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(54) **A system for manufacturing substantially rigid and self-supporting network structures**

(57) A system for manufacturing substantially rigid and self-supporting three-dimensional and two-dimensional

space frame structures starting from a plurality of substantially flexible connection elements (3) connected by joining means (2).

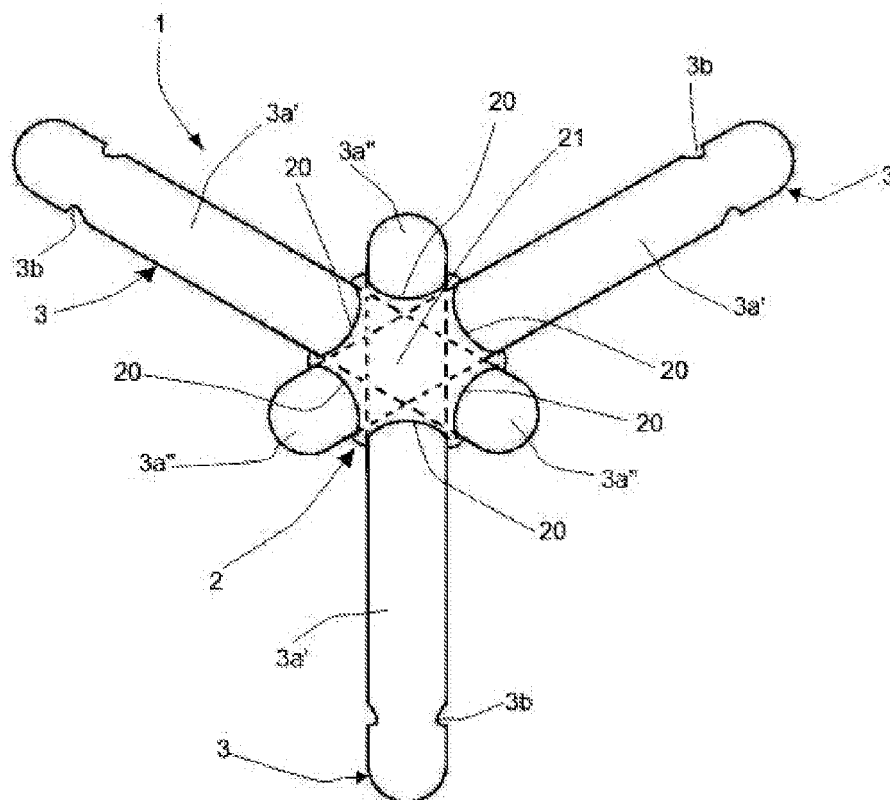


Fig.1

Description

DESCRIPTION

[0001] The present invention refers to the field of furniture and more specifically to objects such as lampshades, structures for supporting frames and/or lampsockets, decorative elements etc. In particular the invention concerns a system for providing self-supporting and substantially rigid furniture elements and objects such as those mentioned above.

[0002] In particular, the users feel stronger and stronger the need for an aesthetically valuable and customizable product that can be simply modified in accordance with changes brought in the furniture style and design of the room.

[0003] Considering the continuous evolution of the market and fashion, the search is very active for a new solution offering results susceptible of particular appreciation compared to the products currently available in the field of the furniture, in order to satisfy the request for originality by the clients/users

[0004] For these reasons, the furniture field is crowded with the most different solutions, aiming at anticipating the wishes and the tastes of the user, in terms of an effective design, customisation and of the possibility of customizing the product without affecting the practical and functional aspects of the product.

[0005] The current trend is providing products with complex shape and which are simultaneously capable of offering a sense of lightness and fluidity and, furthermore, which are made of biological or recyclable material.

[0006] The user is more oriented to buy innovative and especially customisable products or even "do it yourself" products; actually, the user finds pleasure and satisfaction at personally manufacturing the structure, such as for example a furnishing element. The user can obtain products customised according to own taste and ability after an assembly operation from which the user also finds satisfaction and fun.

[0007] Particularly appreciated objects which at least partly meet the needs related to customisation, design and lightness mentioned above are two-dimensional and three-dimensional space frame structures that are provided through assembly of rigid elements with flexible joints.

