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(54) Spatial structural element prefabricated by means of folding and/or molding.

(57) The spatial structural prefabricated element is the result of the formation by means of folding, molding or extruding of polygon surfaces limited by edges which coincide with the linear elements of which the spatial structures are composed, in such a way that the basis of the pyramids (normal or inverted), are closed by means of plates or continuous flat
meshes made with an adequate material.

The prefabricated element is a rigid body, sandwich type with a high resistance to stress, bending and sagging and with an inner texture which corresponds to the texture of a spatial structure with embodied inner faces.

The prefabricated element can be obtained from a wide variety of materials and the application fields are: industry, engineering, building and even agriculture to make forging, walls, insulation panels, floating items, sills, etc.

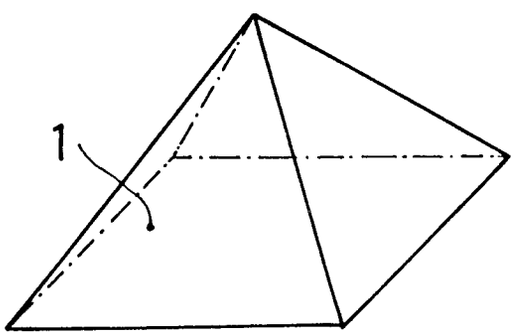

FIG. 1

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The invention deals with a spatial structural prefabricated element made by means of folding and/or molding,
conceived to make a rigid body, like a sandwich, with a high resistance to compression, bending and sagging in such a way that, having an internal structure such as spatial structures, nevertheless, it has the peculiarity that the inner polygons delimited by the bars of the spatial structures themselves are
embodied, and are flat polygonal surfaces. This determines a prefabricated material that can be used in any industrial field, in engineering, building and agriculture to obtain forging, partition walls, enclosures, panels of any kind to build walls, insulation, floating bodies and in general terms,
any kind of application field for many different uses.

The prefabricated element can be obtained easily, either folding a sheet of the adequate material or by means of molding always obtaining a prefabricated material with a light weight and a high resistance thus providing more advantages
and better mechanical and economic performance than the elements and/or products known up to now.

For the architecture and industrial techinque a spatial structure is a setting of resistant elements whose behavior analysis can be determined by the traditional system of independent planes such as in the case of frameworks, roof trusses, tiles, arches, lattices, etc...

The calculation complexity of a spatial structure resides in the determination of the axial stresses of each of the elements (bars) of which the set, taken as a whole consists.

Generally, these sets are composed by a studding or a triangle shaped mesh of equal bars joined at common corners called spatial knots.

The above joints, which are articulated, behave in real life as a hyper static structure, that is, any stress applied on any of its elements is transmitted axially to the other elements and therefore the sizing and the use of the materials
is much more profitable than in traditional structures.

As it is also known the practical application of this building system allows an incomparable gauziness when roofing vast surfaces reducing the abutment points practically to perimetric areas. At the same time it allows to build great projectures which would be impossible (in economic terms) with any other building system.

Nevertheless, the use of the spatial technique is subject to three serious imponderables.

1.- **Its exclusivity**: To each structural design corresponds an application space defined by its specific dimensions.

2.- **Its structural quality**: The linear nature of its elements doesn't allow its practical application in other building units without using additional materials and costs.

3.- **Its economic effectiveness**: It only competes with other building systems when covering wide areas.

The technical know-how of the holder of the invention, a higher architect working in the field since 1968, allows him to add that, unless a better information is submitted, there is no material or execution system, either in the state-of-the-art or in the industrial or building market similar to the proposed by this invention.

Nevertheless, with an informative purpose, and to make it
easier to draw the state-of-the-art report, some known materials and products are mentioned. These, on the grounds of their appearance or usefulness, could be linked with the subproducts of the invention:

1.- **Prefabricated tiles**: Their external finishing is flat but their insides are lightened only with longitudinal holes drilled with a constant section and adopting cylindrical, ovoid, rectangular, prism, etc. shapes.

2.- **Prefabricated panels**: Made with light materials or with materials which are void by means of cardboard threshing inserted between the external sheets.

3.- **Extruded and molded material**: It is usually solid such as, beams, girders, metallic profiles, etc., or void such as fantails, hollow bricks, bricks, cases, tubes, etc. made with several materials.

