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(54) A sturdy I-girder.

(57) The invention relates to a sturdy I-girder. In the previously used corresponding girders, for example in I-girders made of laminated wood, it has not been possible to adjust the dimensioning so that bending stress, shearing stress and bending flexure would all have been equal dimensioning factors, and so it has been necessary to overdimension the girder. The object of the invention is in particular to eliminate this disadvantage and to achieve thereby a considerable saving in material. This is achieved by making the web (u) of the girder from continuous multi-ply wood with 10-60 %, preferably 30 %, of its plies being such that their grain orientation is transverse in relation to the web length and the remainder of the plies being such that their grain orientation is parallel to the web length. The booms(p) of the girder are made from multi-ply wood the plies of which have their grain orientation parallel to the web length.

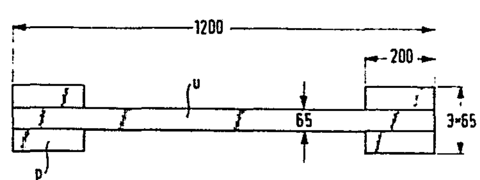

Fig. 5

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Croydon Printing Company Ltd

A sturdy I-girder

The invention relates to a sturdy I-girder. Sturdy timber girders are currently manufactured by gluing laminae of sawn timber together, and the product is called laminated wood. The strength/weight ratio of laminated wood is rather advantageous. However, it is characterized in that the strength property which determines the dimensioning in different load situations varies, whereupon the timber girder in question is overdimensioned as regards other properties.

As regards strength, three main factors are primarily concerned. First there is bending flexure, which is in general approximately girder span/200-300, e.g. 50 mm for a span of 15 m.

The second one is the bending stress produced by the load in the girder. It is at its greatest in the middle of the span in the case of a single-span girder. A certain theoretical bending stress, characteristic of the material, must not be exceeded, since otherwise there is the risk that the girder breaks in the middle.

The third factor is the shearing stress produced by the load in the girder; the ends of the girder are subjected to shearing stress by the supports. With great loads, the shearing force tends to split a laminated-wood girder at its ends in the longitudinal direction in such a way that the lower edge of the girder is stretched because of the bending flexure and the upper surface resists this displacement, whereupon the girder splits at its ends on the horizontal level along the center line.

Starting from one of the extremes of the capacity range of laminated wood, namely, a long span and a small load, the dimensioning factor is bending flexure (span 1 in Figure 1). In the middle of the range the dimensioning factor is bending stress (span 2, Figure 1), and in the opposite extreme, in which the load is great and the span is short, the dimensioning factor is shearing stress (span 3 in Figure 1).

As noted above, when one factor determines the dimensioning, laminated wood is overdimensioned in other respects. To correct this situation, laminated wood has been glued also in the form of an I-profile (Figure 3).

Bending flexure and bending stress can in this way be optimized so that there is no overdimensioning with respect to either one of these factors, which results in a considerable saving in raw material. However, this cannot be realized except in certain special situations, since shearing stress will, when the load increases, dimension the narrowed web in such a way that it should be widened. Thus, sufficient benefit cannot be drawn from this profile so as to make its manufacture economically sensible. Therefore such laminated wood is currently not manufactured to a significant degree.

The use of plywood between wide booms has been studied as a second alternative. The shear strength of plywood is sufficient, but the tendencies of crinkling and buckling owing to the very slim and narrow structure (Figure 4A) have become a problem. Attempts have been made to solve these problems by gluing so-called box structures (Figure 4B), but in this case expensive joint alternatives have been required, because if economical use of plywood sheets is desired, they must be made into sheets having the same length as the girder. The fact that plywood-webbed sturdy composite girders are generally not manufactured is evidently due, in addition to the above, to the difficult control of the behavior of the girder in question in conditions of varying dampness and to its non-existent fire resistant properties.