[0008] Two and three-dimensional space frame structures are formed by the assembly of a plurality of connection elements arranged mutually spaced and tilted (with variable angle) so as to form two-dimensional or three-dimensional objects. An example of this type of structures is described in WO93/04750. The structures that can be obtained from the elements described in WO93/04750, are three-dimensional structures with flat faces which provide a rigidity and typically geometric effect; this type of structures poorly meets the aesthetic needs of the user, who prefers more smooth and fluid structures. In addition, all the flat faces of the three-di-

mensional space frame structure have equivalent sides, hence the faces have substantially the same surface extension. In addition, the structure, though self-supporting, is not sufficiently rigid to be able to support the weight of objects such as lamp shades and frames: so the structure results unable for interior furniture purpose.

[0009] In accordance with the present invention, a system for manufacturing furniture elements is provided that reaches the aforementioned objects for obtaining a surprisingly efficient result in terms of functionality as well as originality and valuable aesthetic effect.

[0010] Furthermore, the object of the present invention is to provide structures that are easy to customise and which also obtain a surprisingly efficient result in terms of innovation and design.

[0011] Such objects are achieved by a system for manufacturing substantially rigid and self-supporting space frame structures according to the invention and by a respective connection joint, whose essential characteristics are defined in the first and tenth of the attached claims.

[0012] The characteristics and advantages of the system according to the present invention will be apparent from the following description of an embodiment thereof, given as a non-limiting example with reference to the attached drawings, wherein:

- figure 1 is a front view of a node of the system according to the invention;
- figure 2 shows a front view of the joint according to the invention of the node shown in figure 1;
- figure 3 is a front view of a rod of the system according to the invention;
- figure 4 shows an example of a two-dimensional structure comprising a plurality of nodes of figure 1;
- figure 5 is a view of an example of a spherical modular element comprising a plurality of nodes according to figure 1;
- figure 6 shows a three-dimensional space frame structure assembled starting from a plurality of rods and joints of the system according to the invention; and
- figure 7 is a further embodiment of the joint of figure 2.

[0013] With reference to the above figures, a system for providing two-dimensional or three-dimensional space frame structures according to the present invention comprises a plurality of substantially flexible connection elements such as rods 3; The rods 3 are connected to each other through joining means such as, for example, flat joints 2. As will become clearer later, in the preferred embodiment, the joint is sufficiently deformable to allow the insertion and the connection of the rods; in addition, the joint is substantially flat when it is not stretched.

[0014] In the present description the definition of each connection element as substantially flexible is used to indicate an elastically deformable connection element, mainly to the longitudinal flexure and torsion; at the same

time, the connection element is substantially resistant to be adapted for manufacturing sufficient rigid and self-supporting structures.

[0015] A node 1 of the two-dimensional or three-dimensional structure comprises each joint 2 and the plurality of rods 3 connected thereby, as illustrated in figure 1.

[0016] The term rod in the present description is used to indicate any substantially elongated connection element adapted to be connected through said joints to manufacture two-dimensional or three-dimensional structures according to the present invention.

[0017] As shown in figure 2, cuts 20 are provided on a flat joint 2; the cuts 20 are arranged in a symmetrical and opposite fashion on the surface of the joint so as to define couples of symmetrically opposite cuts. In the example shown in figure 2 and according to the preferred embodiment, the joint 2 is hexagonal shaped and the cuts 20 are arranged substantially parallel to each of the sides 2a defining the joint. Though the joint 2 may have a number of cuts equivalent to the number of sides of the joint, the hexagonal shape is particularly advantageous in that, preferably, a joint according to the invention is provided with at least six cuts so as to connect at least three rods 3.

[0018] As shown in figure 1, the rods 3 are inserted in the joint 2 so as to cross each a respective couple of symmetrically opposite cuts 20 and so as to be mutually overlapped within the joint.

[0019] In detail, each rod 3 has dimensions such to be inserted in the cuts 20; in the example of figure 1 or 3, each rod 3 is substantially an elongated bar with rectangular cross-section and sufficiently flat (i.e. with a high length/thickness ratio) so as to result insertable into the cuts 20. Furthermore, each rod 3 also has a width comparable to the length of each cut 20, so that the rod can be inserted into the cut with a slight lateral interference.

[0020] The joint 2 thus provides a reversible connection of the rods 3; in fact the rods 3 are constrained within the joint first by the forcing that each of the cuts 20 exerts on the single rod 3 and then by the mutual interference action that each rod exerts on the others within the joint in correspondence of a portion 21 of the joint; the portion 21, corresponding to the part of the joint where the rods overlap each other, is delimited by the cuts 20. More in particular, each rod prevents the sliding of the others adjacent rods by a friction action.

