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(54) SEMI-CYLINDRICAL FLEXIBLE JOINT FOR GEODOME STRUCTURES

(57) The invention refers to a geometrical profile and to a flexible assembling method for the module-elements of a geodome construction. The semi-cylindrical flexible joint between two module-elements of a geodom, according to the invention, consists of the processing, on the entire length of the joint, of a convex semi-cylindrical T profile, respectively of a concave M profile, in such a way that the convex profile of the side of a module should assemble with the pair concave profile of the adjacent module. Thus, a self-supporting construction can be created, without the necessary inner beams or additional strengthening veins. In the pre-assembling phase, the sides of the assembling-fastening elements in contact are fastened in an intermediate position so that after the installation of all modules, these should auto-position themselves on the sphere of radius R as a result of the natural tendency of the minimum effort, retrieving and equally redistributing the execution inaccuracies to all modules; then, all connections will stiffen at the final fastening of the elements. In this way, a self-supporting construction is built, without the necessary inner beams or additional strengthening veins.

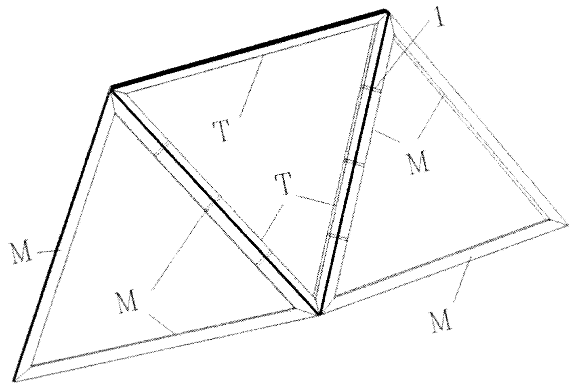

Fig. 2

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Description

[0001] The invention refers to a geometrical profile and a flexible assembling method for the module-elements of a geodome.

[0002] It is well known that the structure of a geodome attempts to reproduce the form of a spherical dome of polygons (rectangles, pentagons, hexagons), which can also be split into triangles of various sizes. A construction designed on such a structure is particularly appreciated because of the advantages offered by the fact that it represents a minimum area which encloses a maximum volume and also because of the advantage of being an isotropic structure for the mechanical external forces.

[0003] There are known mathematical procedures to determine the decomposition polygons, the form, the number and optimum size of polygonal and triangular elements, depending on the size and conditions of the desired location and on the destination of the construction. The way the structure is realized is difficult due to the angles of the jointing of edges and facets.

[0004] Two possible approaches are known in order for a construction to be carried out under the form of a geodome: by predefining the angles between edges in each node of their intersection using purpose-built connectors (there are different connectors known, such as: the star connector, patented in 2007 by Blair F. Wolfram, the conical connector, patented by Richard T. Robinson in 1983, the metal flower, patented by Heather Marie Hava 2013, etc.) and by predefining the dihedral angles between facets by means of creating triangular elements (modules) having their jointing facets appropriately inclined. If for the first method solutions with a high degree of flexibility were found, applicable in various decompositions and triangulations, the second method is less applied because the diversity of the dihedral angles between facets raises serious construction problems.

[0005] In general, most of the geodesic structures are made on a metal or wood frame support connected in the nodes of the intersecting edges. Most approach the geodome as a connected bar-structure, covered afterwards with various materials, and not as a reunion of inter-connected 3D objects. The main inconvenient of such structures is given by the assembling modality and, subsequently, by that of coating and insulation. Special connectors are needed for the peaks and the structure requires a metal or wooden-made frame, over which coating or insulation materials can be applied. Such structures have a high cost, generally a heavy weight, and are sometimes conditioned by the access to the assembling location of the equipment that could enable the handling of the materials.

[0006] There are also structures with curved decompositions of the spherical dome. Such an example would be the invention "SYSTEM AND ETHOD FOR MODULAR CONSTRUCTION OF A DOME STRUCTURE AND ASSEMBLY COMPONENTS FOR FACILITATING SAME" by Salah ELDELIB, No. WO 2008/014587 A1. The implementation of the structure requires a means of transportation, as well as assembling equipment dedicated to the construction. Another example is the invention called "MODULAR CONSTRUCTION FOR A GEODESIC DOME", belonging to the inventor James A Gavette, US Patent No. 5628154. The strength of the structure presented lies in the geodesic form that maintains a spherical shape, but which has the disadvantage that its rigid joint system doesn't allow a high flexibility in case of extreme external conditions.

