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Description

This invention relates to an improved type bar, for junction planar three-dimensional lattice or truss structures without junction knots, and the structures formed in this way.

Three-dimensional lattice structures are known, particularly for covering more or less extended areas, which are assembled by connecting together metal rods or bars in various ways, being required in any case some kind of connecting knot elements at the joints, even in the instance of single or multi-layered planar truss structures. In fact, the rods whose geometrical axes effectively converge in a single point are never directly joined to each other, but it has always been preferred to provide the mutual connections by means of an auxiliary element that materializes, so to speak, the geometrical knot. A number of embodiments are known for said connecting knot elements, of more or less complex construction depending upon the type of structure to be obtained, and in particular upon the number of rods converging towards each knot, but, in any case, it is necessary that in addition to the rods, provision is also made for these usually expensive elements which require skilled labour for the assembly thereof. While this can all be justified, from a financial point of view, for important structures, designed to cover very large size areas, it is not so for less extended ceilings, where it would be desirable to use, as the only structural members, extruded material rods made for instance from aluminum alloy, and the related fastening means.

From AU—B—520 837 a space frame is known which is constructed of elongated members having the above mentioned desired features, with the possibility of direct interconnections of the members to one another without the use of a hub. However, it is always necessary to have two different types of members, not only the lengths ("short" and "long' members) but also the sectional shapes ("X" and "Y" members) differ. Furthermore, as the angle between the arms of the "X" shape or "Y" shape are fixed (90° or 120°), the angle formed by the various members of the space frame also cannot be varied.

It is therefore an object of this invention to provide a rod or bar of the kind mentioned above, comprising substantially radial flanges, where the rod can be obtained through a simple extrusion process, and is adapted to be connected to other identical rods, all having the same shape in cross-section and converging with their longitudinal axes towards a single geometrical center of a virtual knot, without interposition of connecting means at the joint, but only by means of the mechanical fastening of the conjugate rod flanges, overlapping each other. Said mechanical fastening obtained by means of ordinary bolts, rivets, pins and so on, or preferably, where justified, by means of a bolt particularly adapted to be inserted in the narrow areas between said rod flanges, provides for the necessary stiffness to the three-dimensional structure thus assembled. Furthermore, the angles defined between the flanges are so calculated so as to ensure that the flanges of concurring bars overlap.

The bar or rod of the invention is formed as a X-shaped elongate member thus with four flanges, each flange having a first surface which defines a plane belonging to a sheaf of planes having its axis coincident with the longitudinal axis of said bar, the other surface or each rod flange being offset from the plane of the sheaf, the radial planes of the flanges relating to said first surfaces, at least at the bar ends, define therebetween an angle which is dependent on the angles formed by the geometrical axes of the bars converging into the same nodal point with respect to a system of three coordinate axes having its origin in the convergence point, as a function of the respective direction cosines, whereby coupling of a number of identical bars with flanges having the same angular orientation is provided by overlapping the flanges corresponding to conjugate connecting planes in a position of a planar coincident relationship.

More precisely, if the angle defined by the above mentioned planes is φ and the supplemental thereof, its value is given by $\tan \varphi = -c/b$ with b and c being two of the three direction cosines of the longitudinal axis of each bar designed to converge into the same center of the joint or nodal point.

Other objects, advantages and features of the bar according to this invention, and of the corresponding structure provided thereby, will be apparent to those skilled in the art, from the following description of some embodiments, given as non-limiting examples with reference to the attached drawings, in which:

Figures 1 and 1a show a perspective view of a square looped pattern, single-layered truss structure in a general schematic view, and of a section of the same structure hatched in Figure 1 and shown in a larger scale, respectively;

Figures 2 and 2a are geometrical representations of a pyramidal lattice section forming square loop of Figure 1, and of the diagonal rods converging towards a point taken as the origin of three coordinate axes, respectively;

Figures 3a and 3b are two schematic views of a bar according to this invention, to show two different construction approaches thereof;

Figures 4 and 4a show a perspective view and an exploded section in polar coordinates, respectively, for the connection formed by the bars according to this invention and visible in the foreground for a structure according to Figures 1 and 1a;

Figure 5 shows a schematic view of a bolted joint of bars according to this invention, particularly of the kind shown in the following Figure 8, to emphasize the design and operation of the expansion head bolt according to the invention;

Figures 6 to 13 show end views of several embodiments of four-flanged bars, all of which can be inscribed in a circle;

Figures 14 and 15 show two further embodiments of four-flanged bars of the invention, having peripheral square shaped profiles, closed and open, respectively.

Referring now to the drawings, Figures 1 and 1a show a planar three-dimensional lattice structure, in particular a single-layered structure, that can be advantageously built by fastening the bars of the invention to each other without nodal connecting elements in the areas where several bars meet, which are shown here simply by the longitudinal axes thereof. This kind of a structure, which could of course comprise two or more layers, one over the other, includes a certain number of square loop elements 10 adjacent to each other, and forming the base of pyramidal elements 3 whose apex is located in a geometrical knot point 0. Rods or bars 1 form the sides and the diagonals of loop elements 10 and of pyramidal elements 3. In the case shown here, a maximum of eight rods 1 can converge towards an apex 0, while in the instance where more layers are provided the rods can be twelve in number.