[0021] Given that the joint is preferably made of deformable material, the rigidity of the constraint - represented by the joint - increases proportionally to the number of rods that are connected therewith. The joint increases the constraint among the rods and prevents the mutual sliding thanks to the increase of the friction between the surfaces of the adjacent rods. Therefore, the rigidity of the structure proportionally increases as the number of rods linked by each joint (because the stress on the joint increases and thus the force that the joint exerts on the rods). Thus, the rigidity of the structure

increases proportionally to the number of the rods, and the joint opposes the sliding off of the rods.

[0022] The rod portions projecting from the joint 2 define arms and in particular each rod defines two arms 3a' and 3a". As follows from what the previously described, each rod 2 may slide within the joint 1 so as to modify the length of the arms 3a', 3a".

[0023] As previously mentioned, making complex structures (bi-dimensional or three-dimensional structures) necessarily requires assembling a plurality of joints and rods to form a plurality of connection nodes. Each node 1 comprises a joint 2 and the rods 3 connected thereto; in figures from 1 to 7, according to the preferred embodiment, each node comprises a joint 2 and three rods 3. The opportune assembling of the nodes permits to manufacture flat or spherical geometric elements; the further assembling of these elements permits to manufacture complex three-dimensional space frame structures which are self-supporting and substantially rigid thanks to the resistance of the rods and thanks to the variable rigidity of the constraint given by the substantial flexibility of the joint; in view of the above, the structures can be used for supporting elements such as lamp holders, frames etc.. For example, figure 4 shows a hexagonal flat element 6 i.e. consisting of six nodes.

[0024] In detail, three rods 3 are connected on each joint 2 of each node 1. Respectively a first rod 3' provides for the connection between the joint 2 and the subsequent adjacent joint 2' thereof; similarly, a second rod 3" provides for the connection between the joint 2 and the previous adjacent joint 2" thereof; the third and last rod 3''' of each node is free in this configuration. Such sequence is repeated up to the complete formation of the desired modular element. Usually, in order to form any modular element made up of a n number of sides requires n nodes and in particular n joints and 2n rods (for example to realize the hexagonal element of the figure six joints and twelve rods are required).

[0025] Starting from such modular elements it is possible to create space frame structures having flat geometric shapes or having particular degrees of curvature. As known, modular elements with six sides (i.e. made up of 6 nodes) are flat. On the contrary, modular elements with a number of sides lower than six (made up of less than six nodes, for example pentagonal element 5 shown in figure 5) take on a spherical or partly spherical shape. Moreover, modular elements with a number of sides greater than six (made up of more than six nodes) take on opposite spherical shapes, with different angle. Such behaviour is due to the simultaneous deformability of the rods and of the joint. The more the joint is rigid, the more the rods require to be made of more flexible material so as to be able to align with the couple of symmetrically opposite cuts 20 and thus to be able to cross the joint; the flexure and torsion of the rods imply that the modular element becomes spherical.

[0026] As previously mentioned, assembling the described modular elements to each other allows to create

any type of structure and/or shape such as for example the structure of figure 6 (for example the figure shows pentagonal 5 and hexagonal 6 modular elements connected to each other).

[0027] In particular the previously described free rods 3''' are used for connecting two modular elements. For example free rods 3''' of each modular element are connected to each other by a further joint 2 to form an intermediate mutual node between the modular elements.

[0028] Thus, making complex three-dimensional structures (such as for example a complete sphere) using pentagonal and hexagonal modular elements, requires sixty nodes and ninety rods i.e. a number of nodes equivalent to 2/3 of the number of rods.

[0029] As mentioned, the joint does not prevent the translation of the rods along the main direction of development thereof, hence - regarding the cuts 20 - such sliding allows varying the projection of the arms 3a', 3a''. However, grooves 3b are provided on each rod so as to prevent the unintentional sliding of the rod outside the joint 2. The grooves are arranged at both ends of the rod to define a central portion 3c of the rod (figure 3). Thanks to the grooves 3b, the rod can slide inside the joint only within the central portion 3c.

[0030] As mentioned previously, the rigidity of the constraint between the rods and the joint proportionally increases as the number of connection elements associated to the joint increases. This is due to the deformability of the joint which, under the effect of the pressure exerted by a greater number of rods, tends to deform, simultaneously tensioning the constraint and hence increasing the rigidity thereof.