Multi-ply wood is a prior known product, in which there is first manufactured from plies over 2 mm thick, by weather-proof gluing, a 25-75 mm thick and up to 2 meters wide, continuous, up to 30 m long sheet. The grain of most of the plies is longitudinally oriented. Laminated-wood girders, planks or various small profiles are obtained by cutting the sheet. The product has been on the market since the beginning of 1978.

Multi-ply wood has an advantage in being usable for many distinctly different purposes, since it has been possible to vary its structure within a wide range, when necessary. For this reason, the sturdy I-girder was consciously developed through the optimization of multi-ply wood.

The objective set was a sturdy, continuous and fire-resistant girder in which bending flexure, bending stress and shearing stress would all be equal dimensioning factors, whereby a maximal saving of material would be achieved. Surprisingly, this objective was achieved when the solution according to the characteristics of the accompanying claim was invented, by applying multi-ply wood.

For example, in the fire resistance classification, I-girders having a minimum web of 65 mm are prescribed for use in public areas in Finland. The fire resistance of an I-girder according to the invention is at minimum 1/2 hour.

With an I-girder according to the invention, long spans can be achieved in such a way that the cross section is clearly smaller than that of a laminated-wood girder dimensioned for the corresponding span. A table of comparison is enclosed. The table shows the maximum spans for a multi-ply I-girder and corresponding laminated wood, when the effects of the three main dimensioning factors, bending stress, shearing stress and bending flexure, have been taken into consideration separately. The maximum final span of the girder is the minimum of these three span values.

The following advantages can be recorded for the benefit of a multi-ply I-girder as compared with a laminated-wood girder:

- A cross section 37-84 % smaller than with laminated wood can be achieved with a structure of the same height, see table.
- Owing to the cross bands of the web and the booms, the expansion of the girder in the vertical direction is almost completely prevented, whereas in laminated wood there is a difference of about 4 % between completely dry and wet wood.
- Owing to the cross bands in the web, the jointing technique is simpler at the ends of the I-girder.
- Owing to the cross bands and the vertical glued joints of the booms, the pressures, or forces, by which the surfaces of the girder and the underlying support press against each other do not constitute a problem. (The end of a narrow girder collapses, when this pressure is too great.)
- The fire resistance of the multi-ply I-girder, adequate as such, is easily improved by means of fire-resistance classified wool.
- The same manufacturing technique can be used for

manufacturing very sturdy box girders, and since the materials of the web and the booms are to a great extent similar, warping due to dampness can be controlled.

- In addition to being used as a sturdy girder, the profile in question can be used as a pillar, in which case it has very high stability values and makes jointing techniques very simple in such a way that in the pillar the booms continue beyond the pillar web to the extent of the height of the web of the horizontal girder, and the web of the horizontal girder continues beyond the booms of the horizontal girder to the extent of the height of the pillar web. Thus the booms of the pillar can be easily joined to the web of the horizontal girder (Figure 6).

The invention is illustrated below with reference to the accompanying drawings, in which Figure 1 depicts graphically different load cases of laminated wood and Figure 2 depicts graphically a comparison of the strength properties of a laminated wood girder and a multi-ply I-girder. Figure 3 depicts a known I-girder made of laminated wood, and Figure 4 a known I-girder and a box girder made from plywood. Figure 5 depicts a multi-ply I-girder according to the invention, and Figure 6 a special application of an I-girder according to the invention.

Figure 1 shows graphically, with the span L of the girder as the vertical axis and the load F as the horizontal axis, the effect of bending flexure l_w, bending stress l_b and shearing stress l_v on the dimensioning of ordinary laminated wood. The proportions are presented arbitrarily, and so bending stress does not necessarily have the sector width of the type plotted. Bending flexure is the dimensioning factor within span 1, bending stress within span 2, and shearing stress within span 3. Figure 2 depicts graphically the cross-sectional area of laminated wood L (dotted lines) and corresponding multi-ply I-girders K (solid lines) as functions of the product which is obtained by multiplying by each other the maximum span values for bending and shearing strengths and bending flexure. The spacings of the supports are 4.8, 6.0 and 7.2 m (cf. the table). Three spans have been taken for each spacing, and both a laminated-wood girder and a multi-ply I-girder have been optimized for each span, and so the differences indicate that a certain strength property of laminated timber has overcapacity.