4.- **Linear folds**: Made with flat plates shaped into tubes, profiles, etc with different formats and materials.

5.- **Molding**: It usually consists of isolated elements with
reduced dimensions or prototypes of elements manufactured by batches.

6.- **Honey combed**: They are generally made with flexible plastic material, with sealed air bubbles to protect the items they are wrapping.

7.- **Punched**: Usually made of plastic or metallic material. In both cases the roughness of the flat plate, obtained with the punchs, endows it with a higher toughness and the relieves (stopper shaped) allows them to be used for pavement draining.

8.- **Cardboard articles and packages**: the range of shapes, sizes and materials is almost unlimited; some can suggest useful structural designs but their uses have nothing to do with this character or with industrial uses.

Technically speaking, the invention is related to the so called spatial structures but not in its design

and/or its formal execution aspect. The main difference is that whereas spatial structures are assembled like a meccano by means of joints between bars and knots, the prefabricated spatial element, object of the invention is obtained from filling the flat surfaces defined by the above bars (which are transformed into the sides or edges) and the knots (which are transformed in the polyhedral vertices of the resulting pyramids). In
addition, from the point of view of their shaping and the material used, together with the possible application and the marketing, the differences are obvious.

More precisely, the prefabricated element of the invention is the result of the shaping by means of folding, molding or extruding of the geometrical surfaces defined by the bars and the nuts of the spatial structures.

The prefabricated element can be complemented with supplementary fittings, zig-zag shaped, joined to the inclined edges from vertex to vertex in such a way that, as they
coincide with the orthographic crossings of the edges formed in each of the horizontal surfaces, they could easily be electrowelded to any net superimposed on the above horizontal surfaces.

Therefore, the technical problem to be solved is the prefabrication of a new building material, light, in a higher or lower degree according to its components and to the resistance necessary in each case, a material with which we can obtain better advantages and performances than with the materials known up to now.

Therefore, in addition to the advantages offered by the so called spatial mesh such as:

- a better distribution of the load and canvassing.
- a better exploitation of the materials
- a higher building lightness.
- a higher gauziness for covered areas.
- a higher economy for the supports and foundations.
- a higher simplicity in assemblies.
- a higher transport and storage economy.
- an easier remodeling and enlargement.
- more length for juts.
- more freedom to design projects,

We can also include the ones contributed by the features of this new material such as:

- light and resistant prefabricated materials.
- a higher insulation capacity, both thermal and acoustic.
- building of walls, forged material and partition walls.
- building and insulation of roofs
- building of silos and tanks.
- assembling of panels and grooving and tonguing.
- building of resistant floating bodies.
- light agglomerates with different thicknesses.
- prefabrication of industrial premises and buildings.
- groundsills and continuous and insulating pavements.

The prefabricated element obtained in each case either by
folding or by molding or extrusion will have a texture or inner folding and a flat or spherical finishing in one or in both external surfaces independently from the shape of the side edges.

To obtain the desired element can be used plates or sheets of natural or artificial elements provided they can be folded by molds and/or molded.

To simplify the understanding of the features of the invention, we will make a detailed description based in a set of drawings enclosed to this descriptive report in which the following has been depicted with an orientative and non limitative character:

Figure 1 shows, by way of example a regular pyramid with a square basis as the basic element to form a prefabricated element according to the aim of the invention. The pyramid could also be irregular with any number of sides.

Figure 2 shows a tetrahedron of those formed inside the prefabricated element object of the invention when the above is obtained by molding, with the pyramid depicted in the above figure.

Figure 3 shows two perspectives of void bodies formed by a correlative series of inverted pyramids such as the one depicted in figure 1 and by another series of tetrahedrons inserted between them.

Figure 4 shows a general view of the void body obtained by means of four pyramids such as the one depicted in figure 1.

Figure 5 shows a section view of a folded sheet with the spatial texture complemented with a filling and plates, and the upper and lower finishing.

Figure 6 shows a general view of a spatial mesh with the pyramids and tetrahedrons of figures 1 and 2 forming an structural spatial prefabricated material.

Figure 7 is an schematic view, both in plan and elevational of one of the multiple combinations that can be obtained according to the shape and distribution of the basic shapes used to form a spatial prefabricated structural element, according to the aim of the invention.

In view of the above figures and taking into account that to be able to understand the aim of the invention we have used
as a basic geometric shape a regular pyramid with

a square basis (1), and assigning a null thickness to the geometrical bodies, we can check that the regular space between each consecutive pair of pyramids is a regular tethraedron (2).