[0007] A more similar example to the present suggested invention is the "Top-down method of assembling dome structures" belonging to James D McCarten, US Patent No. 07228671, which displays an original method of assembling a modular structure consisting of the carcasses of some modules (the interior part and, possibly, the insulation are to be installed afterwards) using a pulley device. The module elements out of which the structure is made have plane joint facets and, consequently, plane predefined dihedral angles from the modules' manufacturing moment (most likely by leaking into moulds).

[0008] The binding system of module elements exemplified in the above invention, although simple, brings about a number of disadvantages. First, it stiffens the structure and it makes it more vulnerable to extreme external elements. Another disadvantage is rendered by the fact that between the planes of two module-elements, there is a dihedral angle generated by the positioning of the peaks of the module-elements on the surface of the geodome's theoretical sphere. This dihedral angle must be made with sufficient precision so that the sides of two module-elements remain in contact after the assembly of all module-elements. This condition would mainly provide self-supporting, meaning that all module-elements would consistently retreive and transmit the mechanical forces given by the structure's weight and by the exterior forces, such as wind pressure, snow weight or frost, as well as it would meet the sealing condition. The constructive solution of the analysed invention has the disadvantage that the dihedral angle between two adjacent assembled modules is constructively predefined at a fixed value that does not allow angular positioning of the modules under real manufacturing and assembling conditions of the construction. This is likely to introduce internal tensions in the construction since its installation, which could lead to damaging the assembly profile, breaking the indexing profile, discontinuing the path of transmitting mechanical loads from one element to another element, and thus to overloading other elements and, eventually, to destructing the balance of forces within the structure.

[0009] Another disadvantage of the assembly system previously introduced consists of the fact that, for each decomposition (triangulation) chosen to build a geodome, the dihedral angles between the module-elements differ, so it is not possible to reach a serialisation of these modules, which leads to high execution costs.

[0010] A purpose of the present invention is to provide an assembly between module-elements which is no longer dependent on the value of the dihedral angle between the planes of two adjacent modules. In this way, it becomes a universal joint for all geodome modules, regardless of decomposition (triangulation).

[0011] Another purpose of the invention is to provide a profile for the joint between two module-elements which would allow the angular auto-positioning of the modules through redistributing and equalizing angular deviations caused by execution imperfections.

[0012] Another purpose of the invention is to provide a profile of the joint between two module-elements which would retrieve and evenly distribute the mechanical forces within the structure and which would ensure, at the same time, the sealing of the joint.

[0013] The semi-cylindrical flexible joint between two module-elements of a geodome, according to the invention, consists of the processing, on the entire length of the joint, of a semi-cylindrical convex or, respectively, concave profile so that the convex profile of the side of a module should get assembled with the pair concave profile of the side of the adjacent module.

[0014] Two neighbouring modules join the assembling-fastening elements of the sides that get into contact. In this this way, a self-supporting construction is created without being necessary for the inner beams or for the additional strengthening veins to exist.

[0015] In the pre-assembling phase, the assembling-fastening elements of the sides which come into contact are fastened in an intermediate position so that after installing all the modules they should auto-position themselves on the sphere, as a result of the natural tendency of the minimum effort, retrieving and equally redistributing to all modules the inaccuracies of execution; afterwards, all connections will stiffen in the final tightening stage of the assembling-fastening elements.

[0016] The auto-positioning is possible due to the concave/convex semi-cylindrical contact surface, between two adjacent modules.

[0017] To ensure also the sealing between the two semi-cylindrical contact surfaces a thin diaphragm made of a waterproof elastic material, such as a strip of rubber or plastic foil, will be inserted. This diaphragm will allow, in the pre-assembling stage, the sliding and auto-positioning of the sides of these modules in contact, after which, at the final fastening, the diaphragm will be crushed between the contact surfaces, taking on their unevenness and roughness, ensuring, on the one hand, the sealing, and on the other hand, an enhanced grip between the sides of the two adjacent modules.

[0018] The semi-cylindrical flexible joint between the module-elements of a geodome, according to the invention, has the advantage that it eliminates the difficulty of the strict implementation of the jointing dihedral angle of the elements, as well as the difficulties caused by the imperfections of the surface where the construction will be located.

[0019] Another advantage of the invention is that the semi-cylindrical profile is universally valid for all sizes of module-elements.