Figure 3 shows a known laminated-wood girder made in the shape of an I-profile, having a web u and booms p. Figure 4A depicts a known I-girder, in which the web u is made of plywood and fitted between wide booms p. Figure 4B for its part shows an also known box-structured plywood girder.

Figure 5 depicts one example of the dimensioning of a girder according to the invention.

Figure 6 shows how an I-girder according to the invention can be used as a pillar and be joined in a simple manner to a horizontal girder in such a way that the booms p_p of the pillar continue beyond the pillar web u_p to the extent of the height of the web u_v of the horizontal girder, and the web u_v of the horizontal girder for its part continues beyond the booms p_v of the horizontal girder to the extent of the height of the pillar web u_p.

Figures 5 and 6 illustrate clearly the general structure of the I-girder according to the invention. Thus, the girder comprises a web u and a total of four booms p, which have been glued to the edges of the web on both sides of the web. The booms also consist of multi-ply wood, and their grain orientation is always in the longitudinal direction of the web, in addition to which the grains of most of the different plies of the web are in the longitudinal direction of the web. One conventional arrangement is such that the web is assembled from a great number of plies, for example 26 plies one on top of the other, the second, fourth and tenth ply, calculated from each surface of the web, having a transverse grain orientation. In the arrangement of the grain orientation, an arrangement symmetrical in relation to the center plane is generally used, and the installation of transverse-grain plies on the surface is avoided so that they would not be destroyed first in a fire.

TABLE

	INVENTION				LAMINATED WOOD					
Profile height (mm)	Mutual distance between roof rafters (m)	Maximum span for optimal multi-ply I-girder[1] (m)			Girder width x height (mm x mm)	Mutual distance between roof rafters (m)	Maximum span for optimal laminated-wood girder, with the same span and load (m)			Ratio between amounts of wood Optimal laminated wood/ optimal multi-ply wood
		Bending	Shearing	Flexure			Bending	Shearing	Flexure	
900	4.8	14.8	16.9	14.2	140x1080	4.8	15.3	17.2	14.6	1.37
	6.0	13.1	13.4	12.8		6.0	13.6	13.6	13.6	
	7.2	11.9	11.1	11.5		7.2	12.4	11.1	12.2	
1200	4.8	19.0	24.1	18.4	165x1260	4.8	19.4	24.1	18.7	1.60
	6.0	17.0	19.1	16.7		6.0	17.4	19.3	17.0	
	7.2	15.0	15.1	15.0		7.2	15.4	15.2	15.5	
1800	4.8	28.1	34.9	27.1	210x1710	4.8	28.2	39.3	27.2	1.84
	6.0	24.9	27.5	24.6		6.0	24.9	30.7	25.1	
	7.2	22.5	22.6	22.9		7.2	22.8	25.6	22.9	

1) 6 of the plies in the web structure have a transverse grain orientation and 17 of them longitudinal grain orientation in relation to the longitudinal direction of the girder.

Claims

1. Sturdy I-girder, characterised in that the web (u) of the girder is made from continuous multi-ply wood, 10-60 %, preferably 30 %, of its plies having the grain transverse in relation to the web (u) length and the remainder of the plies having the grain parallel to the web length, and the booms (p) of the girder are made of multi-ply wood having the ply grain parallel to the length of the web (u).

2. An I-girder made of timber-based material, characterised in that it comprises a web (u) which is a laminate of a plurality of plies of wood, of which 10-60 % have their grain transverse in relation to the longitudinal direction of the girder, the remaining plies having their grain parallel to the said direction; together with narrow parts (p) at the edges of the web, projecting beyond the faces of the web (u) to give the I-section, said narrower parts (p) being laminates of a plurality of plies of wood having their grain parallel to the said direction.