[0031] However, the same effect is also obtained with a rigid joint: in this case, the greater stability of the rods within the joint and the stability of the constraint is given by the number of rods connected to the constraint; the number of rods that can be inserted in the joint depends on the sum of thicknesses of the rods.

[0032] The previously described system presents various advantages. Firstly, it allows making three-dimensional structures - also complex - starting from the simple and intuitive assembly of structurally basic elements such as rods and joints; due to the elastic deformability and simultaneous supporting capacity of the rods and rigidity of the constraint, the obtained structure is substantially rigid and self-supporting, thus it does not require hooks or external supports but, in case of a three-dimensional structure, it can be simply placed on the ground.

[0033] As mentioned, the rod must to be sufficiently flexible to be inflected so as to follow the curvature imposed by the constraint and by the association with the other nodes to form curved three-dimensional structures etc.

[0034] Such flexibility can be provided by the material the rod is made of or possibly by the low ratio between the thickness and the length of the rod, which is flat (or thin) and thus more flexible.

[0035] Thanks to the sliding of the rods within the joint,

the obtained three-dimensional structure can be reduced or expanded, i.e. the nodes can be closer or more spaced depending on the shape that the user desires to obtain.

[0036] The structure is such that it does not collapse, even in the absence of a joint, but the remaining constraints however allow the tensioning required to maintain the desired shape.

[0037] The assembly can be supported by a series of assembly diagrams that are intuitive and easily understandable by a user.

[0038] Assembling the above-described elements the user will be able to create entirely personal and original shapes and structures, with great satisfaction and fun.

[0039] A further advantage of the system according to the invention lies in the fact that the manufactured structures can be assembled/disassembled many times, so that the user can vary the structure according to own taste (or, for example, according to the changing in the furniture of the house). This is possible because the connection between rods and joint is reversible.

[0040] A further advantage is that the system according to the invention enables the formation of extremely light structures, exclusively made up of an external framework, hence the obtained space frame structures are internally hollow. The absence of internal support elements permits the insertion of lighting means, such as for example lamp-holder elements, so as the structure can be used as lamp shades or a lighting structure in general. Regarding this, fastening means can be provided on the joint, for example hooks to attach the structure to the ceiling or generally to the wall, in case the structure is used as a lamp shade.

[0041] In addition, the described structures can be used as flowerpot holders or support structures for climbing plants, photographs and any other type of use selected by the user.

[0042] The joint can be also modified as shown in figure 7, in order to increase the lightness effect and reduce the visual impact.

[0043] Figure 7 shows a different embodiment of a joint 200 in which a plurality of ribs 201 are connected by a perimeter edge 202. The edge 202 and the ribs 201 create openings 203 through which the rods 3 are inserted. The openings 203 are, analogously to the cuts 20, arranged symmetrically opposite. According to figure 7 the joint can be hexagonal-shaped; in this case, the ribs depart from each respective angle defining six slice-shaped openings. The joint 200 can also be made of materials having a very low elasticity since the described embodiment allows obtaining a more deformable joint and also sufficiently resistant to stably connect the rods.

[0044] As mentioned above, even though in the preferred embodiment the joint has six sides for a total of three couples of symmetrically opposite cuts, joints with a greater number of sides can also be provided for; the couples of symmetrically opposite cuts shall thus be $n/2$, where n is the number of sides of the joint. The joint may also be possibly circular-shaped: the cuts in this

case represent the sides of a polygon inscribed within the perimeter of the joint. It is thus obvious that the limit to the number of rods that can be inserted within the joint is given by the sum of thicknesses of the rods as a function of the deformability of the joint.

[0045] The joint can also be coloured or have particular decorations, to be further customised by the user. Similarly, also the rods can be natural coloured, depending on the material used to make them, or coloured, to create customised colour effects.

[0046] Even though in the described example the rods have a rectangular cross-section, it is obvious that rods having different cross-section such as for example circular, hexagonal etc, can be provided for. The shape should however be such to meet the longitudinal flexibility and rod torsion requirements.