[0020] What follows is an example of the way in which the invention can be leaked into shape, without thereby limiting the applicability of the invention, in direct connection to the figures below, which represent:

Fig. 1 Overview of a geodome with triangular module-elements
Fig. 2 Assembly of side-by-side module-elements
Fig. 3 Display of module-elements on the sphere and on the dihedral angle between them
Fig. 4 Cross section through the M shaped frame of a module-element
Fig. 5 Cross section through the T shaped frame of a module-element
Fig. 6 Dihedral angle within the concave/convex semi-cylinder joint
Fig. 7 Semi-cylindrical surfaces with longitudinal channels applied

[0021] The module-elements that give the best approximation of the theoretically spherical surface of the geodome are the triangles (**Fig. 1, Fig. 2**). Depending on the required application, the structure can be adapted by changing the number of component modules and module size. Triangles assembling is carried out by fastening the adjacent sides (**Fig. 2**) with some fastening elements **1**. Under these conditions, between the flat surfaces of triangular module-elements the dihedral angle α appears (**Fig. 3**).

[0022] It can be seen that, for a family of geodomes, using the same module-element, but increasing or decreasing the number of module-elements, and/or proportionally changing the length of the sides, the dihedral angle α encompassed in the range (**166°- 173°**) enables the peaks to fit on the surface of the sphere; in addition, with the same geodome, the classification in the range $\Delta\alpha$ = (166°-173°) satisfactory covers the execution of the module-elements with an acceptable economic precision.

[0023] The adjacent sides are processed with semi-cylindrical coupling profiles of a concave/convex type, marked "M" (**Fig. 4**) or "T" (**Fig. 5**).

[0024] The processing of the longitudinal semi-cylindrical concave surface "M" of radius **R** (**Fig. 4**) is made at a **h<R** depth, so that the centre of the cylinder of radius **R** is at a distance **X** from the frontal surface of the ruler (**R=h+X**). At the intersection of the frontal surface of the ruler and the semi-cylindrical concave surface, a generator **A** appears.

[0025] The processing of the longitudinal semi-cylindrical convex surface "T" of radius **R** (**Fig. 5**) is made following the depth **R** so that the connection of the semi-cylinder with the side of the ruler should be made according to a generator **B**.

[0026] By assembling the T-M profiles of the sides of two side-by-side module-elements (**Fig. 6**) it can be seen that the dihedral angle α can have the minimum value when the generator A of the convex profile T gets into contact with the generator **B** from the concave profile M.

[0027] Taking into consideration the minimum value α**=166°**, hence β**=14°**, and by an elementary trigonometric calculation it results that the maximum value that X can have is X=R* sin 14°, respectively X=0.24*R. (**Fig. 6**), the depth of the processing cavity being h=0.76*R. Using the same reasoning, it appears that the mounting surface, as the contact area that retrieves and transmits the mechanical forces into the structure, in the case of the semi-cylindrical assembling, is **32,5%** higher than if the module-elements had the flat contact surfaces inclined at the same angle.

$$\text{L. mounting} = (180-2^*\beta)^*\pi^*R/180=2.65^*R=2R+0.65R=2R+\mathbf{0.325^*2R}$$

[0028] Between the two semi-cylindrical contact surfaces there may be interposed a thin elastic and waterproof diaphragm **2** (**Fig. 6**). This diaphragm would allow, in the pre-assembling phase, the sliding and auto-positioning of the sides of the modules in contact, and after that, in the final fastening stage, it would be crushed between the contact surfaces taking on their irregularities and roughness, thus providing at first their sealing and then an enhanced grip between the sides of two adjacent modules.

[0029] To increase the capacity of retrieving and redistributing the mechanical forces occurring in the geodome's structure, the semi-cylindrical surfaces can be processed with triangular longitudinal grooves or of other forms, which, at the final fastening of the assembling, will engage/get fixed between them (**Fig. 7**)

Claims

1. Flexible semi-cylindrical joint for a geodome structure **characterised by** the fact that the contact sides of the two module-elements are profiled along their entire length according to a semi-cylindrical form of radius R, concave of type M or convex of type T.

2. Flexible semi-cylindrical joint for a geodome structure **characterised by** the fact that the concave shape processing is done to a depth of 76% of the radius R of the cylinder.

3. Flexible semi-cylindrical joint for a geodome structure, according to claims 1 and 2, **characterized by** the fact that in the pre-assembling phase it enables the angular auto-positioning of the module-elements with the equalization of the dihedral angles and the uniform distribution of the mechanical forces across the structure.