An essential requirement that has to be met by bars 1 according to this invention is that they must have substantially radial members, or suitably oriented "flanges" 5, in order to define, about the bar longitudinal axis, such angles as to allow for an overlapping in a position of geometrical planar coincidence of the conjugate flanges belonging to bars whose axes converge in the same joint point 0 which is the virtual center of the knot or, as it could be better defined, a "no-knot node" since the same point is not materalized in the space as an actual structure element. The angular arrangement of flanges 5 of a certain bar 1 is then related according to the invention, to the angles mutually formed by the same bars to each other, or better by the longitudinal axes thereof.

Referring now to Figures 2 and 2a said concept is better described making reference to a purely geometrical representation, respectively of a single pyramidal element 3, taken out of a square looped lattice structure, as shown in Figures 1 and 1a, and of a node 0' taken as the origin of a set of three coordinate axes in order to determine the angle orientation of a diagonal rod having its origin in said node. The subject diagonal rod is that designated 1' in Figure 2 wherein there is also shown the three coordinate axes x, y, and z, then reproduced in Figure 2a. In the latter figure there has been indicated with ρ a unitary length of rod 1', whose components along the three coordinate axes are a, b, and c, respectively, while the angles that said unitary length form with the three coordinate axes in the planes marked by shading respectively with horizontal lines, sloping lines and dots have been shown as α, β, γ. The following equations can be obtained:

$$a=\rho \cos \alpha$$
$$b=\rho \cos \beta$$
$$c=\rho \cos \gamma$$

therefore a, b and c are those quantities usually defined as the diagonal rod 1' direction cosines referred to the three coordinate axes, two of which coincide with two bars of square looped element 10, or base of the pyramidal element 3.

It has been found that the angular orientation of flanges 5 of each bar 1 has to be a function of said direction cosines in order to obtain a mutual planar direct flange connection in a point where the bars meet. In the far preferred instance, i.e. that of four-flanged bars having X-arranged flanges to form square loop elements of a pyramidal configuration, angle φ between these flanges, as shown in Figures 3a and 3b, is simply given by the following equation:

$$\tan \varphi = -c/b$$

as can be verified starting from the equations given above. In fact, once the angle φ has been calculated, the same and the supplement $180°-\varphi$ thereof, identify two X-oriented planes intersecting along the bar longitudinal axis and providing the conjugate planes which must be mutually coincident at the node geometrical virtual center (or "no-knot node"). In other words, the longitudinal geometrical axis of the bars is considered as the axis of a sheaf of planes whose direction cosines coincide with those of the bars; among the planes belonging to said sheaf just those conjugate planes are determined, as shown in Figures 3a and 3b, which provide the geometrical coupling planes, in particular by means of the above equation. The contact surfaces between two matching flanges are determined in this way, as indicated on the drawing by a thicker dash-and-dot line, but of course the flanges have a thickness, limited only by the size of mechanical junction elements in addition to cost evaluations related to the weight of the overall structure. Due to said thickness the flanges cannot be defined as actually radial with respect to the bar geometrical axis as, if a surface thereof coincides with one of said planes, this is not true for the second one which will be offset from said plane, for all the flanges of a same bar, in the same direction, clockwise or counterclockwise, when rotating around the bar geometrical axis as it is shown in Figure 3a (counterclockwise rotation). This is the most general way of arranging the flanges, but for four-flanged bars a mirror-image arrangement is also feasible, as it is shown in Figure 3b, where the flange arrangement is symmetrical to the axis S—S bisecting two opposite angles, in this case the φ amplitude angles.

Based on the foregoing, the values of the angles defined between the flange planes depend upon the geometrical properties of the modular lattice structure, and therefore they depend for instance, upon the different height that is desired for the structural layer of Figure 1, since the

diagonal rod angles, and consequently the direction cosines thereof, are in fact a function of said height. In particular, based upon the aforementioned equation tan $\varphi = -c/b$ and for a structure composed of pyramidal lattice elements where all the bars have the same length (i.e. diagonal rods of same length as those forming the sides of each loop) the calculations show that the bar flanges form alternate angles whose values are approximately 70°31'44" and the supplement value thereof i.e. 109°28'16".

In Figures 4 and 4a there is shown the meeting area, about a nodal point 0, of only the rods visible in the foreground among the twelve that can converge with their geometrical axes in the point 0, of a two-layered pyramidal lattice structure. Rods 5 have been shown here as X-shaped rods and bars, and in Figure 4 without the central intersection area, whereby they are caused to be lightened while of course an outer tubular element (not shown) is provided, which encirlces and rigidly restrains the flanges. In this way the connection surface and its efficiency are increased, but obviously other different embodiments are possible (as shown for instance in Figure 4a) among those hereinafter disclosed taking into account in particular that the bar can have any desired shape, with any desired flange orientation, provided that, at least at the ends thereof designed for connection to other bars, its flanges have the orientation necessary to ensure that the flanges can overlap at conjugate connection planes. As it is apparent from Figure 4a, the diagonal rods provide the connecting element between the stringers.

In Figures 4 and 4a there is also schematically shown the fastening means 7 for mechanical connection of the overlapping flanges of bars converging towards the centre point 0, having only the function of withstanding shear stresses. As a consequence, in order to solve the problem of the limited room available to insert and to tighten means 7, in particular where the angle between the flanges is less than 90°, this invention provides for use of an expansion head type bolt which is described in the following referring to Figure 5. Bolt 11 is shown in a side view outside a rod 1 having flanges 5 shaped as shown in Figure 4 or, more completely, in Figure 9, in addition to a sectional view where it is shown tightened with expanded head for the fastening of two flanges of two separate associated bars. In fact it is apparent that insertion of a normal screw having a head integral with the shank, and tightening thereof by means of a nut, would prove to be very difficult, if not impossible, also because screwing operations on a structure made up of bars according to the invention have necessarily to be performed sideways of the screw.

