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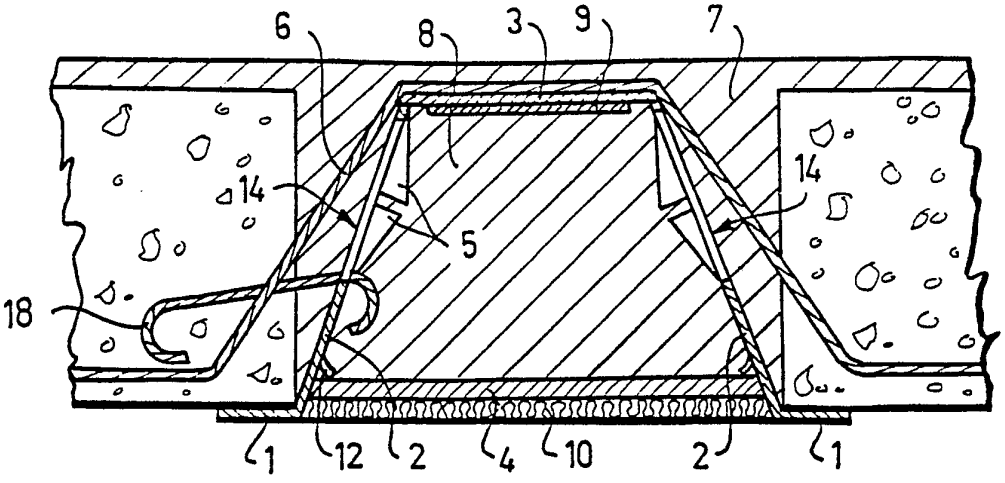

(57) Abstract

The invention relates to a fire-resistant prefabricated steel beam arranged to act together with concrete as a load-bearing jointing construction for various slabs. The beam comprises two web portions and horizontally projecting flange portions extending beyond the web portions. To achieve a simple beam easy to install at least each web portion (2) with its horizontally projecting flange portion (1) is formed by an integral material strip so that the web portion (2) and the projecting flange portion adjoining it form a jointless entity and so that the web portion (2) is in a slanting position with respect to the flange portion. The web portions (2) are arranged side by side so as to slant towards each other and interconnected at edges closer to each other by means of a horizontal upper part (3). The edges of the web portions (2) farther apart from each other are interconnected by means of a plate (4) welded to the web portions. Openings (14) are formed close to the upper edges of the web portions (2) and/or in the horizontal upper part (3) to fill the space defined between the upper part (3) of the web portions (2) and the plate (4) with concrete in a manner known per se.

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A fire-resistant prefabricated steel beam

The invention relates to a fire-resistant prefabricated steel beam arranged to act together with concrete as a load-bearing jointing structure for various slabs and comprising two web portions and horizontally projecting flange portions extending beyond the web portions.

The frame of a prefabricated building is often formed by floor and ceiling structures carried by columns and beams. As the beams act as horizontal load-bearing structures, they have to be sufficiently rigid, that is, about 500 to 800 mm high when made of steel concrete. For heat, water, ventilation and electricity installations, the beams have to be perforated or the height of the floor structure has to be increased correspondingly. In certain cases the high beam structure has been replaced with a lowered beam structure, whereby the web of the beam remains within the floor structure. The height of the lowered beam has been minimized by prestressing, for instance. Technically, a jaw beam is more difficult to manufacture than a normal beam, and the minimum thickness of the lowered portion will nevertheless be 100 to 150 mm.

Beams are also often manufactured of steel. Steel beams are easier to manufacture than prefabricated concrete beams in addition to which they are light to transport and install. Moreover, steel beams are easier to modify at the working site. As steel beams do not require grouting and are light to displace, they can be installed more rapidly than concrete beams. By adjusting the building to the frame construction timetable, the total building time can be decreased. In case of fire the strength of

steel deteriorates with increasing temperature, wherefore a steel beam has to be protected from fire. The fire protection is preferably made by embedding the steel profile in a concrete floor structure, whereby the lower flange only has to be protected. The protection is made either by covering the lower flange with a fire-resistant plate, insulation, paint or spray. For reasons of appearance, the piping and the fire protection are often covered with a so-called suspended ceiling.

This way of fire protection has led to the use of low hat profiles approximately of the same height as the floor unit. In the hat profile the lower flange of a rectangular basic beam is broader than the rest of the beam, thus forming projections for the floor units. Since the structure is low, the steel cannot be utilized optimally with regard to the rigidity of the structure. Despite the extra steel kilos, the hat beam (THQ beam) has been used rather widely in business buildings, for instance, so as to utilize the building volume as efficiently as possible by means of the low floor structure. Considerable savings have also been obtained by means of the low floor structure in special cases where it would otherwise have been necessary to increase the depth of foundation and support the foundations of adjacent buildings on urban building sites.

