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(54) **Connecting device for reticular spatial structures, and reticular structures employing such devices.**

(57) This invention concerns a connecting device (10) for reticular spatial structures having nodal junctions to connect rods (14), said device being able to form said nodal junctions (16, 116) of said structures and comprising a middle area (11) of a substantially quadrangular shape, to which are connected four other perimetric areas (12) sloped at 45° to the plane on which said middle area (11) substantially lies, so that the assemblage of six of said devices (10) forms a nodal junction element (16, 116) having a geometric shape substantially comparable to a parallelepiped.

The invention also concerns reticular spatial structures comprising nodal junctions (16, 116) formed with the device of the claims hereinbefore.

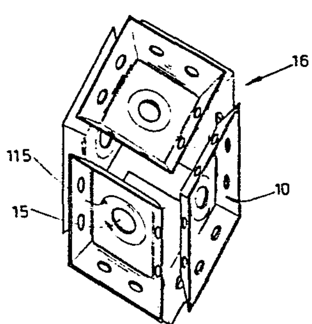

fig.2 a

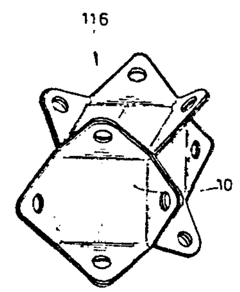

fig 2 b

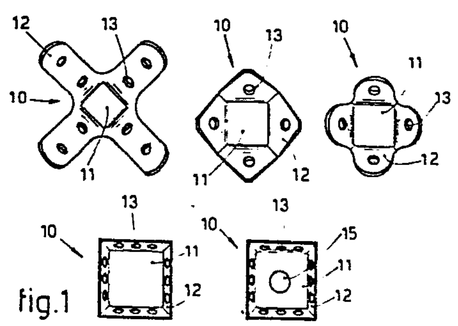

fig.1

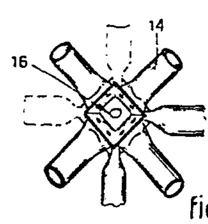

fig 8a

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Description of the invention entitled:
"CONNECTING DEVICE FOR RETICULAR SPATIAL STRUCTURES, AND RETICULAR STRUCTURES EMPLOYING SUCH DEVICES"
in the name of Alfonso VOCCA at Eboli (SA).

This invention concerns a connecting device for reticular spatial structures and also concerns structures set up with said device.

To be more exact, this invention concerns a device able to form nodal junctions for connecting the rods in reticular spatial structures, which we shall also call grills or lattices hereinafter.

The invention also concerns grills of which the nodal junctions are obtained by fitting together the devices of the invention.

Reticular spatial systems have made considerable progress over the last ten years owing to the high technology employed in making the materials, to the highly precise processing methods and to the use of computers for the methods of calculation.

Connections, anchorages and supports for the remainder of the structure are covered in the acknowledged standards of engineering. All building materials used in resisting, enclosing and covering structures are adapted to said standards.

Spatial latticework and structures with a cubic mesh have a very great field of employment. A few examples thereof are flat roofing, or roofs of several pitches or in steps or of a pseudocupola type, etc. having small, medium and big. spans for cantilever roofs, parking lots, sheds, service stations, motels, workshops, churches, swimming pools, gymnasia, bowls courts, bowling alleys, tennis courts, buildings for restaurants, shops, supermarkets, areas for shows, exhibitions and markets, cinemas, concert halls, conference halls, auditoria, grandstands, cycle tracks, sports stadia, aircraft hangers, shelters for playgrounds and pedestrian islands, open sheds for agriculture and livestock husbandry, large greenhouses, beams for big spans, large-scale antennas and towers, bridges and marine platforms, bearing structures for private and public buildings, bearing structures for skyscrapers, underwater structures, structures above ground to enclose dwelling spaces, macrostructures of plants for alternative sources of energy, radar and telescope equipment, latticework for tanks, equipment for airports, space travelling equipment, frames for satellites and space stations and so on.

In particular, cubic latticework finds an immediate application as a basic framework for structures resistant to earthquakes.

The reticular constructional systems at present on the market are relatively not very competitive with other building systems because either they (Mero type) have too high production costs owing to the extreme sophistication of processing and need skilled labour, or they (Unistrut type) are not very versatile as regards the use of types of grills or sections (only two-directional grills and U-shaped sections), or else they (Triodetic type) require special techniques and equipment for assembling the elements on the building site (pneumatic hammer for joining the ends of the rods to the nodal junction).

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In any event a limit to the use of all the systems employed now lies in the inability to go below a given thickness and therefore below a given weight.

There does not exist at present on the market a cubic mesh system which is a natural support for industrialized building components. All efforts made in this field have always met with only partial success.

The modular nature of the system should ensure excellent integration of the building components and also permit standardisation of computation of the structure, which, to be a cubic mesh, should comply with the laws and standards acquired to calculate its stresses without any need of a computer.

Standardisation of the lattice should also represent an improvement in the "response" of the structure to seismic stresses.

It is the purpose of our invention to provide a device which enables the foregoing shortcomings of reticular spatial structures to be avoided.