If we consider the set composed by the four pyramids (1) of figure 4 joined between them by two of the edges of their basis, we will obtain a common point, an assembly point "0" which in turn will be common for the lower vertices of the internal sides of the regular tetrahedrons (2), inserted between every two pyramids (1).

The four inner sides of the above tetrahedrons and their common assembly point "0" are precisely the sides and the vertex of the respective inverted pyramid (1') of figure 3, whose inclined edges coincide exactly with de edges, equally inclined of the pyramids converging at point "0". The sides of
the basis of such inverted pyramid (1'), are in turn the upper edges of each of the inserted tetrahedrons (2), with sides equal to the distance between each of two consecutive vertexes, within the set of the four pyramids considered (1) shown in figure 4.

Extending the above reasoning to an undefined number of pyramids (1) laying on a horizontal plane we will obtain the same number of inverted pyramids (1') with the basis on a horizontal plane parallel to the former, hiding between the faces of the pyramids the tetrahedral spaces that can be inserted in figure 4 as it could be obtained projecting (joining) figures 3 and 4.

Once the above geometric abstraction has been admitted as a whole and considering non existent the plans of the basis of
both sets of pyramids (the normal and the inverted ones), we obtain a geometrical body with a continuous folded spatial texture, in which the obverse and the reverse are the same, that is, a set of orthographic edges on two parallel plans, with depressions shaped as regular pyramids whose heights are equal to the distance between the above planes.

Therefore, as it has already been said, the final result will be to obtain the triangular faces of the pyramids formed between the linear elements of the spatial structures and thus it is obvious to assume that their mechanic-stress behavior
will have, for any of its possible uses, similar reactions.

Hence, the aim is to obtain a sheet formed by polyhedral figures in which the sides of the relevant pyramids are embodied. That is, the aim is to obtain laminar bodies of any adequate material but this body should be formed by a series of pyramid figures obtained by means of any polygon configuration; or similarly, to obtain a spatial structure in which the faces defined by the bars of the above spatial structure are embodied such as it happens with the circle which is the embodiment of the inner space of the circunference.

The material execution of the laminar body which will constitute the spatial structural prefabricated material, according to the object of the invention, can be made by means of folding or molding.

Should the prefabricated element be obtained by means of folding, obviously two molds will be necessary: a lower one (a tongue) and an upper one (a groove), logically inserting between them the sheet that has to be folded to obtain the relevant spatial structural prefabricated element.

The lower mold (the tongue) will be composed by a series of pyramids (1) arranged as shown in figure 4, whereas the upper mold (groove) will be composed by as many void pyramids (fig. 1) as necessary, and arranged as the above to make the upper and the lower fit.

As it has already been mentioned, before joining the two molds, the relevant semi rigid material will be inserted, a sheet capable to fold so as to obtain the adequate relief and texture by means of the pyramidal denting of each mold as it is shown by figure 4. The approximation inner spaces between the faces of the above molds will be proportional to the thickness of the sheet inserted.

The texture and the stress properties of the relevant prefabricated element will be obtained either with a single folded sheet or with two folded sheets, one in the position shown by figure 4 and the other according to figure 3 (1') joined together by adherence, fusion or welding by their inclined edges, as they are inverted with respect to each other.

Once the spatial inner texture is obtained, the external faces are closed by means of an adequate sheet or mesh with determines the plane shape of the former. This is achieved by means of adherence or welding of the edges of the basis of the
pyramids to the above sheet or mesh thus obtaining the sandwich element already mentioned.

When the prefabricated element is obtained by means of molding, this differs in the material used and of course in the manufacturing process even though the final element is the
same.

Logically, the mold should be identical and they should have as many tetrahedrons as necessary to be fitted between every two consecutive pyramids.

On the other hand, independently of the procedure to obtain the prefabricated element, the edges of the above should be made according to the kinds of joint that should be obtained between the different panels.

Thus, figure 5 shows an straight external edge (3); figure 6 shows a projective external edge (3');

figure 7 shows a French roof edge (3''). In this last case a specific element shape can be obtained according to the polygon combination chosen. The left area A shows a plan view with some pyramids missing; the right area B corresponds to the depiction of the upper edges; the lower area C shows the lower
edges whereas the lower area D, shows the inclined edges.