4. Flexible semi-cylindrical joint for a geodome structure, according to claims 1, 2 and 3, **characterized by** the fact that the entire structure is self-supporting and does not require additional support and consolidation frames.

5. Flexible semi-cylindrical joint for a geodome structure, according to claims 1 and 2, **characterized by** the fact that it favours the realization of a geodome family, with different diameters, the dihedral angle between the two modules between 166° and 173° using the same module-elements, but in different amounts.

6. Flexible semi-cylindrical joint for a geodome structure, according to claims 1 and 2, **characterized by** the fact that between the two semi-cylindrical coupling surfaces there can be applied a waterproof elastic sealing foil to increase the adherence between the semi-cylindrical surfaces in contact.

7. Flexible semi-cylindrical joint for a geodome structure, according to claims 1 and 2, **characterized by** the fact that on the two semi-cylindrical coupling surfaces there can be processed some longitudinal grooves, triangular or of other shape, which, at the final fastening of the assembly, will engage each other.

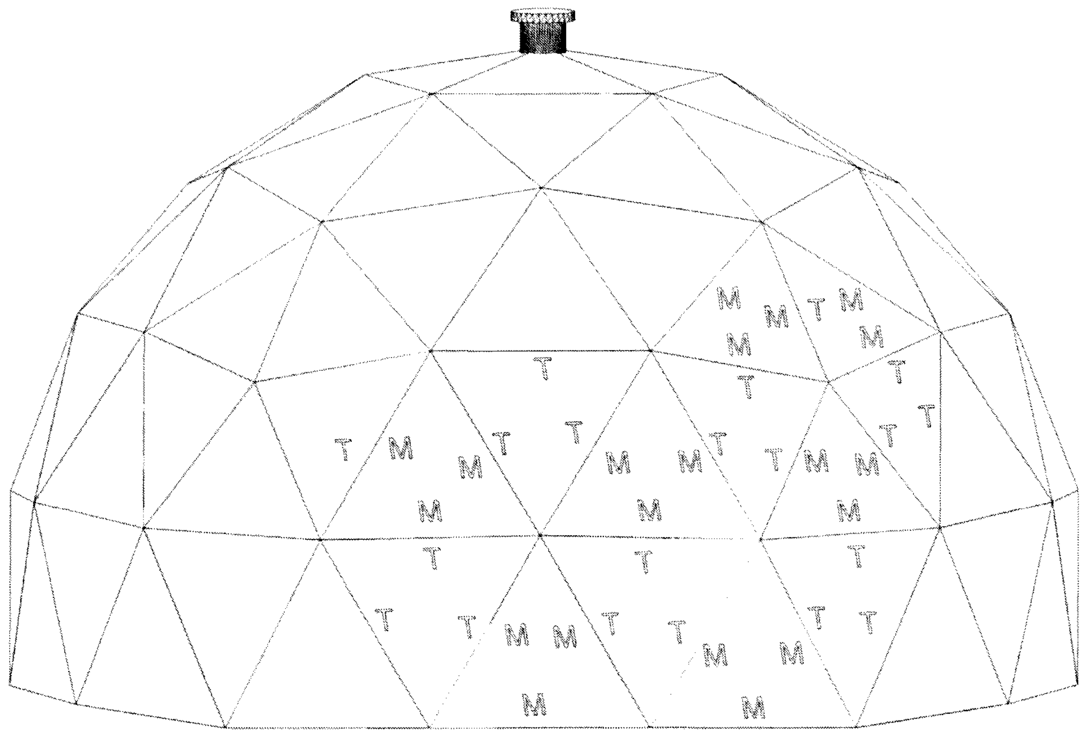

Fig. 1

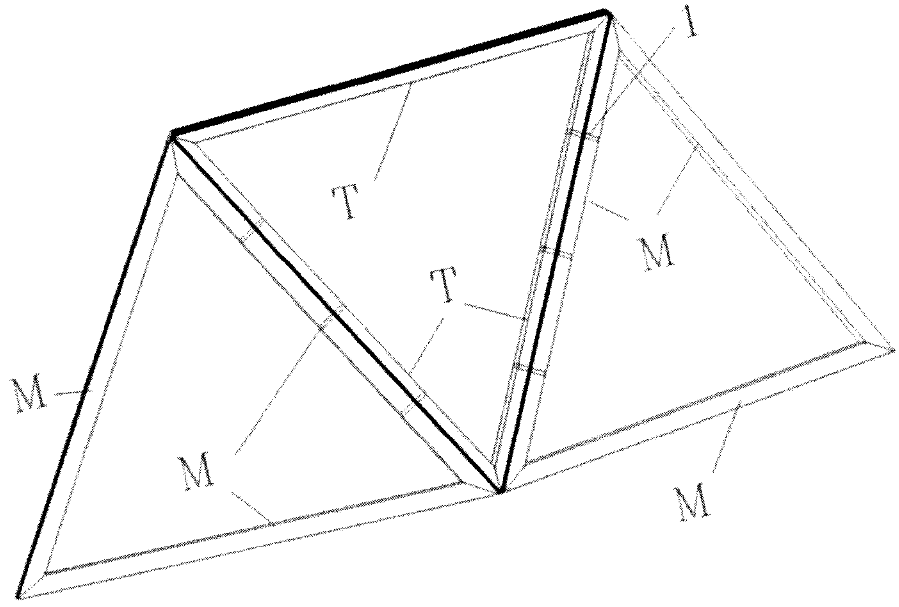

Fig. 2

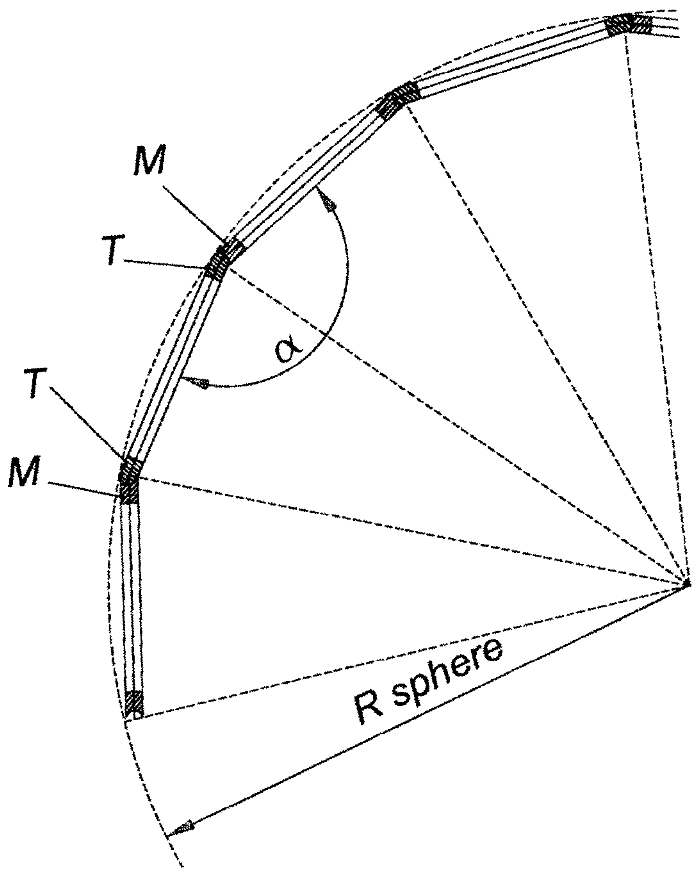

Fig. 3

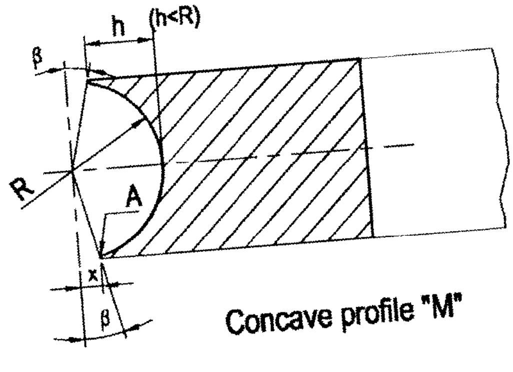

Fig. 4

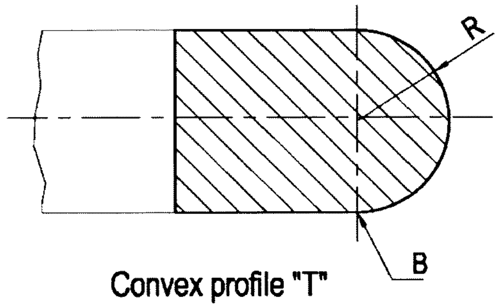

Fig. 5

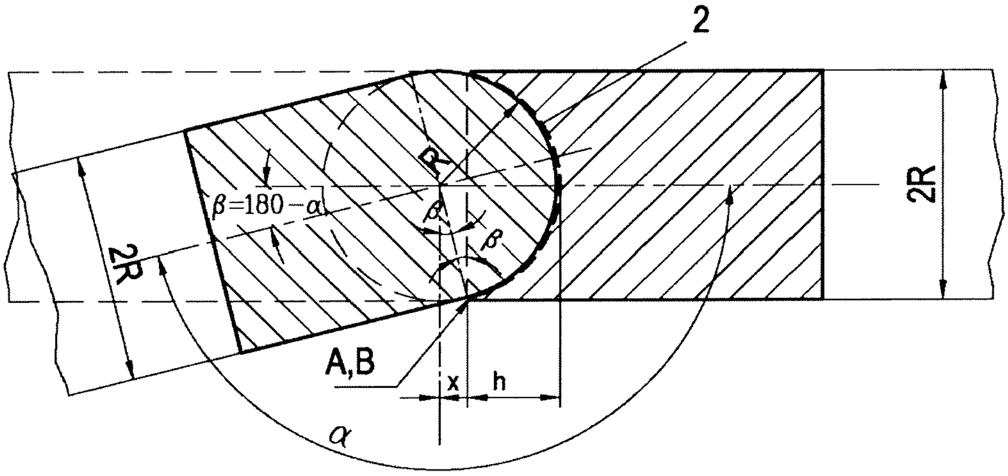

Fig. 6

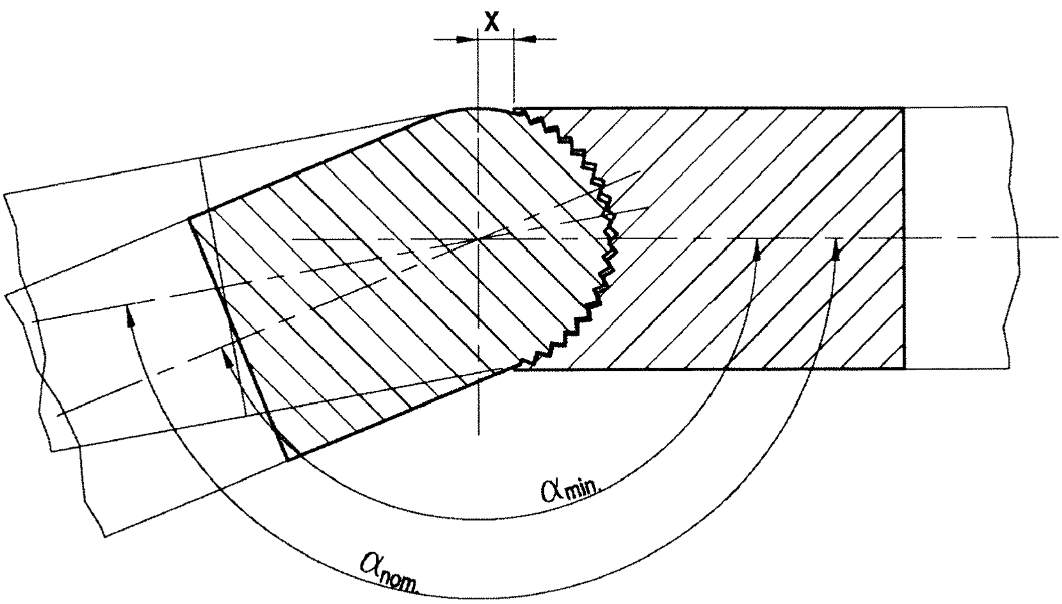

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 15 46 4005

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	BE 399 434 A (P. VERDIER) 30 November 1933 (1933-11-30) * page 1, line 1 - page 5, line 1; figures 1-5 *	1-6	INV. E04B1/32
X	WO 97/39201 A1 (HAVELOCK EUROPA PLC [GB]; IZATT ALAN DOUGLAS [GB]; WELDON RONALD JAMES) 23 October 1997 (1997-10-23) * page 6, line 1 - page 8, line 17; figures 1,4 *	1,7	
			TECHNICAL FIELDS SEARCHED (IPC)
			E04B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	21 September 2015	Delzor, François

CATEGORY OF CITED DOCUMENTS

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21-09-2015

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- US 07228671 B, James D McCarten **[0007]**