3. An-I girder according to claim 1 or claim 2 wherein the web (u) is at least 65 mm thick.

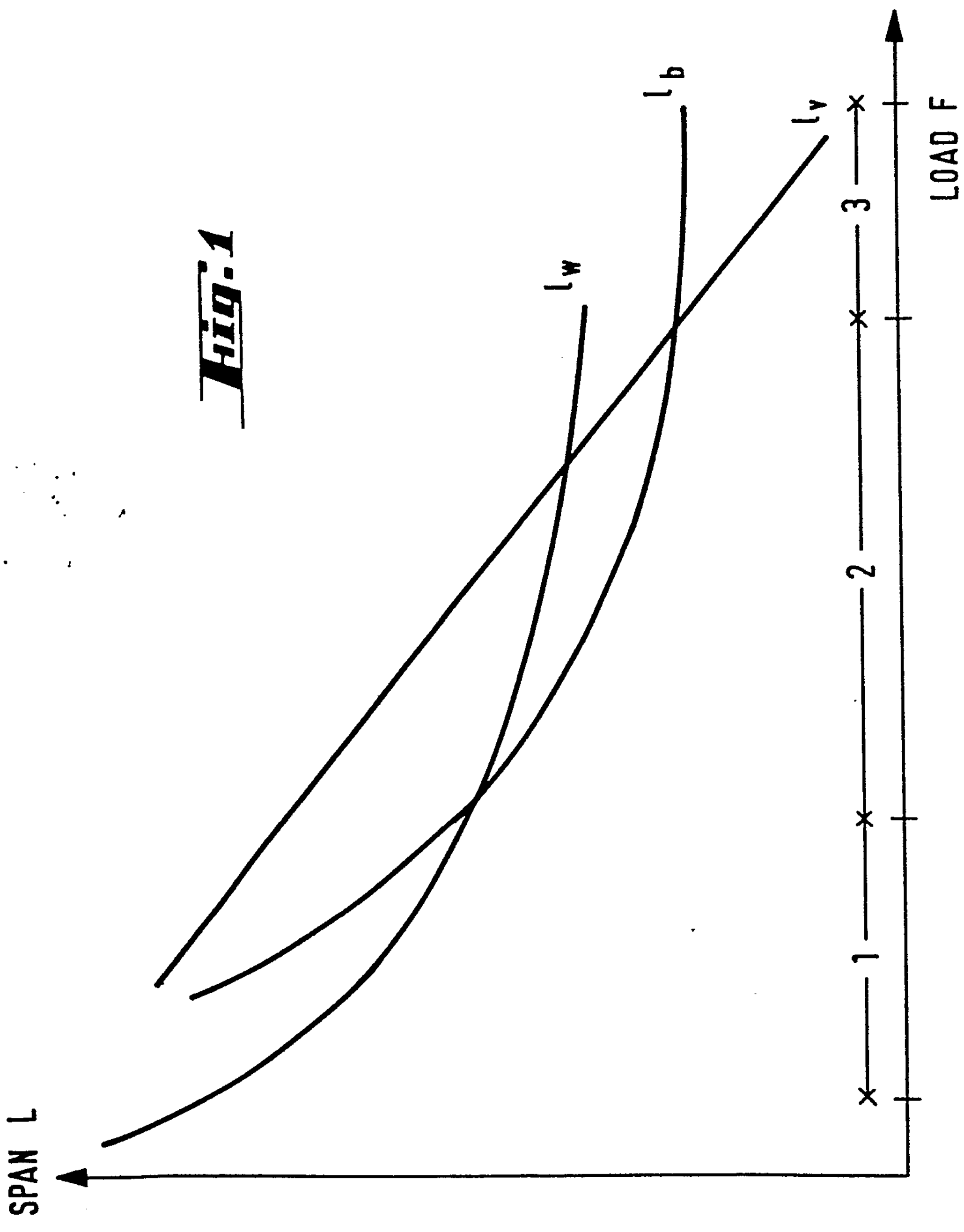
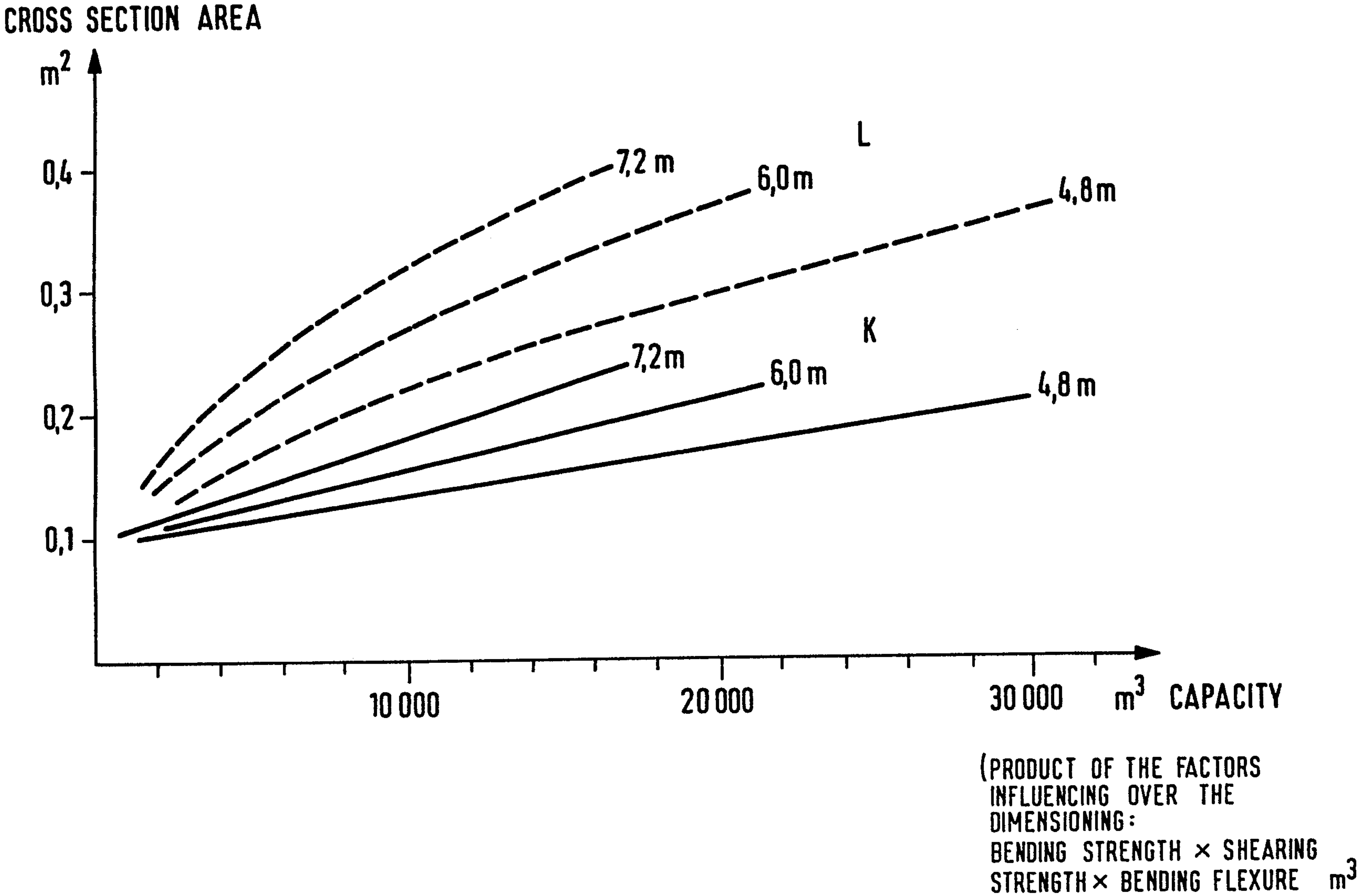