The lower figure (elevational view) corresponding to figure 7, shows the French roof edge (3'') and the plates (4) which could close horizontally the upper and lower side of the prefabricated element obtained.

As it has already been mentioned, the spatial structural prefabricated element obtained either by folding or molding, according to the invention and generally referred to as #5, in addition to the insulation panels (6) of figure 5, can be stiffened by means of bars either in zig-zag or broken which would follow the relevant edges.

Finally, we must say that, independently from the different geometrical shapes and combinations in which the obtention of the prefabricated element (5) can be based, the basis of the resulting pyramids will always have to rest on horizontal planes, parallel between them. They will also have the peculiarity that in addition to the inner spatial structure which the prefabricated element should have, externally they can be finished with flat spherical surfaces independently of the finishing of its lateral edges.

In addition we must also add that a specific number of elements can be superimposed on similar ones with parallel faces and with a final spherical configuration.

Claims

1. Spatial structural element prefabricated by means of folding and/or molding which, based on the concept of spatial structure, is generally composed by a network or polygonal mesh of identical bars joined in common vertexes called spatial knots. Its main feature is that it is composed by a hollow and open body obtained by means of folding and/or molding which embodies the polygonal surfaces delimited by the edges which coincide with the assumed linear bars of a spatial structure, determining an inner texture composed by inclined
   flat surfaces and an external finishing either flat or spherical.

2. Spatial structural element prefabricated by means of folding and/or molding, according to claim 1, whose main feature is that the hollow body which constitutes the prefabricated element is obtained by means of sheets or plates of a material either natural or artificial that can be folded and/or molded.

3. Spatial structural element prefabricated by means of folding and/or molding, according to claims 1 and 2 whose main
   feature is that the polygonal surfaces which embody it are constituted by pyramids whose inner edges are joined together by adherence, fusion or welding, if they are composed of two or more folded elements.

4. Spatial structural element prefabricated by means of folding and/or molding according to the above claim, whose main feature is that the inclined edges of the pyramids and of the basis are complemented by stress bars thus constituting a supplementary mesh or net also spatial.

5. Spatial structural element prefabricated by means of folding and/or molding according to the above claims whose main feature is that it can be superimposed or fitted on similar ones to determine a final geometric configuration of flat and parallel external faces or with a general spherical shape.

6. Spatial structural element prefabricated by means of folding and/or molding according to the above claims, whose main feature is that the basis of the pyramids can be closed both on the top and bottom side by means of horizontal sheets or meshes, parallel to each other. The edges can have any lateral finishing to determine edges with the following shapes cornice, French roof, vertical or grooved and tongued combinations.