The device of the invention offers the following advantages in comparison to the prior art:-

1) ease of production with low costs;
2) ability to employ rods having any desired profile;
3) assembly and dismantling do not require skilled labour (pairs of workmen with at least two keys or at most an automatic wrench for bolts);
4) it enables roofing to be built up in steps or with a pseudocupola as well as flat or sloped roofing or roofing with one or more pitches, since it is possible to employ any thickness of grill, given an equal basic module;
5) it is extremely easy to transport;
6) small, medium and large thicknesses can be used for small, medium or large spans respectively; this leads to a considerable reduction in weight as compared to other retic-

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ular systems;

7) it enables a covering roof to be built for any rectangular space by using latticework with a rectangular module of which the two sides are submultiples of the sides of the area to be covered;

8) cubic latticework, which is used advantageously for buildings that have to resist earthquakes, forms the most natural basic bearing structure in industrialized building work;

9) unlike all the other systems now in use, any damaging hyperstatic condition in the systems of our invention, whether in the spatial grills or in cubic lattices, is balanced and compensated by the fact that the nodal junction does not consist of one single piece but arises from the assembly of six devices; this enables the whole structure at all its nodal junctions to absorb stresses better and to respond better and evenly to variations in heat (expansion and contraction) and to stresses, even of a seismic nature;

10) the special method of attachment of the rods to the nodal junctions eliminates shear stresses which are present in other systems and which are due to compression and traction at the ends of the rods;

11) costs for making the device are very low; setting-up on site is very easy; given an equal module, the weight per square metre is lower owing to the ability to choose the most suitable thickness. These advantages mean that the system is very competitive compared to all the other building systems.

The spatial aggregations which can be made by using the device of the invention are almost unending: cubic lattices, latticework in layers, flat grills with a triangular and quadrangular module, corrugated grills, grills with several pitches and any slope, beams, latticework towers, cantilever structures, etc.

It is known that such reticular systems find an immediate practical application as bearing and covering structures.

In particular, the cubic lattice finds an immediate application as a basic framework for structures to resist earthquakes.

The device of the invention has a substantially quadrangular shape with a substantially square middle area and with four other perimetric areas sloped at 45° to the plane of the middle area, said perimetric areas comprising holes for assembly by means of nuts and bolts or possibly rivets.

For the sake of simplicity we shall refer hereinafter, where not otherwise specified, to bolted connections.

The nodal junction is formed with six devices of the invention fitted together, which connect a maximum of twelve rods and provide spatial grills.

The nodal junction thus formed enables grills to be made with small, medium and large thicknesses for small, medium and large spans respectively.

When the device of the invention is butt-welded to any rolled or drawn section the axis of which is perpendicular to the middle area of the device itself, it gives rise to a lattice formed in three orthogonal directions, which is cubic if all the rods employed are of the same size.

For the sake of simplicity we shall refer hereinafter to a "cubic lattice", thereby also meaning the ability to obtain elongated parallelepipedal cells. For this latter particular lattice the device can also be made with a rectangular middle area.

In such a case the nodal junctions will have a prismatic shape with square bases if four of the devices are rectangular and two are square, or will have a parellelepipedal shape if the six devices fitted together to form the nodal junction are all rectangular and pairs of them are the same as each other.

The rods which can be used in conjunction with the device of the invention and with the nodal junctions formed with said device consist normally of a rolled or drawn rod having an opened or closed section and comprising blade-wise ends belonging to the same plane as that on which the axis of the rod lies.

One or more through holes made in the two ends enable the rod to be connected with elements which can be dismantled, such as bolts, or with fixed elements such as rivets, to the nodal junction formed with devices of the invention.

It is posssible to employ rods of two different sizes to make grills, as will be described better hereinafter.

The blade-wise ends of a rod may perhaps not lie on the same plane as each other; this enables hyperbolic paraboloid grills to be made since in this way the orientation of the nodal junctions varies progressively along the structure.

The profile of the transition surface between the body and end of a rod may also be different from the profile of the corresponding edge of the perimetric area of the device to which the rod itself is connected.

In cubic lattice structures the rolled or drawn section is butt-welded to the device and therefore does not need blade-wise ends.

Rolled and drawn rods with an open section (I-sections, H-sections, etc.) are advantageously employed together with the device for this latter kind of structure.

The device of the invention can be made of pressed plate of a suitable thickness so as to obtain the shape and size wished or can be made by casting or die-casting.

Besides steels and light alloys, synthetic resins too can be considered, depending on the dimensional class to which the product is manufactured.

A device suitable for forming cubic lattices can generally be made by casting as well as with plates welded together to constitute the device, which is then butt-welded to the rod.

A layer of sprayed asbestos cement can be envisaged to prevent fires and corrosion on reticular spatial steel structures.

Otherwise, self-expanding varnishes can be used for fireproofing, while varnishing and hot-dip galvanising can be employed for corrosion resistance.

Rods used in conjunction with the device of the invention can include suitable holes for the passage and/or anchorage of equipment.

The middle area of the device of the invention can be provided in its turn with one or more holes.Said holes can cooperate in the fixture of perpendicular rods to said area so as to obtain cubic lattices or can serve for the passage of equipment or for other purposes, as may be necessary.

According to the law of stability of structures ($a=3n-6$, wherein $a=$ the number of rods and $n=$ the number of nodal junctions) the tetrahedron and octahedron are stable, and so those structures are stable which comprise tetrahedra and octahedra and which can be obtained by using nodal junctions formed with the device of the invention.

When a link undergoes tensions, through overloading for instance, the theory of strains shows that yielding should always take place at the same time through the whole system since the stresses in the grills are always distributed through the nodal junctions to all the rods, and the latter will undergo traction or compression, depending on the circumstances.

Instead, yielding of the grill takes place, above all, following on concentrated loads (strain and localised breakdown of the material).