The use of steel beams has been restricted mainly by the span length. With long span lengths the beam structure is very heavy and it has been necessary to camber the beams to eliminate deflections. With ever increasing construction costs, buildings are today built so that they can be modified later on for other uses. Such versatility is obtained by long floor units and sparse supporting structures by dis-

placing light partition walls. In view of the manufacturing technique, long beams are difficult to handle, appropriate cambering has to be provided according to the span length despite the thermal stresses caused by welding, and the welding time increases with increasing plate thickness.

To eliminate the above drawbacks, it has more recently been suggested to use a combined structure of a steel beam and concrete. An example of such solutions would be the solution of FI Patent Application 882186. A steel beam of such a combined structure is lighter and can be used with longer span lengths than previously. The steel beam of FI Patent Application 882186 requires less welding as the beam is formed by profile parts preformed by hot rolling. However, the solution of FI Patent Application 882186 is complicated to manufacture because the inserts joining the different materials increase the amount of required welding and the great number of small pieces complicates the manufacture of the beam.

The object of the invention is to provide a steel beam to be used with concrete, which avoids the drawbacks of prior art. This is achieved by means of a beam of the invention, which is characterized in that at least each web portion with its horizontally projecting flange portion is formed by an integral material strip so that the web portion and the projecting flange portion adjoining it form a jointless entity and so that the web portion is in a slanting position with respect to the flange portion, the web portions being arranged side by side so as to slant towards each other and interconnected at edges closer to each other by means of a horizontal upper part, and at edges farther apart from each other by means of a plate welded to the web portions, and openings

being formed close to the upper edges of the web portions and/or in the horizontal upper part to fill the space defined between the upper part of the web portions and the plate with concrete in a manner known per se. As to the advantages offered by the invention, it is to be mentioned generally that in addition to all the above-mentioned good properties of a steel beam, i.e. easy adaptability to the frame system of the working site, low and light structure, rapid installation, and simple installation of heat, water, ventilation and electricity, the invention offers other considerable advantages.

The beam of the invention is so designed that its steel parts carry the loads of the slab units during installation. The casing formed by the steel beam and the gap defined between the slabs and the steel profile are filled up in connection with the pouring of concrete into the joints of the slabs. In a finished structure, the beam of the invention carries the loads exerted on it due to the adhesion between concrete and steel. The beam is also suited for use together with a jointing slab to be cast on site. The slab and the beam can thus be concreted in one step. The beam of the invention can be fabricated on an automated line, optimizing the required welding in accordance with the required rigidity. The web portions can be simply perforated to improve adhesion. Projections possibly remaining on the edges of the holes or openings in connection with the perforation improve adhesion between the concrete and the steel. The openings are positioned, for instance, in the upper portion of the slanting web portions, so the grout passes easily inside the beam. The slanting web portions of the beam also enable the slab units to be placed quite close to the bends of the project-

ing flange portions without hampering the grouting. For this reason, the jaw is strained to a lesser extent than in solutions in which a separate casting space has to be left between the slab unit and the vertical web portion of the beam. The shape advantageous in case of fire and the pouring of concrete into the joints of the floor units wedge the slabs in place, leaving the projecting flanges solely for the installation of the units. The draw flange of the beam, positioned within the profile can be protected from fire in advance in connection with the manufacture of the beam unit without increasing the height of the floor structure. The projecting flanges protect the fire protection layer during transport and installation. The fire protection layer may also be protected from mechanical wear and damages by means of a thin plate attached to the projecting flanges.

In the following the invention will be described by means of preferred embodiments shown in the attached drawing, in which

Figure 1 is a cross-sectional view of a beam of the invention;

Figure 2 is a side view of the beam of the invention;

Figure 3 illustrates the attachment of the beam of the invention to a vertical structure;

Figure 4 is a side view of another embodiment of the attachment of the beam of the invention to a vertical structure;

Figure 5 is a cross-sectional view of another embodiment of the beam of the invention;

Figure 6 is a block diagram of an automated production line of the beam of the invention; and

Figure 7 is a cross-sectional view of still

another embodiment of the beam of the invention.

Figure 1 is a cross-sectional view of the beam of the invention in a situation where slabs rest on the beam and concrete has been poured inside the beam and into the gaps between the beam and the slabs. In the beam of Figure 1, each web portion 2 with an adjoining horizontally projecting flange portion 1 is made of an integral material strip. The web portions 2 are in a slanted position with respect to the projecting flanges 1. The web portion 2 and the projecting flange portion 1 adjoining it may be formed, e.g., by bending from a suitable strip of steel.