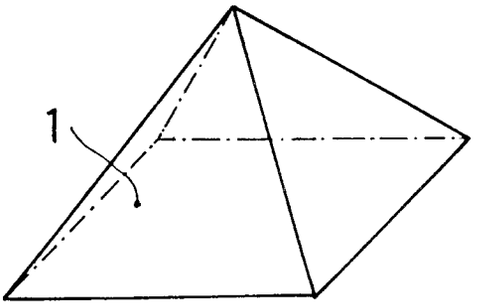

FIG. 1

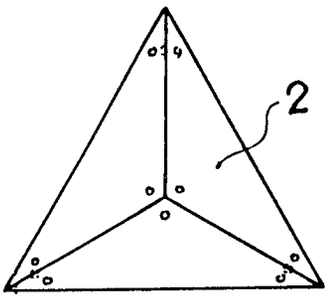

FIG. 2

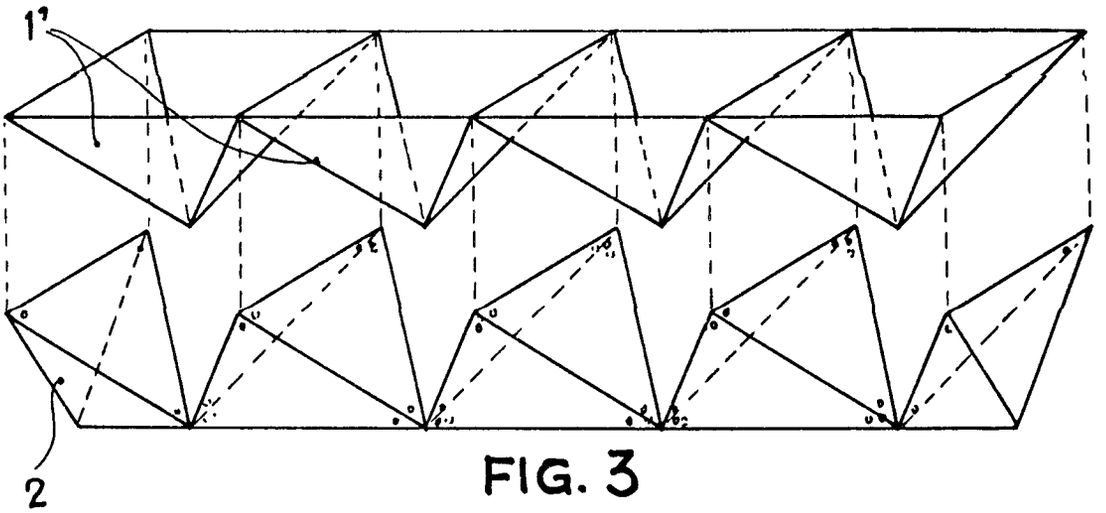

FIG. 3

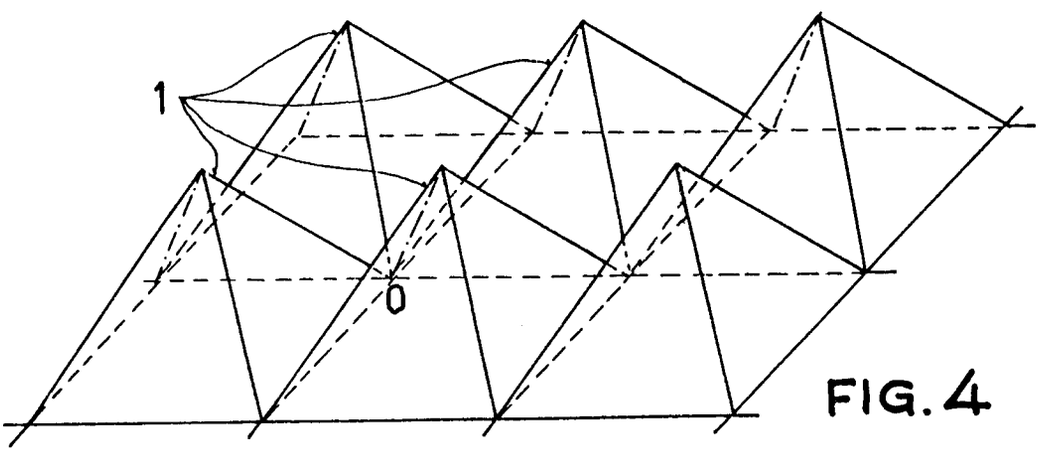

FIG. 4

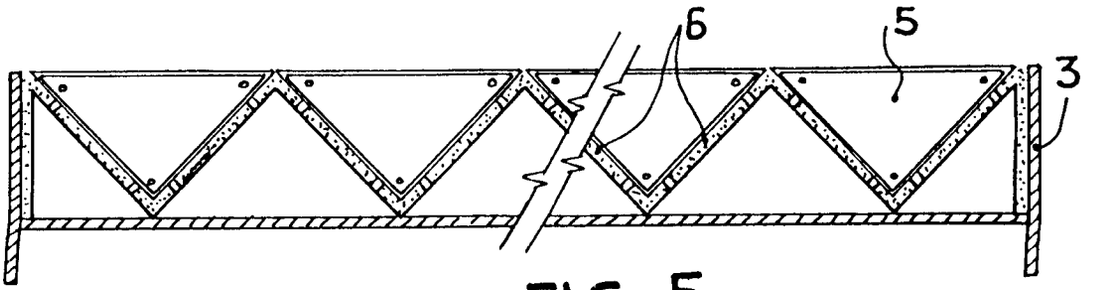

FIG. 5

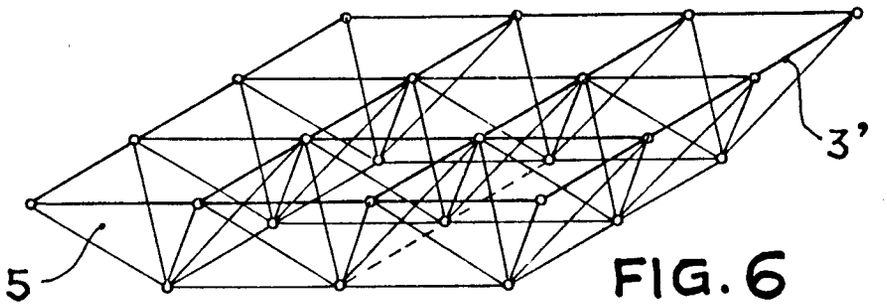

FIG. 6

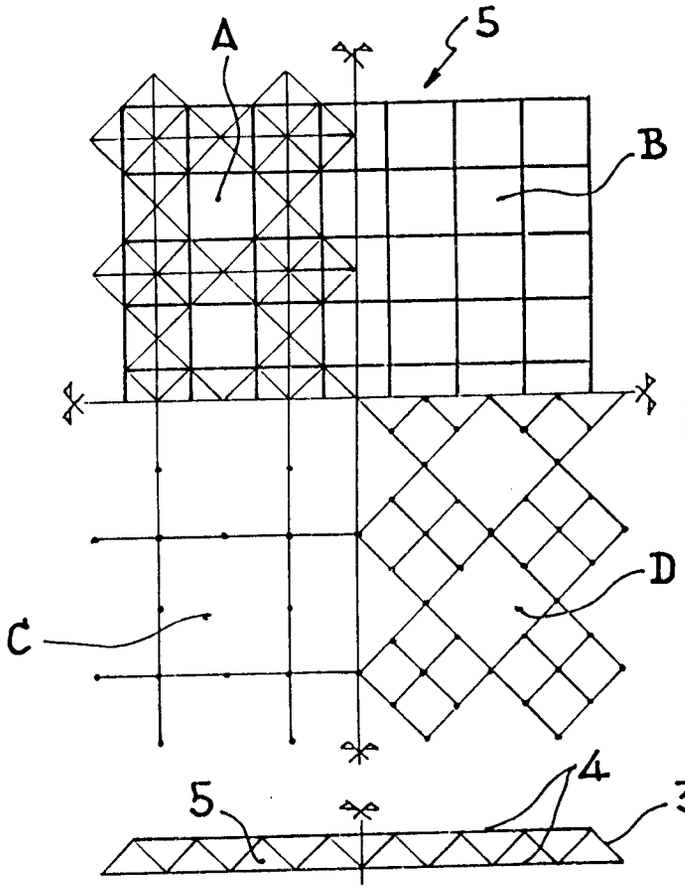

FIG. 7

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EUROPEAN SEARCH REPORT

Application Number
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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.5)
X	DE-C-615 360 (GABO-PEWSNER) * the whole document * ---	1-4	E04C2/32 E04B7/10
X	NL-A-6 506 083 (WILDSCHUT) * the whole document * ---	1-6	
X	PLASTICONSTRUCTION vol. 1, no. 1 , 1971 , MUNCHEN DE pages 3 - 11 WILDSCHUT ET AL 'Forschungen über Kunststofftragwerke' ---	1-6	
X	US-A-4 685 257 (RICHTER) * the whole document * ---	1-6	
X	DE-A-33 04 668 (MÜHL) * the whole document * ---	1-6	
X	CH-A-681 550 (ZEMP) * the whole document * ---	1-4	
X	'Plastics in building structures' June 1965 , BRADLEY & SON , READING, UK GILKIE ET AL 'Recent developments in plastics stressed-skin pyramidal roof systems', Paper 25, page 165-173 ---	1-6	TECHNICAL FIELDS SEARCHED (Int.Cl.5) E04B E04C
X	US-A-3 906 571 (ZETLIN) * the whole document * ---	1-6	
X	US-A-3 932 248 (KEATON) * abstract; figures * ---	1-6	
X	PLASTICONSTRUCTION vol. 3, no. 6 , 1973 , MUNCHEN DE page 291 '12000 m2 Kunststoffdach' ---	1	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	30 November 1993	Scholvinck, T

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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X	BOUW vol. 20, no. 34 , 21 August 1965 , ROTTERDAM NL page 1228 HUYBERS 'Dragende kunststofconstructies' * figures * ---	1	
X	TECHNIQUES ET ARCHITECTURE no. 350 , November 1983 , PARIS FR pages 125 - 127 'Exposition itinérante IBM' -----	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

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