Referring now to Figure 5, an expansion head bolt 11 which advantageously embodies a fastening device 7, comprises a partially threaded shank 21 provided with a central through bore, a cylindrical pin 23 being housed in said through bore and having an end thereof shaped as a square tang 23a, while the other end is shaped as a conical disc 25. Both ends 23a and 25 project from shank 21 and pin 23 is made integral therewith by means of a suitable bonding adhesive. The size of the maximum diameter section of pin conical head 25 is equal, and in any case no larger than the outer diameter of shank 21, in order to define, together with the associate end of shank 21, a cavity adapted to provide a seat for helical spring 20 whose inner end is attached to pin 23, said spring being normally held into position by a washer 27 whose inner diameter corresponds, irrespectively of a small clearance, to the outer diameter of shank 21. At the opposite, outerly threaded end of the shank, in the proximity of tang 23a a tightening nut 29 is screwed.

Thereby the bolt 11 can be inserted and tightened in any case operating from the same side, i.e. the side of tang 23a, no operation being necessary on the other side of the bolted connection, that side having been chosen that affords more room available, i.e. a larger angular opening, as it is apparent from Figure 5. First, shank 21 carrying the pin integral therewith is inserted in the aperture provided on the flanges to be joined, starting with end 25. Once washer 27, obviously larger than the through bore, has come into contact with the flanges to be joined, tang 23a is caused to back up by hitting it with a suitable tool, and in meantime the seat of helical spring 20 is released whereas the spring is still compressed when passing through aperture of flanges 5, and eventually expands coming out of the opposite side, until it takes the form of open head as shown in cross-section in Figure 5. To make the disengagement of spring 20 from washer 27 easier, the inner opening of the latter is chamfered. Thereafter tightening is performed by keeping the shank stationary through pin tang 23a and screwing at the same time hexagonal nut 29 up until the two flanges to be joined are tightly clamped between the expanded head formed of spring 20, and washer 27.

It is possible to disassemble the flanges and therefore, the structure, either partially or completely, by holding with a suitable hooked tool the helical spring head whereby it is made to coil up on itself while the pin is rotated through tang 23a. The shank is then taken out by hitting it at end 25, for instance by means of the same hooked tool which can be inserted in a narrow space, or removing the same by means of the tang as well.

Referring now to Figures 6 to 13, some examples of four flanged rod cross-sections are shown, all of which can be circumscribed in a circle, among them those of Figures 6, 7 and 8 having a continuous open X-shape, which in Figures 7 and 8 is provided with dependent peripheral elements. Figures 9 and 10 show two additional examples of bars formed of enclosed tubular elements having inner or outer flanges; i.e. converging from the periphery towards the center of diverging towards the periphery, respectively. While the exemplary embodiment of Figure 6 has already been shown in Figure 4a, the

one of Figure 9 has already been shown in Figures 4 and 5, and in particular in Figure 4 without the tubular peripheral part, also because in this case, as usual when dealing with closed profiles, or with open cross-section with peripheral elements, the crossing near the joint nodes is obtained by removing the peripheral portions. All of these different available shapes of the bar cross-sections are advantageously obtained simply by extrusion for instance from aluminium alloys, as well as the embodiments of Figure 12 showing a variation of Figure 6, where two opposite closed peripheral elements are provided, and of Figure 13 which can be considered in turn a variation of Figure 12, where two flanges on the same radial plane are cut in the central area.

The embodiment of Figure 11 is rather different, but always in accordance with the requirements of the invention, as it comprises a simple tubular element having local flanges, only at each rod end, wherein the flanges are formed for instance by plastic deformation of the tube, or by addition of material. On the other hand, as already mentioned, no matter how the bars are obtained, the only essential and sufficient condition is that the flanges have the required angular orientation to allow for coupling with conjugate flanges of converging rods, even though at the ends only, for instance by means of material added. It is understood that where the necessary shape is provided at the ends only, the advantage of obtaining a constant cross-section bar by means of a simple extrusion process is lost.

It is finally possible to use rods whose flanges are circumscribed inside a peripheral square enclosure completely or partially closed, as it is shown in Figures 14 and 15 respectively.

It should be noted that the outer upper and lower planes can be completed by using stub sections of the missing diagonals, or by means of wings made as lengths of the missing diagonal rod flanges.

In such a way, with no need for structural elements other than the abovementioned rods which are available through extrusion, subjected to the only cutting (at size or in order to take away the peripheral enclosures at the node areas), and drilling operations to allow for bolt insertion, as well as bolt tightening, also by hiring unskilled labour it is possible to assemble roof covering of a fairly large size. The peripheral complementary members mentioned above, besides fulfilling a structural function, can also be utilized as a connecting means for vertical panels, or horizontal panelling for covering or ceiling.

Possible additions and/or modifications can be made by those skilled in the art to the embodiments described above of the structural bar according to the invention, without exceeding the scope of this invention. In particular different cross-sectional shapes from those shown can be adopted, provided that they meet the requirements concerning mutual orientation of the flanges.