The two web portions 2 with the projecting flanges 1 are positioned side by side so that the web portions slant towards each other and are interconnected at the edges closer to each other by means of a horizontal upper part 3. The horizontal upper part 3 may be formed by a separate material strip, such as a steel strip, which is welded to the upper edges of the web portions.

In the embodiment of Figure 1, the two entities formed by the web portion 2 and the projecting flange 1 are completely jointless.

A horizontal steel plate 4 is welded between the edges of the web portions 2 farther apart from each other in such a manner that the plate acts both as a lower mould wall for the concrete 8 to be poured inside the basic profile and as a lower flange bearing the loads of the beam. In the example of the figure, the plate 4 is positioned higher than the level of the lower surfaces of the projecting flanges 1. This arrangement enables the beam to be protected 10 from fire without increasing its structural thickness.

Shoulders 12 may be attached to the web por-

tions 2 slanting towards each other. The plate 4 forming the lower flange rests on the shoulders during welding.

To fill the beam with concrete, the slanting web portions are provided with holes or openings 14. To ensure adhesion between the steel and the concrete, the edges of the openings 14 are provided with prodlike or platelike projections 5 at the fabrication stage, for instance.

Suspension rods 6 made of steel pass from the upper edge of the beam to the lower edge of the slabs to be supported. The suspension rods increase the ability of the beams to support the slabs together with a wedgelike concrete part 7 formed outside the beam when the beam is being concreted. In addition to the suspension rods 6 it is also possible to use gripping hooks 18 which efficiently anchor the wedgelike concrete part 7 in position. To increase the rigidity of the beam during installation, the steel area of the upper surface can be increased by means of a steel plate 9 or concrete steels welded under or above the upper part of the basic profile. The use of concrete steels improves the adhesive properties.

At the installation stage the beam is supported in the middle on structures beneath it before the slabs are placed in position. The middle support is removed after the grouting has gained sufficient strength. The use of support during grouting ensures efficient adhesion, which decreases deflection during and after construction so that the need of cambering is reduced. The support decreases substantially the need of steel on the compression side caused by stresses occurring during installation.

Figure 2 shows the beam of Figure 1 from the side. The openings in the web portions 2 of the beam

are so positioned that no cast cavities are formed under the horizontal upper part 3 of the beam in connection with concreting. The openings 14 are positioned in the web portions close to the upper edges. The openings 14 may also be used for laying reinforcements for slab fields and pipings for heat, water, ventilation and electricity installations.

Figure 3 shows the attachment of the beam of Figures 1 and 2 to a vertical supporting structure or column. The end of the beam is so shaped that a beam bracket 11 can be wholly fitted within the beam. The horizontal upper part of the beam forming the upper flange rests on the bracket, and the beam is tightened to the bracket by means of bolts 13 from the side of the beam against the side of the bracket. The tightening can also be carried out by means of installing wedges. This ensures that the beam has sufficient torsional rigidity during installation. Support torque is produced in the jointing beam by providing the bracket with a concrete reinforcement 15 extending through it before the grouting of the joint. The support torque decreases the deformations of the beam and increases the load carrying capacity. An alternative way of producing support torque is shown in Figure 4. Draw-bars 16 are arranged to go through the column. They are fixed to the end of the beam by means of pinching nuts 17. The nuts are tightened through the opening 14 of the web of the beam.

Figure 5 shows another embodiment of the beam of the invention. In this embodiment, the grouting of the beam has been carried out at the fabrication stage. The bending capacity of the beam can be increased by a prestressing technique conventionally applied to concrete beams. The degree of prestressing

can be higher than conventionally as the steel profile around the concrete efficiently limits the cleaving of concrete, functioning as a kind of web reinforcement. In the embodiment of Figure 5, the horizontal upper part 3 of the beam can be provided with openings or holes 20 through which concrete 21 is poured into the inner space of the beam. The edges of the openings or holes 20 can be provided with projections 22 similar to the projections 5 of the openings 14 described above. The embodiment of Figure 5 is otherwise structurally similar to the embodiment of Figure 1.

In the embodiment of Figure 5, no additional steels have to be provided on the upper surface of the beam because the beam itself forms a jointing structure at the installation stage. When the beam is bent, the plate 4 receives the tensile stress while the upper portion of the concrete filling of the beam receives the compression stress.

Due to the shape of the beam of the invention it can be produced efficiently on an automated production line. Figure 6 is a block diagram of the beam production line. The desired shape of the beam is achieved, e.g., by bending thin steel plate. Holes are made by any suitable means in the web portions, for instance. The projections improving the adhesion are also formed at the perforation stage. The parts are sawed into determined dimensions and the beam is cambered according to its span length if desired. The upper part, the possible additional steel of the upper part, and the plate forming the lower flange, which are flame-cut into dimensions, are cambered so as to correspond to the profile in shape. The welding of the additional steels can be carried out easily by means of an automatic welder by submerged arc welding

through welding grooves formed in the corners of the steel plates. Beam head details are welded by robot welding. Finally, the beam is coated and protected from fire if required.

