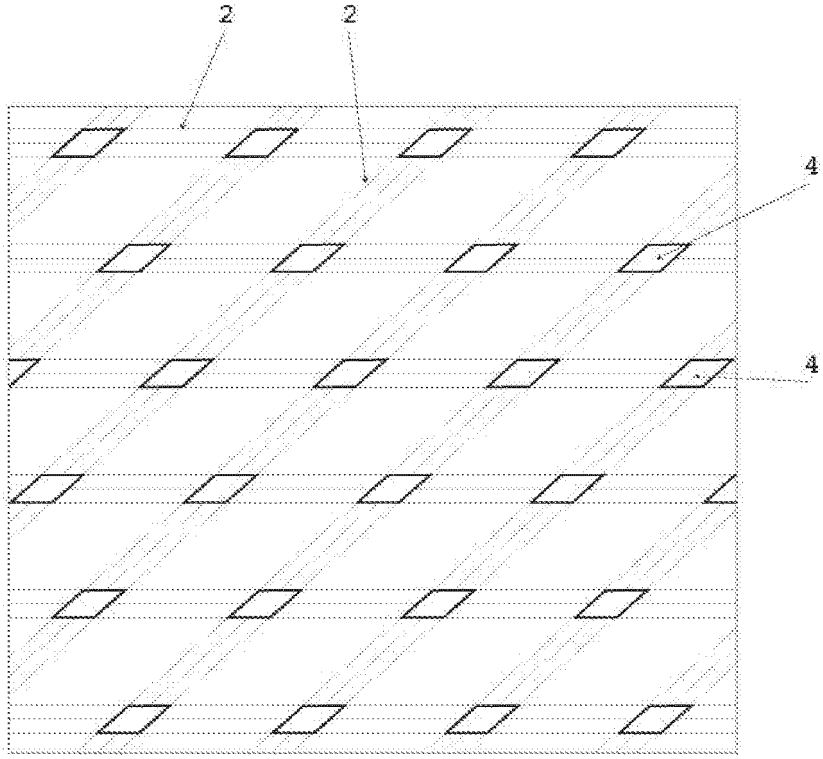

Fig. 7

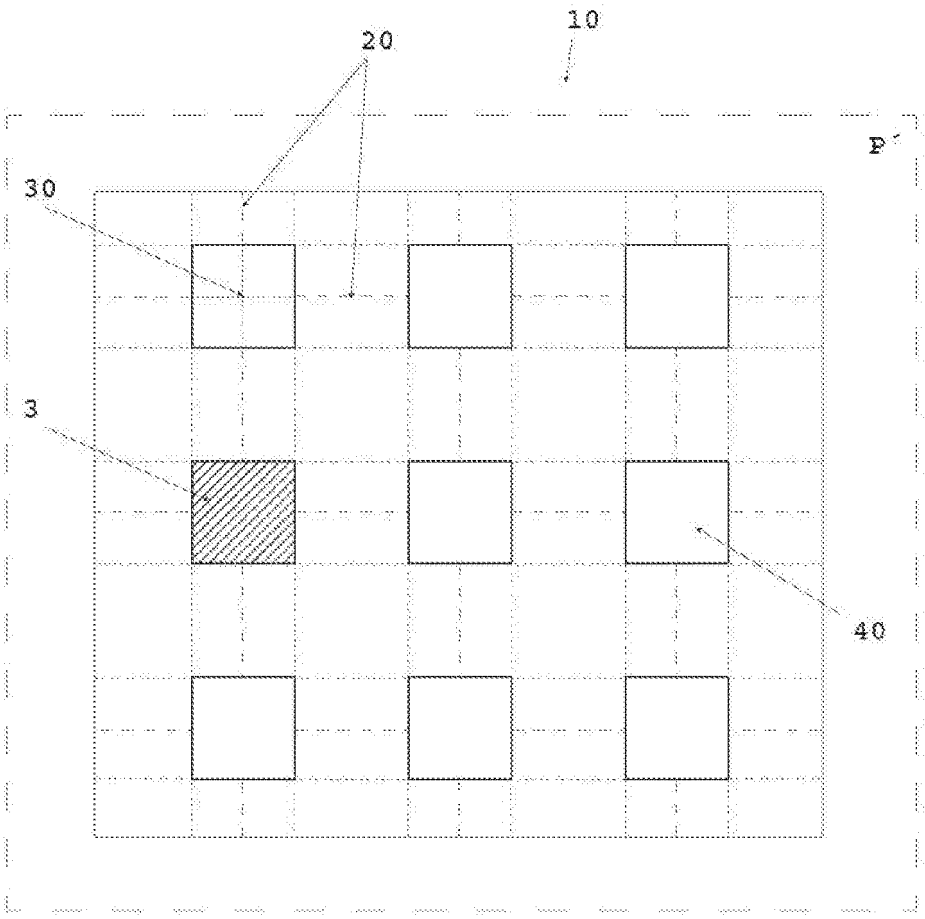

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/PT2016/050023

A. CLASSIFICATION OF SUBJECT MATTER
INV. B21D47/00 B21D11/20 B21D5/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 397 902 A (RESCH RONALD D) 9 August 1983 (1983-08-09) abstract; figures 1-5	1-15
X	US 5 162 143 A (PORTER CHRISTOPHER C [US] ET AL) 10 November 1992 (1992-11-10) abstract; figures 2,3	1-15
X	US 2007/015000 A1 (BURDON ROBERT L J [US]) 18 January 2007 (2007-01-18) abstract; figures 1,2,5,6,14	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
8 March 2017	16/03/2017

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/PT2016/050023

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