[0047] The rods can be made of wood, metal, leather, Plexiglas, cardboard, vegetable fibres (such as for example bamboo fibre), plastic or any other material suitable for the purpose and normally used in architectonic and/or design productions. In any case any type of material may be used; in particular can be used materials sufficiently resistant to be able to withstand the weight of the structure and thus to provide a self-supporting structure, while having a given degree of flexibility so as to adapt to the curvature in case of the three-dimensional structure. The rods may also have length and width variable from a few millimetres to tens of centimetres. The dimensions of the joint and more generally the dimensions of the obtained structure shall depend on the dimensions of the rods.

[0048] The joint may be made of any substantially flexible material. In particular, the joint is sufficiently flexible to allow the insertion of the rod: actually, for such purpose, each cut should deform sufficiently to allow the overlapping of the rods within the joint and simultaneously, the joint should be sufficiently flexible to contain a number of rods equivalent to the number of the couples of cuts formed on the joint. Obviously, the greater the number of the couples of cuts and the number of rods, the greater the stress to which the joint is subjected; the joint will reach a stress degree such to attain the deformability limit, hence, as mentioned previously, the rigidity of the constraint increases proportionally to the number of rods interconnected by the constraint.

[0049] Usually, the materials used for making the joint are plastic, textile, leather, rubber, synthetic leather, cardboard, fabric material etc.

[0050] However the joint can also be rigid, for example being made of rigid plastic, PVC etc. In this case, the greater the rigidity of the joint, the greater the flexibility of the connection elements shall be.

[0051] In view of the above, the system is extremely inexpensive given that the joints and rods can also be made using inexpensive materials such as, and preferably, wood and leather. Actually, the use of such materials allows obtaining extremely light structures. Furthermore, they also meet the current design trends which

favour the use of ecological and biodegradable materials.

[0052] The system can also be sold as a kit separately containing the joints and the rods in a variable number.

[0053] Each kit contains the number of rods and joints sufficient to provide a particular structure. More generally, the kit can be sold as a "do it yourself" kit or as a playing and fun object. Actually, the system can also be used as a game or learning instrument for example in schools and educational centres. In particular, suitably reducing the dimensions of the rods and joints allows obtaining board games with thousands of pieces and infinite embodiment possibilities.

[0054] Lastly the kit could be sold with simple pre-assembled two-dimensional elements, such as hexagons so as to quicken the assembly of large structures.

[0055] The system can also be used in the production of structures for urban furnishing (such as fences or hedges or architectonic works in general).

[0056] The present invention has been indeed described with reference to a preferred embodiment. It should be understood that there can be other embodiments that belong to the same inventive concept, as covered by the scope of protection of the following claims.

Claims

1. A system for manufacturing self-supporting and substantially rigid three-dimensional or two-dimensional space frame structures starting from a plurality of substantially flexible elongated connection elements connected through joining means, said system being **characterised in that** said joining means are flat joints (2), each joint (2) being provided with symmetrically opposite cuts (20) in even number so as to define couples of said symmetrically opposite cuts (20), each of said substantially flexible connection elements (3) being associable to each of said couples of symmetrically opposite cuts, so that said connection elements (3) cross said joint (2) being mutually overlapped so as to result adjacent in correspondence of a portion (21) of said joint delimited by said cuts (20); the connection between said joint (2) and said elements (3) being reversible.
2. The system according to claim 1, wherein said flat joint (2) is hexagonal shaped and said cuts (20) are substantially parallel to each side (2a) defining said joint (2).
3. The system according to claim 2, wherein said connection elements (3) are elongated rods (3) substantially flat with a rectangular cross-sections and thickness such to be inserted in said cuts (20), said connection elements (3) having also width such to be inserted in said cuts with slight lateral interference.
4. The system according to claim 3, wherein grooves

(3b) are provided in each of said rods (3) to prevent the unintentional sliding of the rod outside the joint (2), said grooves (3b) being formed in proximity of ends of said rod to define a central portion (3c).