Claims

1. A bar (1) for planar three-dimensional lattice structures, comprising substantially radial flanges (5), each having a first surface defining a plane in a sheaf of planes having its axis coincident with the geometrical longitudinal axis of the bar (1), the other surface of each flange (5) of a bar (1) being offset from the said first surface, characterized by the fact that said bar (1) is an X-shaped member, thus with four flanges (5), the radial planes of which relating to said first surfaces, at least at bar ends, define therebetween an angle (φ) which is dependent upon the angles (α, β, γ) formed by the geometrical axes of the bars (1) converging into the same nodal point (0) with respect to a system of three coordinate axes having its origin in the center of said node (0), as a function of the respective direction cosines (a, b, c) of said angles, so that tan $\varphi = -c/b$ whereby coupling of a number of identical bars (1) with flanges having the same angular orientation is provided by overlapping the flanges (5) relating to conjugate coupling planes in a position of planar coincident relationship.

2. The structural bar of Claim 1, characterized in that said other surfaces, being offset from the associate plane defining angle (φ), are directed all to the same direction of rotation about the said longitudinal axis.

3. The structural bar of Claim 1, characterized in that said other surfaces, being offset from the associate plane defining angle (φ), are symmetrically arranged relative to a plane (S—S) bisecting a pair of opposite angles (φ; $180° - \varphi$).

4. The structural bar according to Claim 2 or 3, characterized in that said four flanges (5) have associated therewith peripheral elements that can be inscribed in a circle whose center lies on said longitudinal axis.

5. The structural bar according to Claim 4, wherein said peripheral elements provide an enclosed tubular profile from which said flanges (5) extend, in a substantially radial direction, to a position close to said geometrical axis, without reaching the same, there being also provided that said outer tubular enclosure is missing at the joint nodes, where the bars (1), connect to each other.

6. The structural bar according to Claim 2 or 3, characterized in that said flanges (5) extend from a central tubular element, co-axial with said geometrical longitudinal axis of said bar (1).

7. The structural bar according to Claim 2 or 3, comprising a longitudinal tubular element adapted to assume an X-shape by forming said four flanges (5), with the angular orientations required, only in a region close to the bar ends by squashing of said tubular element.

8. The structural bar according to any of preceding Claims 1 to 6, made of continuously extruded material, in particular of aluminum alloy, and cut to the desired size.

9. A planar three-dimensional structure formed by at least a single layer of pyramidal trusses (3) having a square loop base (10) formed of bars (1)

according to Claim 1 and one of Claims 2 or 3 and 4 to 7, with fastening elements (7) to join to each other the flanges (5) of bars converging in the same virtual geometric node (0), and overlapping at said first surface associated with said conjugate coupling planes.

Patentansprüche

1. Ein Stab (1) für ebene dreidimensionale Fachwerkstrukturen mit im wesentlichen radialen Flanschen (5), von denen jeder eine erste Oberfläche hat, welche eine Ebene in einem Ebenenbündel definieren, deren Achse mit der geometrischen Längsachse des Stabes (1) zusammenfällt, wobei die andere Oberfläche eines jeden Flansches (5) des Stabes (1) außerhalb der ersten Oberfläche liegt, dadurch gekennzeichnet, daß der Stab (1) ein X-förmiges Bauteil ist, somit vier Flansche (5) aufweist, deren radiale Ebenen zu den ersten Oberflächen gehören und die wenigstens an den Stabenden zwischen sich einen Winkel (φ) bilden, der von der Winkeln (α, β, γ) abhängt, welche durch die geometrischen Achsen der Stäbe (1) gebildet werden, welche im gleichen Knotenpunkt (0) relativ zu einem System von drei Koordinatenachsen zusammenlaufen, deren Ursprung im Mittelpunkt des Knotens (0) liegt als Funktion der entsprechenden Richtungskosinen (a, b, c) der Winkel, derart daß tan $\varphi = -c/b$ ist, wobei ein verbinden einer Anzahl von identischen Stäben (1) mit Flanschen, welche die Winkelausrichtung haben durch Überlappung der Flansche (5) erfolgt, welche zu konjungierten Verbindungsebenen in einer Lage ebener übereinstimmender Beziehungen gehören.

2. Der Strukturstab nach Anspruch 1, dadurch gekennzeichnet, daß die anderen Oberflächen, welche außerhalb der zugehörigen Ebene liegen, welche den Winkel (φ) definiert, alle in gleicher Drehrichtung um die Längsachse ausgerichtet sind.

3. Der Strukturstab nach Anspruch 1, dadurch gekennzeichnet, daß die anderen Oberflächen, welche außerhalb der zugehörigen Ebene liegen, welche den Winkel (φ) definiert symmetrisch relativ zu einer Ebene (S—S) angeordnet sind, welche ein Paar von entgegengesetzten Winkeln (φ; $180° - \varphi$) schneidet.

4. Der Strukturstab nach Anspruch 2 oder 3, dadurch gekennzeichnet, daß vier Flansche (5) umfangsseitige Elemente so zugehörig aufweisen, daß diese in einem Kreis eingeschrieben werden können, dessen Mitte auf der Längsachse liegt.

5. Der Strukturstab nach Anspruch 4, wobei die umfangsseitigen Elemente ein geschlossenes rohrförmiges Profil erzeugen, von dem sich die Flansche (5) aus erstrecken in einer im wesentlichen radialen Richtung in eine Lage nahe der geometrischen Achse, onhe diese zu erreichen, wobei weiterhin vorgesehen ist, daß die äußere rohrförmige Einschließung an den Verbindungsknoten fehlt, wo die Stäbe (1) miteinander verbunden sind.

6. Der Strukturstab nach Anspruch 2 oder 3, dadurch gekennzeichnet, daß sich die Flansche (5) von einem mittigen rohrförmigen Element aus erstrecken, welches koaxial mit der geometrischen Längsachse des Stabes (1) ist.