Strains should decrease progressively from the zone of concentrated load to the periphery.

Nodal junctions formed with the device of the invention are such that the rods in a grill under tension undergo torsion also at the same time as traction or compression. The blade-wise ends of the rods will then tend not to lie on the same plane as each other.

The torsion undergone by the rods is a wholly favourable fact since it opposes the forces of compression or traction, which are parallel to the surfaces gripped by the bolts and are in the direction of the rods, so that they tend to overcome the forces of friction in the links of the ends of the rods.

The perimetric areas of six devices fitted together to form a cube with "fins" at the edges or a pseudohypercube enhance the creation of this torsion (tending to deform a grill having a square module into a hyperbolic paraboloid) and thereby enhance said forces of friction.

This invention is therefore embodied with a connecting device for reticular spatial structures having nodal junctions to connect rods, said device being able to form said nodal junctions of said structures and being characterized by comprising a middle area with a substantially quadrangular shape, to which four other perimetric areas are connected and sloped at 45° to the plane on which said middle area substantially lies, so that the assembly of six of said devices forms a nodal junction element having a geometric shape substantially comparable to a parallelepiped.

Moreover, the invention is embodied with reticular spatial structures or grills comprising nodal junctions formed with said device.

We shall describe hereinafter, as a non-restrictive example, some preferential lay-outs and applications of the invention with the help of the attached tables, wherein:-

Figs.1 show some possible shapes of the device of the invention;

Figs.2 show assemblages of devices of the invention;

Figs.3 show details of tubular rods to be used in conjunction with devices of the invention;

Fig.4 shows a possible bolted connection of a rod to a nodal junction;

Fig.5 shows a tilted connection between a rod and a device;

Figs.6, 7 and 8 give various views of nodal junctions formed with the device of the invention and of the corresponding grills which can be obtained;

Figs.9,10 and 11 show grills which can be obtained according to the invention by using rods of two different sizes;

Figs.12 and 13 give examples of the formation of grills with a cubic mesh;

Fig.14 shows a tubular rod with ends which are not coplanar;

Fig.15 shows a hyperbolic paraboloid grill;

Fig.16 shows a build-up of tetrahedral and semi-octahedral meshes made by employing the device in question.

In the figures the same parts or parts having the same functions bear the same reference numbers.

Figs.1 show some shapes of the device of the invention. Said device 10 comprises a substantially quadrangular middle area 11, in relation to which four other perimetric areas 12 are sloped at 45°.

Each of the four perimetric areas 12 comprises one or more through holes 13, which have the same distances between their centres as those between the centres of the holes 113 in the ends 114 of the rods 14 (see Fig.3a).

The middle area 11 of the device may comprise, or not,a central through hole 15, which may be surrounded, or not, by a strengthening ring 115 (Fig.2a).

The perimetric profile of the device 10 and the number and lay-out of the holes 13 in the perimetric areas 12 can vary and there will correspondingly be the same variations as regards the holes 113 in the ends 114 of the rods 14 as well.

Figs.2a and 2b respectively show two nodal junctions 16-116 which can be obtained with two forms of the device of the invention. Said nodal junctions 16-116 have a shape substantially comparable to a cube.

When necessary or wanted, it is possible to assemble less than six devices 10 of the invention, thus obtaining nodal junctions 16-116 lacking one or more faces.

Fig.3a shows a detail of a blade-wise end 114 of a tubular rod 14. In this example said ends 114 are flattened so as to obtain the blade-wise profile desired. The holes 113 to secure the rod 14 can be clearly seen.

The rod 14 is shown in Fig.3b with its ends 114 coplanar in this instance.

One (or more) hole 17 is comprised near the end 114 of the rod 14 for the passage of galvanising metal inwards (Fig.3a).

The ends can be conformed also as in Fig.3c, thereby obviating the hole on the outer surface near the end 114. In this way the galvanising metal will enter through the holes 17 made in the end itself.

Fig.4 shows diagrammatically a possible connection between devices 10 of a nodal junction 16 and a rod 14. In this instance said connection is made with bolts 22 but could be made with rivets, when so wished, or by welding.

In the case of one or more through holes 113 made in the ends 114 and when grills with rods of two different sizes are

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employed, the line between the centres of the holes will have a variation corresponding to the angle 18 (Fig.5).

The ends 114 of a rod may not lie on the same plane as each other (see Fig.14); this enables hyperbolic paraboloid grills 19 to be constructed (see Fig.15).

Fig.6a shows a nodal junction 16 made with devices of the invention in a view which gives the spatial position of said nodal junction 16 as comprised in the spatial structure or grill 20 of Fig.6b, where a nodal junction 16 oriented and having its rods positioned as in Fig.6a is indicated with an arrow.

Fig.7a shows a nodal junction 16 according to the orientation of the nodal junction indicated with an arrow in Fig.7b. The tetrahedral arrangement which can be obtained by the invention for the grill 20 should be noted.

The plan of the grills 20 of Figs.6 and 7 comprises a triangular module 120.

The lay-out of Fig.8b shows, instead, a grill 21 with a quadrangular module 121. The relative orientation of the nodal junction 16 indicated with the arrow is shown in Fig.8a.

The figures make it clear how the two lay-outs arise from a different spatial orientation of the nodal junctions 16 in relation to the basic plane of the structure 20 or structure 21 respectively.

If M= the size of the rod, we shall have H=M, H-0.816 x M and H-0.707 x M respectively in Figs.6b, 7b and 8b.