5. The system according to any of claims 3 and 4, wherein, each rod (3) prevents through a friction action the sliding of the others adjacent rods in said joint (2).
6. The system according to claim 5, wherein said joint is made of substantially deformable material, said joint (2) exerting on said rods (3) a constraint having increasing rigidity with the number of rods (3) simultaneously engaged in said joint, said joint exerting a compression force on said rods (3) internally overlapped so as to mutually forces them and increases the mutual friction action thereof.
7. The system according to any of claims 3 to 6, wherein said substantially flexible rods (3) are made of a material such as wood, plastic material, metal, etc.
8. The system according to any of the previous claims, wherein said joint (2) is made of substantially deformable material such as leather, fabric, etc.
9. The system according to any of claims 1 to 8, wherein said joint is made of rigid material such as plastic, PVC, etc.
10. A joint for the connection of substantially flexible elongated connection elements (3) for the manufacturing of three-dimensional and two-dimensional self-supporting and substantially rigid space frame structures **characterised in that** said joint is provided with symmetrically opposite cuts (20) in even number so as to define couples of said symmetrically opposite cuts (20), each of said couples being associable to one of said connection elements (3), so that a plurality of said connection elements (3) numerically equivalent to said couples crosses said joint (2), said connection elements (3) being mutually overlapped so as to be adjacent in correspondence of a portion (21) of said joint delimited by said cuts (20); the connection between said joint (2) and said elements (3) being reversible.
11. The joint according to claim 10, wherein said joint is hexagonal shaped and said cuts (20) are substantially parallel to each side (2a) of said joint (2).
12. The joint according to claims 10 and 11, made of substantially deformable material, such as leather, fabric etc, said joint exerting on said connection elements (3) a constraint having increasing rigidity with the number of connection elements (3) simultaneously engaged inside it, said joint exerting a com-

pression force on said connection elements (3) internally overlapped so as to force mutually them and to increase the mutual friction action thereof.

13. The joint according to claims 10 and 11, made of rigid material such as plastic, PVC etc.
14. A kit for making three-dimensional and two-dimensional self-supporting and substantially rigid space frame structures comprising a joint according to any one of claims 10 to 13 and connection elements such as substantially flat elongated rods (3) with rectangular cross-sections and with thickness such to be insertable in said cuts (20), said rods (3) also having width so to be insertable into the cuts with a slight lateral interference.
15. The kit according to claim 14 comprising two-dimensional and three-dimensional structures made starting from a plurality of said connection elements (3) and said joints (2).