7. Der Strukturstab nach Anspruch 2 oder 3, aufweisend ein langgestrecktes rohrförmiges Element, welches ausgeformt ist, eine X-Form durch Ausbildung der vier Flansche (5) anzunehmen, wobei die nötigen Winkelausreichtungen vorgesehen sind, jedoch nur in einem Bereich nahe der Stabenden, in dem das rohrförmige Element gequetscht ist.

8. Der Strukturstab nach einem der vorhergehenden Ansprüche 1 bis 6, hergestellt aus einem kontinuierlich extrudierten Material, insbesondere einer Aluminiumlegierung und geschnitten in die gewünschte Größe.

9. Eine ebene dreidimensionale Struktur gebildet durch wenigstens eine einzige Schicht von pyramidenförmigen Gittern (3) mit einer quadratischen Grundfläche (10) gebildet aus Stäben (1) nach Anspruch 1 und einem der Anspruch 2 oder 3 und 4 bis 7, mit Befestigungselementen (7) um miteinander die Flansche (5) der Stäbe zu verbinden, welche im gleichen virtuellen geometrischen Knoten (0) zusammenlaufen und sich in der ersten Oberfläche überlappen, welchen den konjungierten Verbindungsebenen zugehörig ist.

Revendications

1. Une barre (1) pour structures planes en treillis tridimensionnelles, comprenant des brides sensiblement radiales (5) chacune présentant une première surface définissant un plan dans un faisceau de plan ayant son axe coïncidant avec l'axe longitudinal géométrique de la barre (1), l'autre surface de chaque bride (5) d'une barre (1) étant décalée de ladite première surface, caractérisée par le fait que ladite barre (1) est un élément en forme de X, ainsi avec quatre brides (5) dont les plans radiaux en rapport avec ladite première surface, au moins aux extrémités de la barre, définissent entre eux un angle (φ) qui est fonction des angles (α, β, γ) formés par les axes géométriques des barres (1) convergeant vers le même point nodal (0) eu égard à un système de trois axes de coordonnée ayant son origine dans le centre dudit noeud (0) comme une fonction des cosinus de direction respectifs (a, b, c) desdits angles, de sorte que tan $\varphi = -c/b$, ce qui permet qu'un couplage d'un certain nombre de barres identiques (1) avec des brides ayant la même orientation angulaire soit assuré par le chevauchement des brides (5) en rapport avec des plans de couplage conjugués dans une position de relation plane coïncidente.

2. La barre structurelle de la revendication 1, caractérisée en ce que lesdites autres surfaces, étant décalées de l'angle définissant un plan associé (φ), sont toutes orientées dans la même direction de rotation autour dudit axe longitudinal

3. La barre structurelle de la revendication 1, caractérisée en ce que lesdites autres surfaces,

étant décalées de l'angle définissant un plan associé (φ), sont disposées symétriquement par rapport à un plan (S—S) coupant en deux une paire d'angles opposés (φ; 180°−φ).

4. La barre structurelle selon la revendication 2 ou 3, caractérisé en ce que lesdites quatre brides (5) ont des éléments périphériques qui leur sont associés lesquels peuvent être inscrits dans un cercle dont le centre se trouvent sur ledit axe longitudinal.

5. La barre structurelle selon la revendication 4, dans laquelle lesdits éléments périphériques constituent un profil tubulaire fermé à partir duquel s'étendent lesdites brides (5), dans une direction sensiblement radiale, vers une position près dudit axe géométrique, sans atteindre celui-ci, étant également prévu que ladite enceinte tubulaire extérieure est manquante au niveau des noeuds de connexion, où les barres (1) s'interconnectent.

6. La barre structurelle selon la revendication 2 ou 3, caractérisée en ce que lesdites brides (5) s'étendent depuis un élément tubulaire central, coaxial avec ledit axe longitudinal géométrique de ladite barre (1).

7. La barre structurelle selon la revendication 2 ou 3, comprenant un élément tubulaire longitudinal prévu pour prendre une forme en X par formation desdites quatre brides (5), avec les orientations angulaires requises, seulement dans une région proche des extrémités de la barre en appliquant une force sur ledit élément tubulaire.

8. La barre structurelle selon l'une quelconque des revendications 1 à 6 précédentes, constituée en une matière extrudée en continu, en particulier en alliage d'aluminium, et coupée à la dimension souhaitée.

9. Une structure plane tridimensionnelle formée par au moins une couche unique d'étais pyramidaux (3) ayant une base en boucle carrée (10) constituée de barres (1) selon la revendication 1 et l'une des revendications 2 ou 3 et 4 à 7, avec des éléments de fixation (7) pour interconnecter les brides (5) des barres convergeant dans le même noeud géométrique virtuel (0) et se chevauchant au niveau de ladite première surface associée auxdits plans de couplage conjugués.