Figs.9 and 10 show the possibility of varying the height of grills formed according to the invention by employing rods of two different sizes. This is made possible because the axis of each rod 14 lies on a plane which contains the corner of the nodal junction-cube and internal diagonal and which can rotate around the axis of the anchorage bolt 22 perpendicular to said plane.

Therefore, in the grill with a triangular module diverse thicknesses H are determined with the same module 120 and can be used for diverse spans (Figs.9 and 10).

In any event, if the basic feature of the invention is preserved (the four perimetric areas 12 sloped at 45° to the middle area), the device 10 will have an edge such as to enable the rod to be secured in directions which are different but which always belong to a plane of rotation of which the axis is the assembly bolt 22.

In the grills 20-21 whereof the devices 10 have more than one through hole 13 in each perimetric area 12, the ends 114 of the rod will have corresponding through holes 113 with the direction of the line between centres of said holes suitably sloped (angle 18 of Fig.5) and depending on the ratio assumed in Fig.9 between the size M of the rod of the basic triangular module 20 and the size of the other three rods.

Thus a greater or lesser thickness H is also determined in the grill 21 with a quadrangular module 121, as shown in a side view in Fig.11b.

The grill with a square module will take up the form of a rectangular module (Figs.11a and 11c), of which the two sizes will be those derived from Fig.9, account being taken of the fact that the nature of the module 120 or 121 depends on the pre-selected orientation of the nodal junctions, or, in other words, on the fact that the basic plane of the grill contains a triangular module 120 or a quadrangular module 121.

It is therefore possible to see the noteworthy advantages which arise from the ability to choose, with this device, the thickness of grill most suitable for the design.

Assembly of the grill of the invention can be performed cantilever-wise by making use of a movable scaffold, or else, if space is available on the building site, it is possible to fit together whole grill elements on the ground and then hoist them and put them in their final position by means of self-propelled cranes or other like lifting means. Said two procedures can be readily combined to suit the circumstances.

Fig.12 shows a possible connection between the ends of rods, which in this instance have an open profile 23 (I-sections, H-sections, etc.), and devices 10 forming a nodal junction 16. Said rods can also be of another type.

In the example shown the connection between rod 23 and device 10 is made by welding.

The assembly of six devices 10 (Fig.12) butt-welded to rods 23 with an open profile determines a grill 24 according to three directions at right angles to each other, said grill being shown in Fig.13 with cubic latticework.

The sizes and dimensions of the rods 23, normally having an open profile, and of the nodal junctions 16 may vary in every way, depending on the design.

For cubic latticework the rod, normally having an open profile, can be pre-arranged, before being fitted, with a device 10 connected to each of its ends.

The rods 24 can be provided with holes 117 variously arranged for the passage and/or anchorage of elements of equipment on the structure.

Fig.14 shows a rod 14 with blade-wise ends 114 which are not coplanar. In this way it is possible to form hyperbolic paraboloid grills 19 (Fig.15) wherein the orientation of the nodal junctions 16 varies continuously along the structure.

Fig.16 shows a build-up 25 of tetrahedra and semi-octahedra forming part of a grill 20-21 according to the invention. Said build-up 25 is seen in this instance as an octahedron-cube.

The quadrangular module 121, here square, is obtained with this build-up 25 by reference to a section plane parallel to one face of the cube 26 drawn with dashes in the figure, and the triangular module 120 is obtained by reference to a section plane equally inclined in relation to three faces of the cube 26 with a common vertex 126.

The repetition in space of the octahedron-cube build-up 25 shown in Fig.16 or of part thereof gives rise to reticular spatial structures which will have a triangular 120 or quadrangular 121 module depending on the choice of the basic plane according to the aforesaid methods. ———————————

INDEX

10 - device
11 - middle area
12 - perimetric areas
13 - holes in perimetric areas
113 - holes in end of rod
14 - tubular rod
114 - blade-wise end
15 - central through hole
115 - strengthening ring
16 - nodal junction
116 - nodal junction
17 - hole
117 - hole
18 - angle
19 - hyperbolic paraboloid grill
20 - grill with triangular module
120 - triangular module
21 - grill with quadrangular module
121 - quadrangular module
22 - fixture bolt
23 - rod with open profile
24 - cubic latticework
25 - build-up
26 - cube
126 - vertex
M - size of rod
H - thickness of grill

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CLAIMS

1 - Connecting device (10) for reticular spatial structures having nodal junctions to connect rods (14-23), said device being able to form said nodal junctions (16-116) of said structures and being characterized by comprising a middle area (11) of a substantially quadrangular shape, to which are connected four other perimetric areas (12) sloped at 45° to the plane on which said middle area (11) substantially lies, so that the assembly of six of said devices (10) forms a nodal junction element (16-116) having a geometric form substantially comparable to a parallelepiped (Figs.2).

2 - Connecting device (10) for reticular spatial structures as in Claim 1, characterized by the fact that the nodal junction element (16-116) has a geometric (cubic) shape with all six devices being the same.

3 - Connecting device (10) for reticular spatial structures as in Claim 1, characterized by the fact that the nodal junction element (16-116) has a geometric shape with at least four devices having a substantially rectangular form.

4 - Connecting device (10) for reticular spatial structures as in Claim I and in one or the other of the Claims thereafter, characterized by the fact that the perimetric areas (12) have a conformation (Figs.1 and 2) with fins.