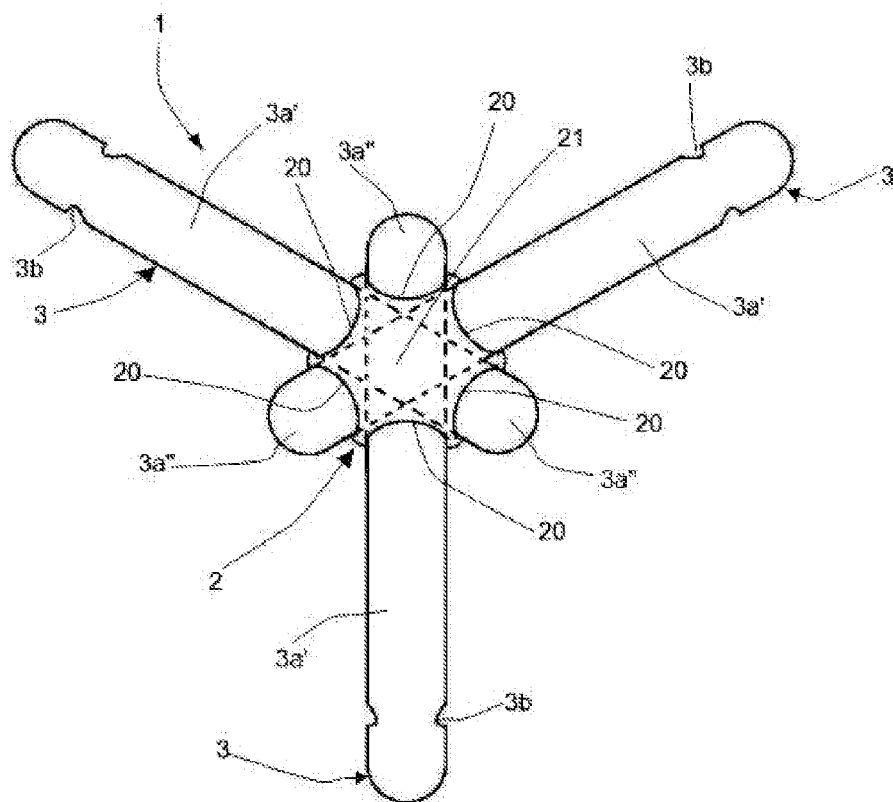


Fig.1

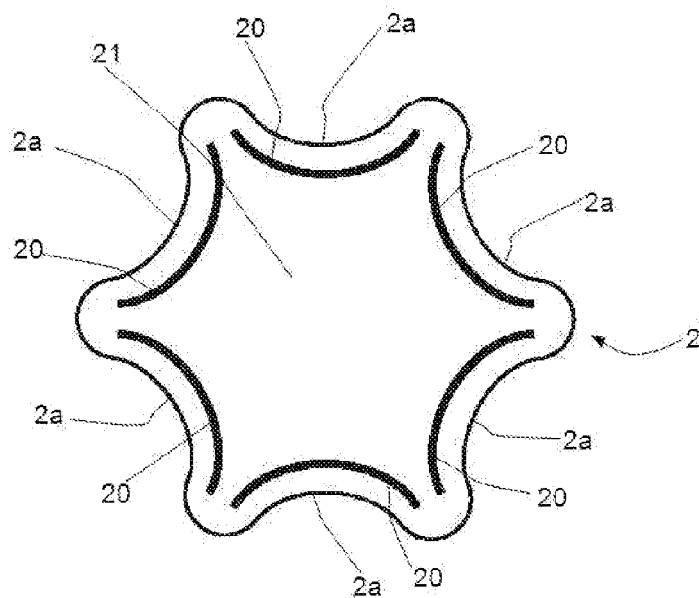


Fig.2

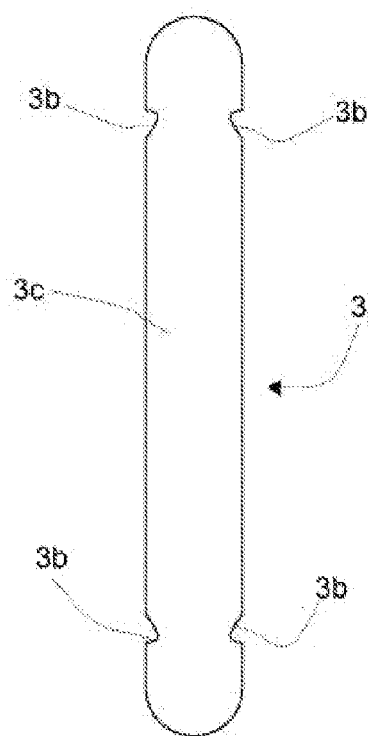


Fig. 3

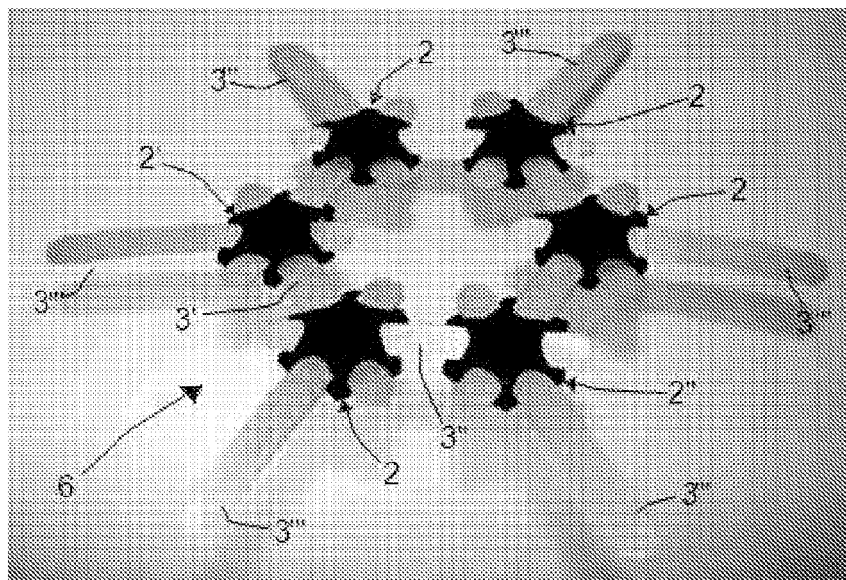


Fig. 4

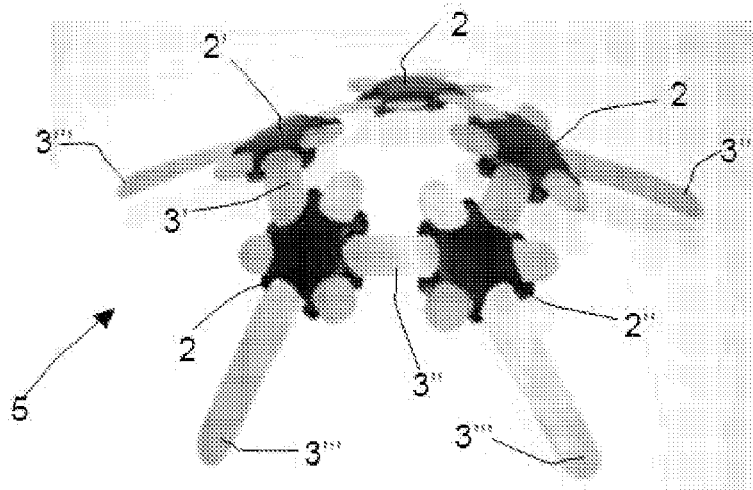


Fig. 5

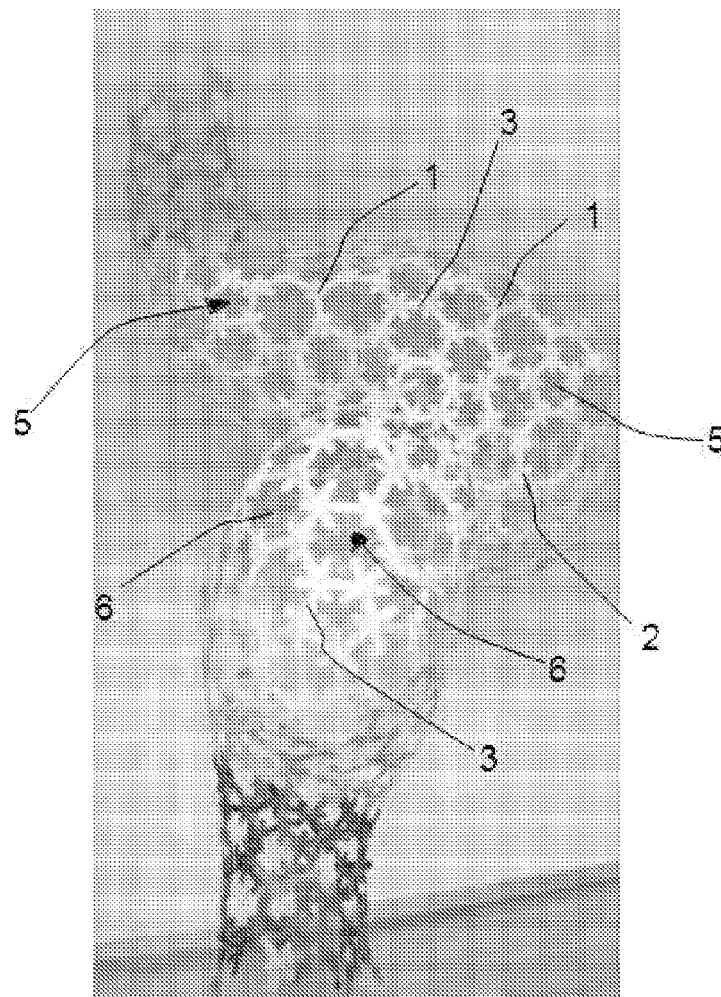


Fig. 6

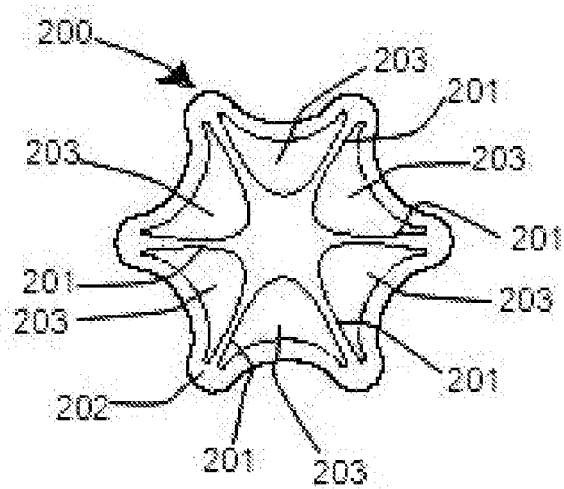


Fig. 7



EUROPEAN SEARCH REPORT

Application Number
EP 11 16 5918

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 2 September 2011	Examiner Shmonin, Vladimir
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 11 16 5918

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02-09-2011

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

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