Fig.1

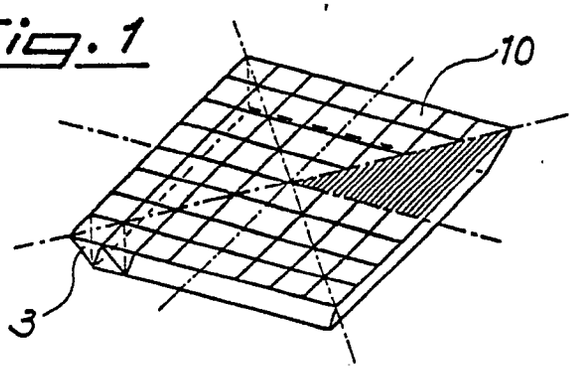


Fig.1a

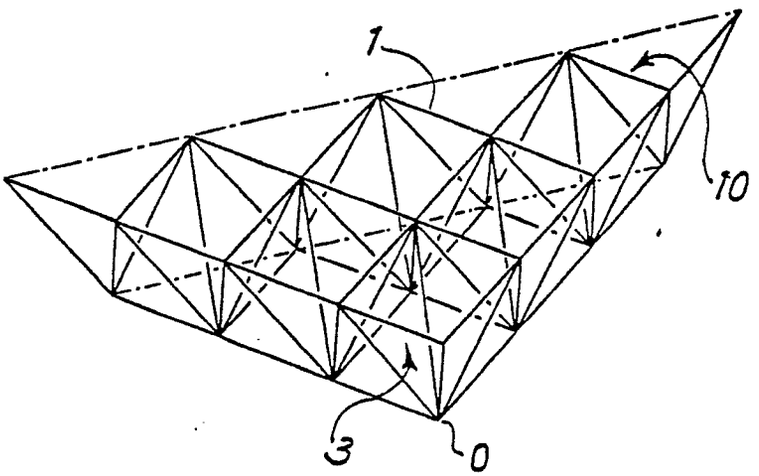


Fig.2

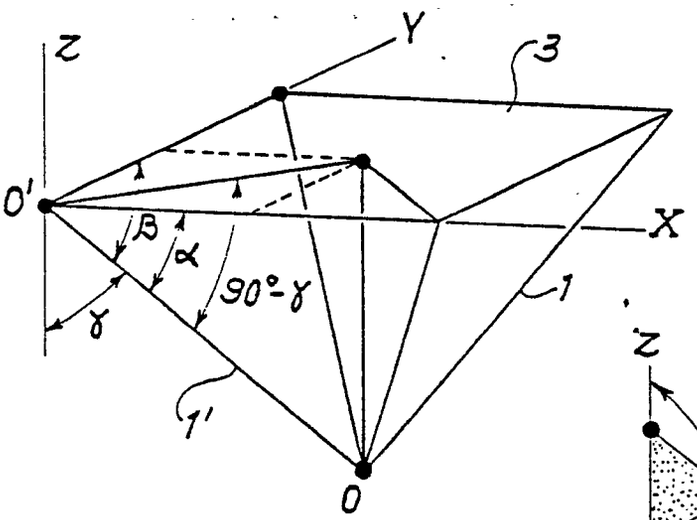


Fig.2a

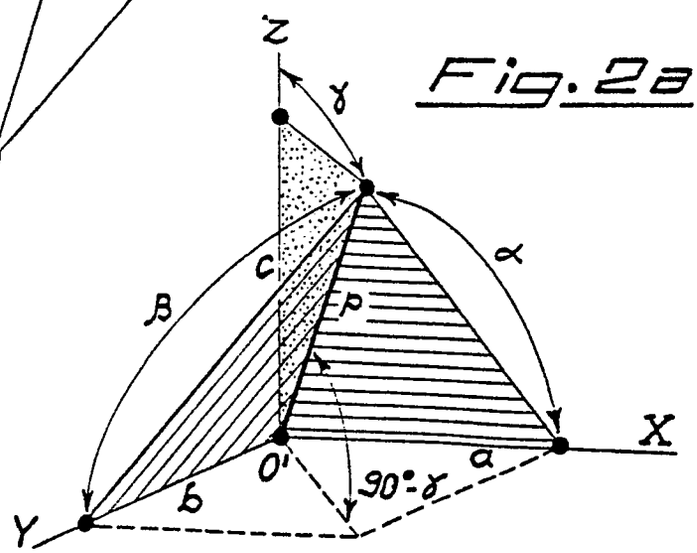