5 - Connecting device (10) for reticular spatial structures as in Claim 1 and in one or another of the Claims thereafter, characterized by the fact that the middle area (11) comprises at least one through hole (15).

6 - Connecting device (10) for reticular spatial structures as in Claim 1 and in one or another of the Claims thereafter, characterized by the fact that each perimetric area (12) comprises at least one hole (13)

7 - Connecting device (10) for reticular spatial structures as in Claim 1 and in one or another of the Claims thereafter,

characterized by consisting of any desired material.

8 - Reticular spatial structure, characterized by comprising nodal junctions (16-116) formed with the device of the Claims hereinbefore.

9 - Reticular spatial structure (20) as in Claim 8, characterized by comprising a triangular module (120)(Figs.6b, 7b, 16).

10 - Reticular spatial structure (21) as in Claim 8, characterized by comprising a quadrangular module (121) (Fig.8b).

11 - Reticular spatial structure (20) as in Claim 8 and in Claim 9 or 10, characterized by comprising at least one nodal junction (16-116) assembled at least partially with rods (14-23) including blade-wise ends (114) that have at least one through hole (113) cooperating with at least one hole (13) comprised in each perimetric area (12).

12 - Reticular spatial structure (20) as in Claim 8 and in Claim 9 or 10, characterized by comprising at least one nodal junction (16-116) assembled at least partially with solidly fixed rods (23) (Fig.12).

13 - Reticular spatial structure (20) as in Claim 8 and in one or another of the Claims thereafter, characterized by the fact that the rods (14 or 23) comprise at least one hole (17-117) near their end zone.

14 - Reticular spatial structure (20) as in Claim 8 and in one or another of the Claims thereafter, characterized by the fact that at least one nodal junction (16-116) cooperates with at least one rod (14) of which the blade-wise end (114) is connected to said nodal junction (16-116) and has a profile substantially the same as the profile of the corresponding perimetric area (12) of the device (10).

15 - Reticular spatial structure as in Claim 8 and in one or another of the Claims thereafter, characterized by the fact that the rods (14) cooperating with a nodal junction (16-116)

have the same length as each other.

16 - Reticular spatial structure as in Claim 8 and in one or another of the Claims thereafter up to Claim 14 inclusive, characterized by the fact that the rods (14) cooperating with a nodal junction (16-116) have different lengths.

17 - Reticular spatial structure as in Claim 8, characterized by comprising a latticework extending in three orthogonal directions (Fig.13).

18 - Reticular spatial structure as in Claim 8 and in one or another of the Claims thereafter, characterized by comprising one or more pitches (Fig.15).

19 - Reticular spatial structure as in Claim 8 and in one or another of the Claims thereafter, characterized by the fact that at least part of the devices (10) forming a nodal junction (16-116) are connected with elements which can be dismantled (bolts, pins, etc.).

20 - Reticular spatial structure as in Claim 8 and in one or another of the Claims thereafter up to Claim 18 inclusive, characterized by the fact that at least part of the devices (10) forming the nodal junction (16-116) are connected in a fixed manner (riveting, welding, etc.).

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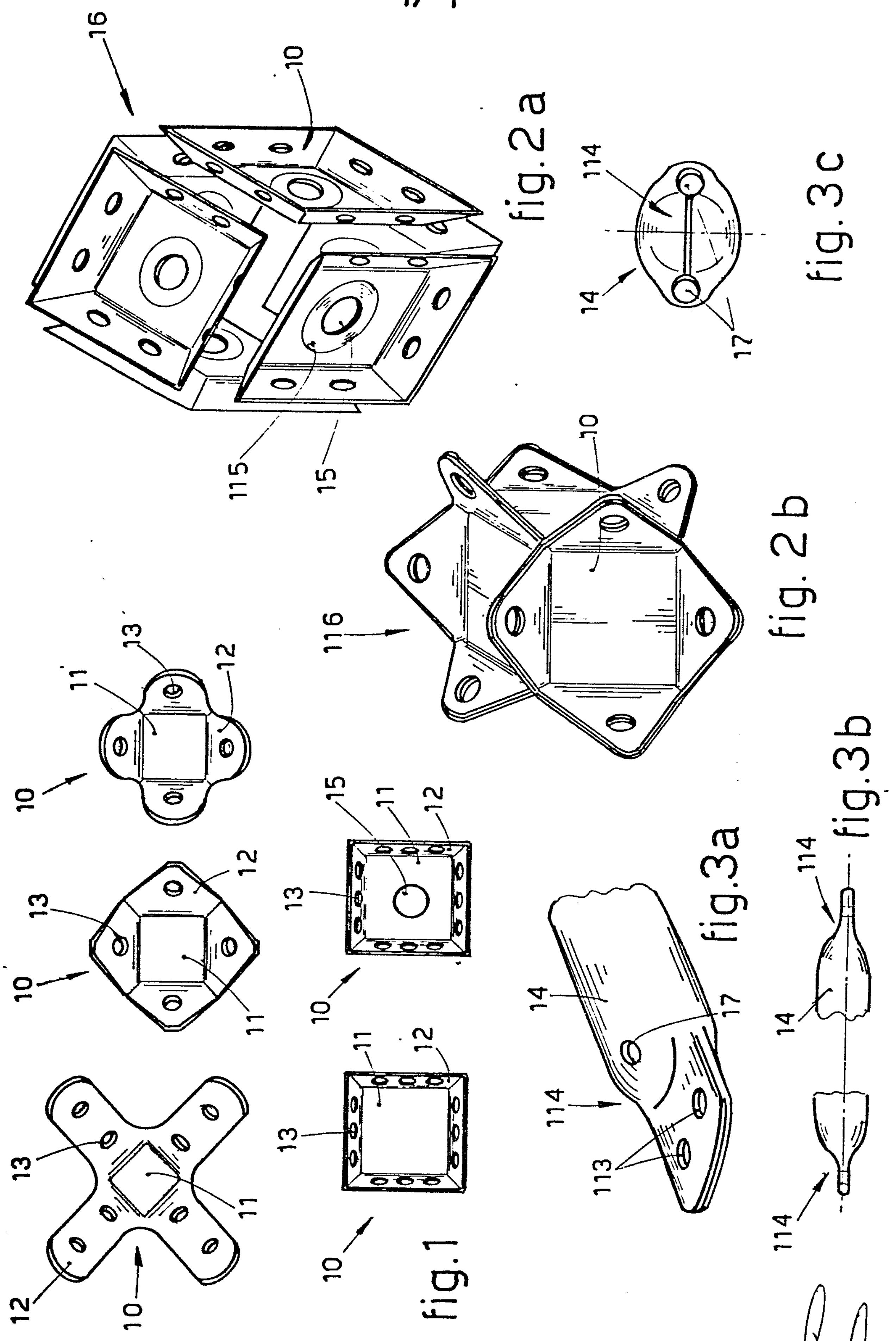