Fig. 1

Fig. 2


CROSS SECTION AREA
m2
0,4
0,3
0,2
0,1
L
K
7,2 m
6,0 m
4,8 m
7,2 m
6,0 m
4,8 m
10 000
20 000
30 000
m3 CAPACITY
(PRODUCT OF THE FACTORS INFLUENCING OVER THE DIMENSIONING:
BENDING STRENGTH × SHEARING STRENGTH × BENDING FLEXURE m3)

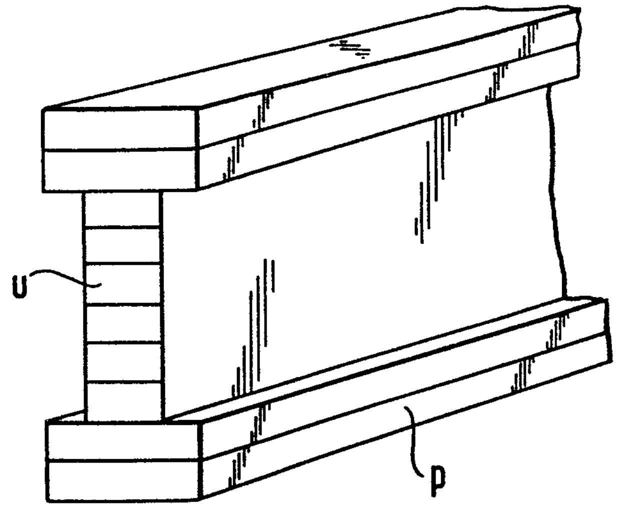


Fig. 3

Fig. 4a

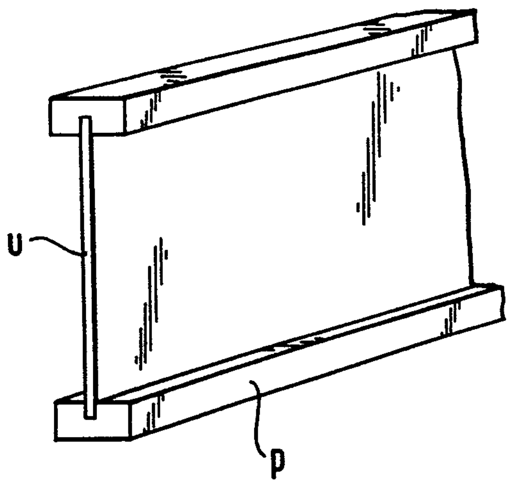


Fig. 4b

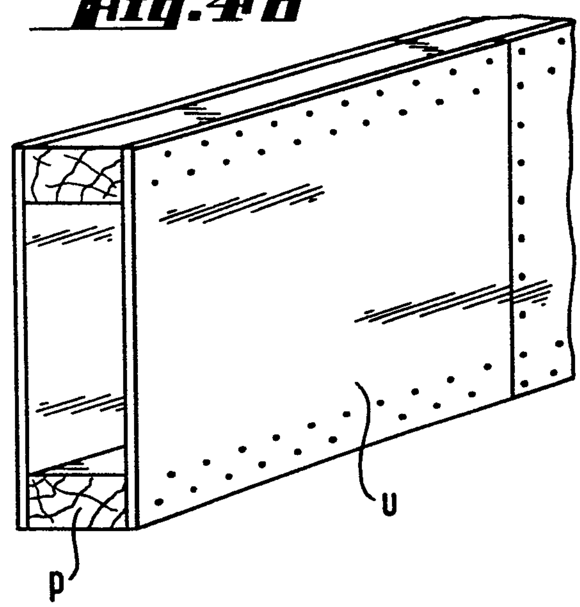


Fig. 4

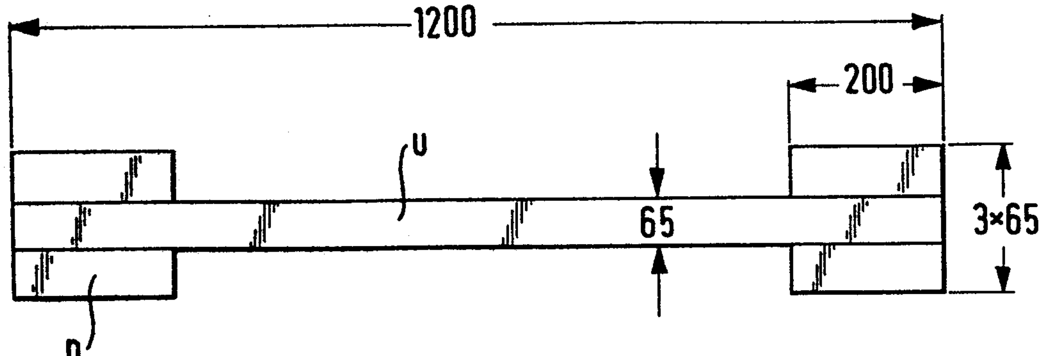


Fig. 5

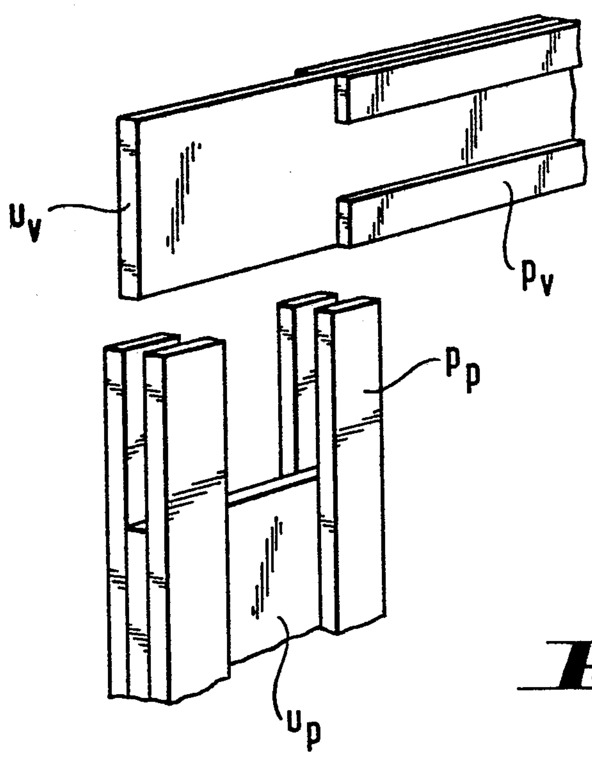


Fig. 6

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EUROPEAN SEARCH REPORT

0079761

Application number

EP 82 30 6003.3

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
A	DE - U - 1 825 643 (W. POPPENSIEKER) * claim ; fig. 1, 2 *	1,2
A	DE - U1 - 8 033 681 (ACHBERGER GMBH) * claims 1, 5 ; fig. 1 *	1
A	FR - A1 - 2 367 883 (UHALDE-BERNIER S.A.) * fig. 13 to 16 *	1
A	GB - A - 1 514 879 (W.A. NICKERSON & CO.) * claims 1, 2, 5 ; fig. 2, 3 *	1
A	DE - U - 7 011 426 (ÖSTERREICHISCHE DOKA SCHALUNGS- U. GERÜSTUNGSTECHNIK GESELLSCHAFT MBH) * fig. 1 *	1

CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)

E 04 C 3/14

TECHNICAL FIELDS SEARCHED (Int.Cl. 3)

E 04 C 3/00

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same category
A: technological background
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E: earlier patent document, but published on, or after the filing date
D: document cited in the application
L: document cited for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Berlin	21-12-1982	v. WITTKEN