Fig. 3a

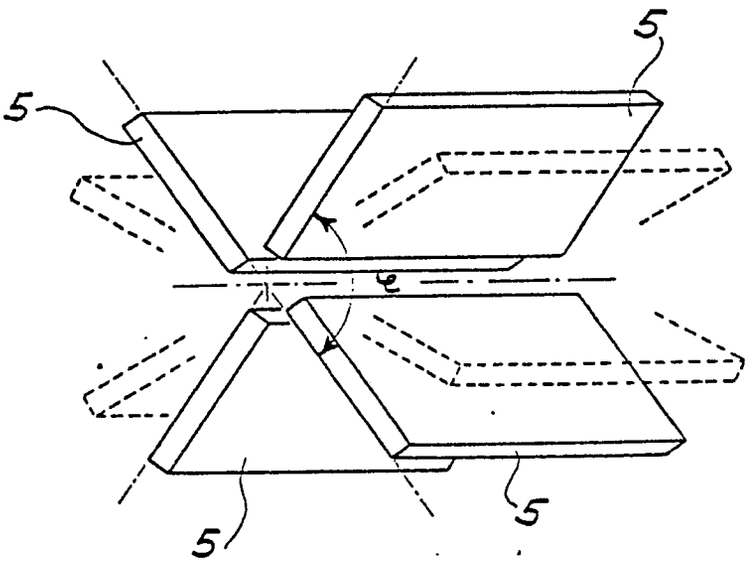


Fig. 3b

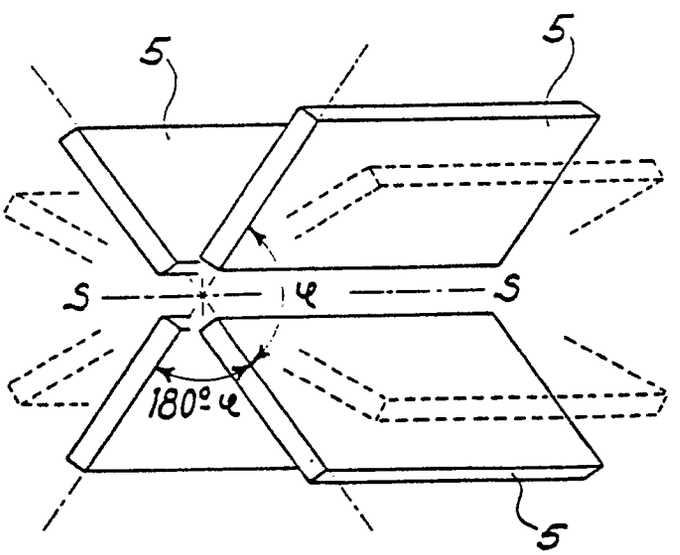


Fig.4

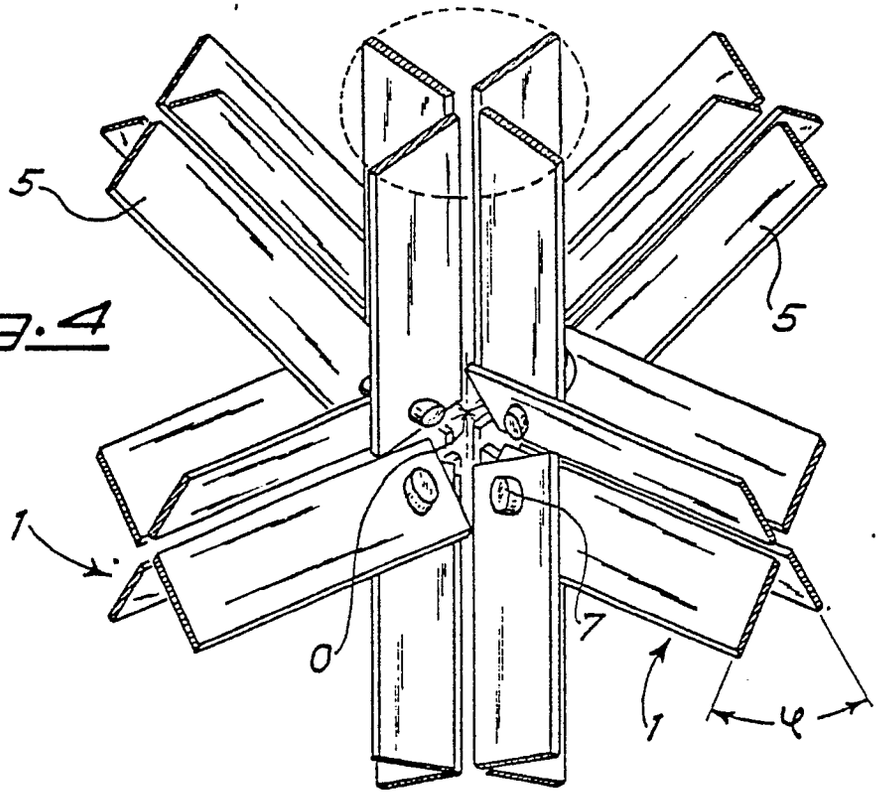
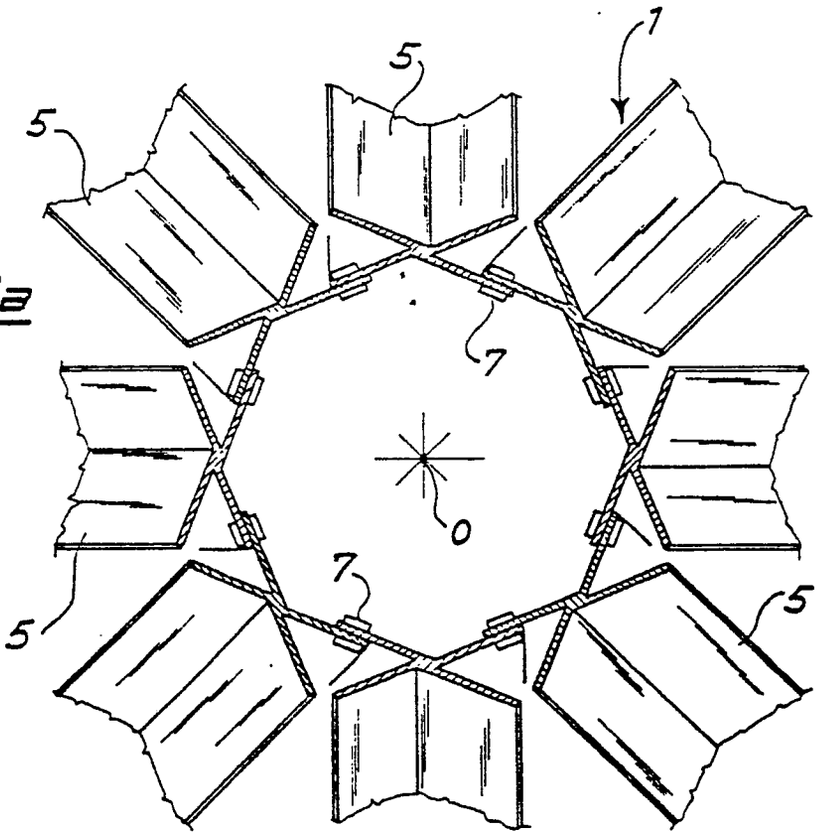