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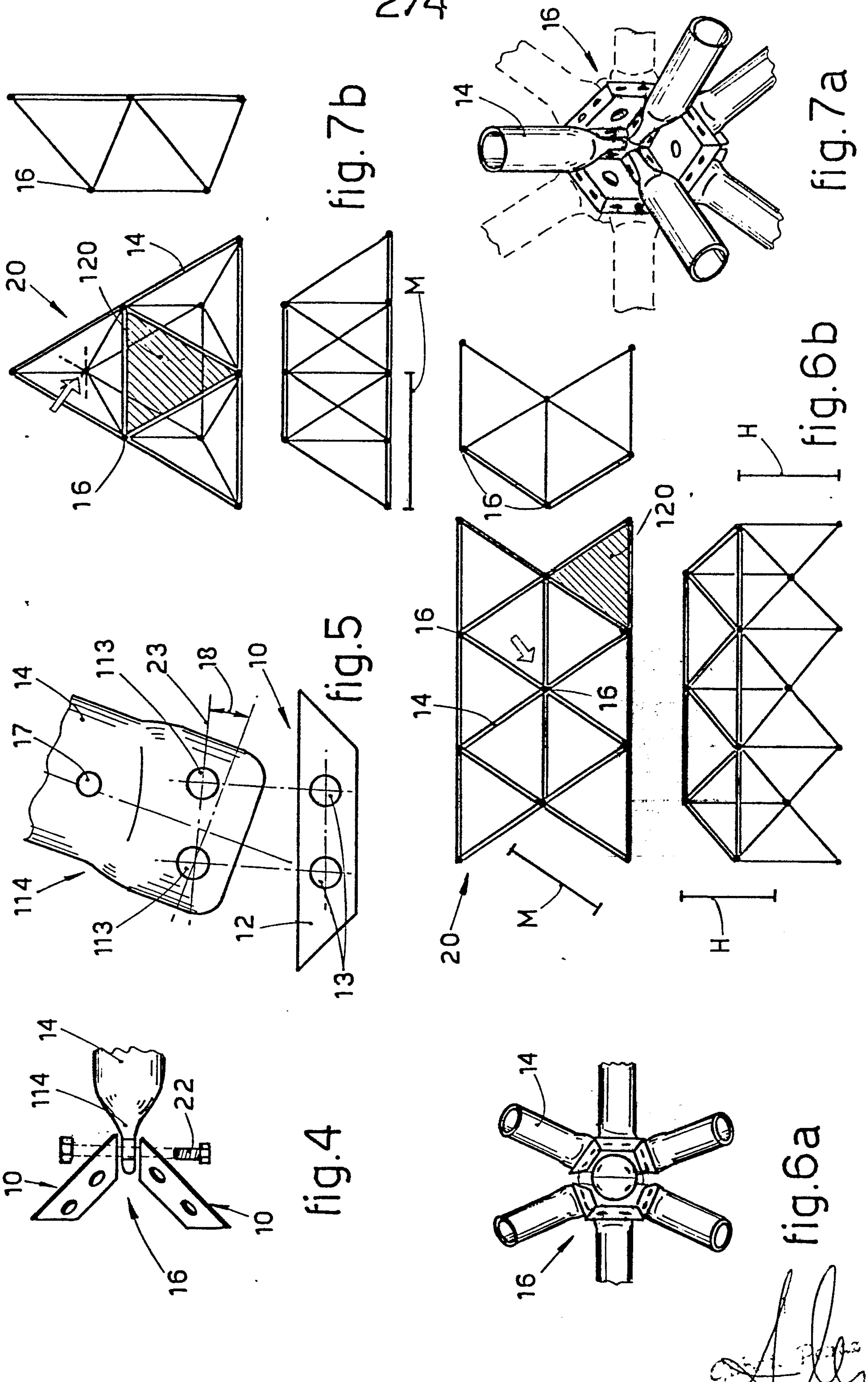

fig.7b

fig.7a

fig.5

fig.6b

fig.4

fig.6a

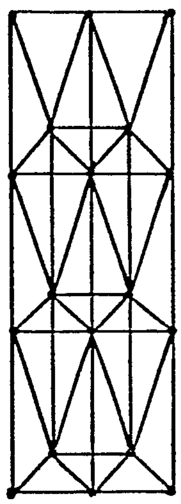

fig.11a

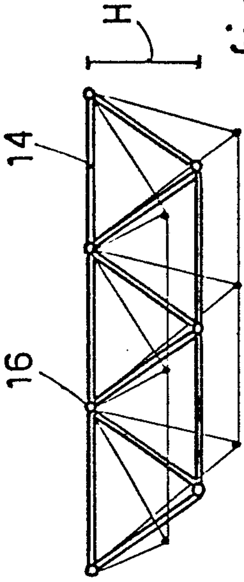

fig.11b

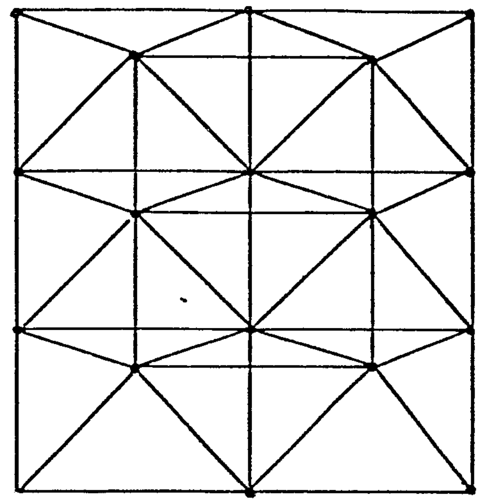

fig.11c

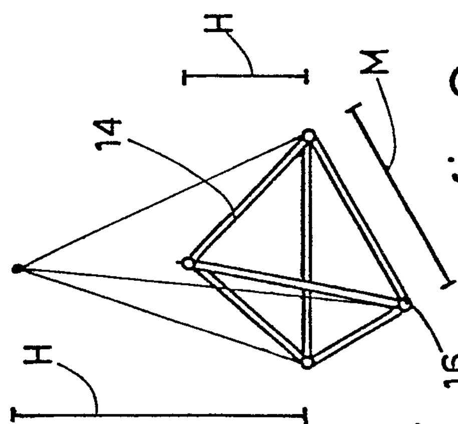

fig.9

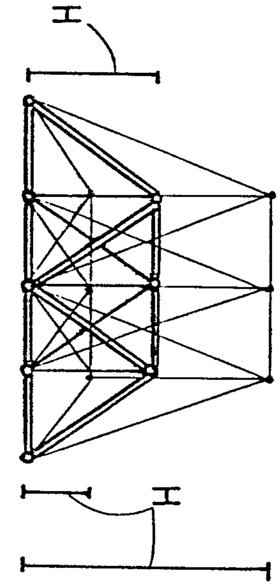

fig.10

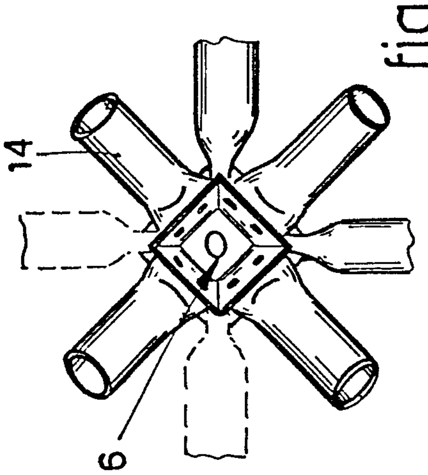

fig.8a

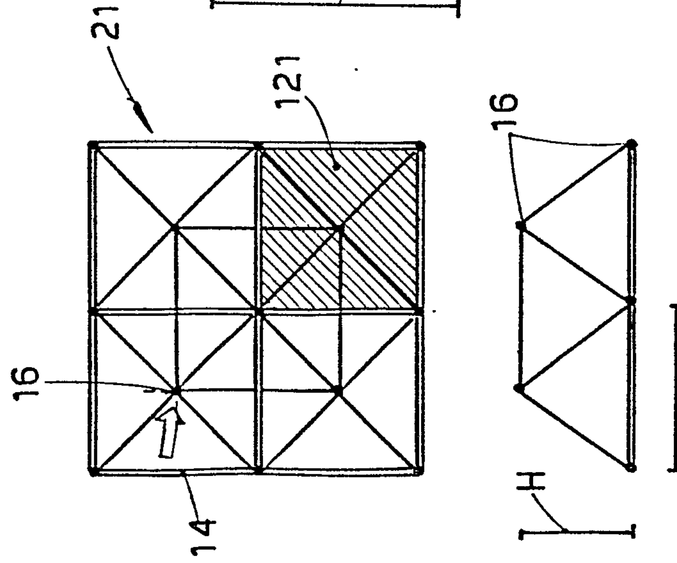

fig.8b

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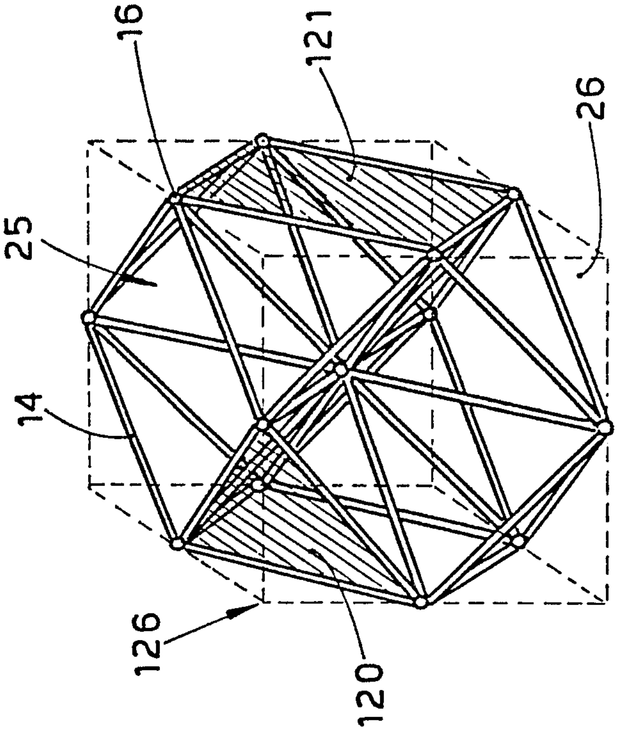

fig.16

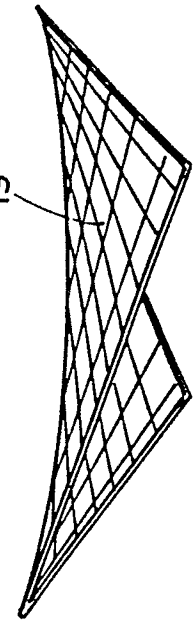

fig.15

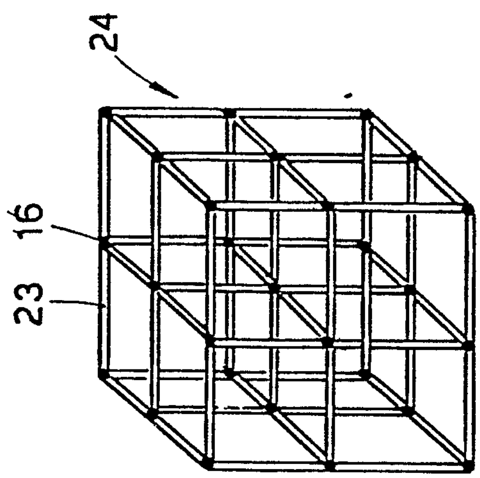

fig.13

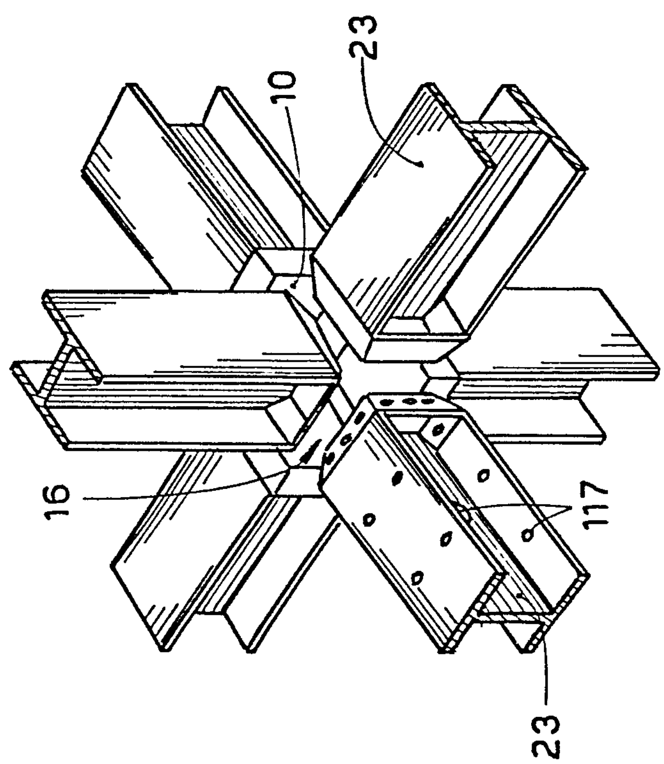

fig.12

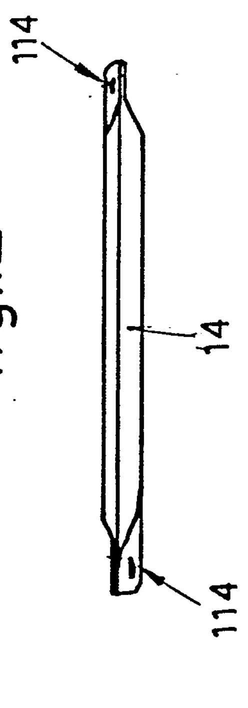

fig.14

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European Patent Office

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Application number

EUROPEAN SEARCH REPORT

EP 82 83 0258

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl 3)
X	US-A-3 563 580 (A.F. BLACK) * complete document *	1-3,6-8,10,11,14-16,19	E 04 B 1/19 E 04 B 1/58
X	FR-A-2 386 714 (C. NASI) * claim 3; figures 7, 16 *	1-4,6,8	
A	DE-B-2 116 707 (WURGAROHR GMBH) * complete document *	1-3,5,7,8,12,17,19,20	
A	FR-A-1 280 634 (S. DU CHATEAU) * figures 1, 3, 4 *	9,10	TECHNICAL FIELDS SEARCHED (Int Cl 3)
A	GB-A-2 014 685 (J.-L. JEANNIN) * figure 1 *	6,11	E 04 B 1/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	07-01-1983	KRABEL A.W.G.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
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