Fig.4a



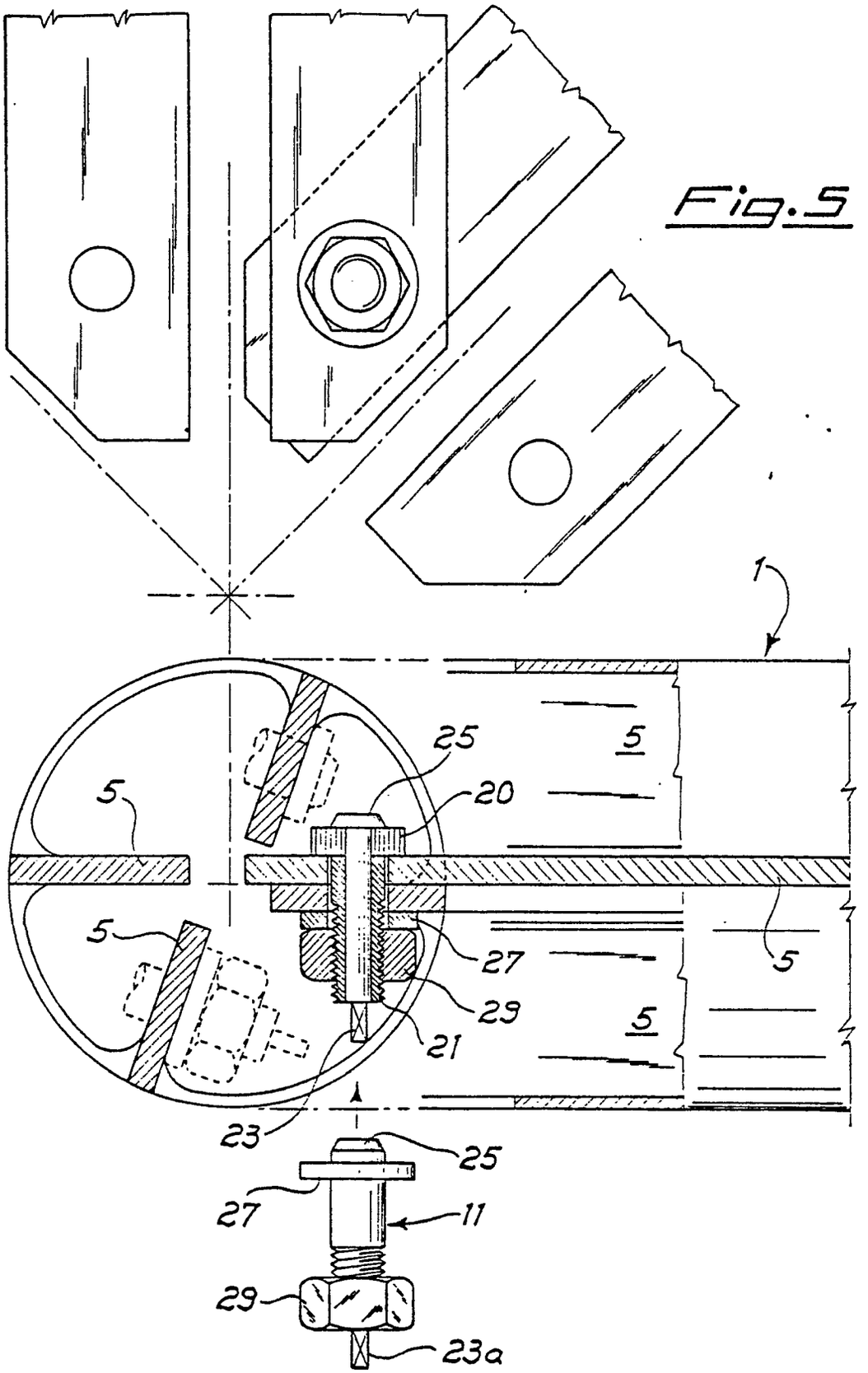


Fig.5

Fig.6



Fig.7

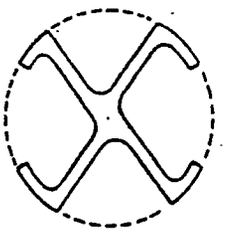


Fig.8



Fig.9

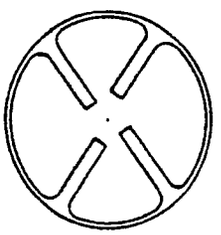


Fig.10

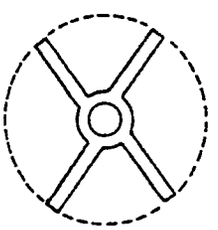


Fig.11

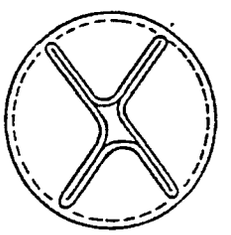


Fig.12



Fig.13

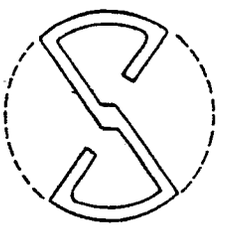


Fig.14

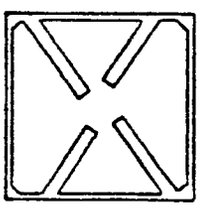


Fig.15