Figure 7 shows still another embodiment of the invention. The embodiment of Figure 7 differs from that of Figures 1 and 2 in that projecting flange portions 31, web portions 32 and an upper part 33 are formed by an integral basic profile in Figure 7. The basic profile may be formed by a cold-moulded profile, for instance. In this embodiment, the projecting flange portions 31, the web portions 32 and the upper part 33 form an integral entity without any joints. The plate forming the lower flange is indicated with the reference numeral 34, the holes with the reference numeral 40, the projections with the reference numeral 42 and the shoulders with the reference numeral 32. Concrete is indicated with the reference numeral 41.

The embodiments described above are not intended to restrict the invention, but the invention can be modified as desired within the scope of the claims. Accordingly, it is obvious that the beam of the invention or its details need not be exactly similar to those shown in the figures but other alternatives are possible as well.

Claims:

1. A fire-resistant prefabricated steel beam arranged to act together with concrete as a load-bearing jointing structure for various slabs and comprising two web portions and horizontally projecting flange portions extending beyond the web portions, c h a r a c t e r i z e d in that at least each web portion (2, 32) with its horizontally projecting flange portion (1, 31) is formed by an integral material strip so that the web portion (2) and the projecting flange portion adjoining it form a jointless entity and so that the web portion (2, 32) is in a slanting position with respect to the flange portion, the web portions (2) being arranged side by side so as to slant towards each other and interconnected at edges closer to each other by means of a horizontal upper part (3, 33), and at edges farther apart from each other by means of a plate (4, 34) welded to the web portions, and openings (14, 20, 40) being formed close to the upper edges of the web portions (2, 32) and/or in the horizontal upper part (3, 33) to fill the space defined between the upper part (3, 33) of the web portions (2, 32) and the plate (4, 34) with concrete in a manner known per se.

2. A steel beam according to claim 1, c h a r a c t e r i z e d in that the upper part (3) interconnecting the web portions (2) at the edges closer to each other is formed by a separate material strip.

3. A steel beam according to claim 1, c h a r a c t e r i z e d in that the web portions (32), the projecting flange portions (31) and the horizontal upper part (33) are formed by an integral basic profile.

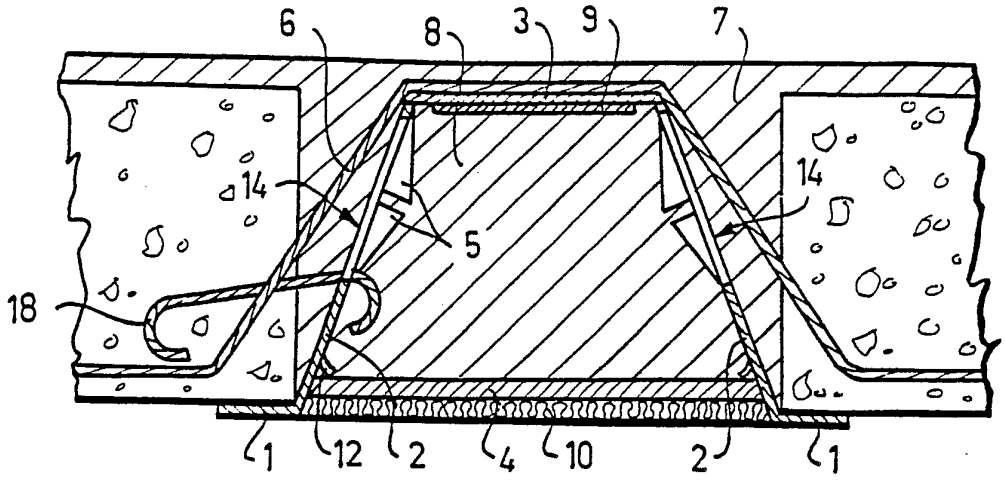
4. A steel beam according to claim 1, 2 or 3,

characterized in that projections (5, 22, 42) protruding from the plane of the web portion (2, 32) or the upper part (3, 33) are formed in the edges of the openings (14, 20, 40) to ensure adhesion between the concrete and steel.

5. A steel beam according to any of the preceding claims, characterized in that the plate (4, 34) connecting the lower edges of the web portions (2, 32) is positioned above the plane of the lower surfaces of the projecting flange portions (1, 31).

6. A steel beam according to any of the preceding claims, characterized in that at least one additional steel plate (9) and/or concrete steel is attached to the horizontal upper part (3, 33).

FIG. 1



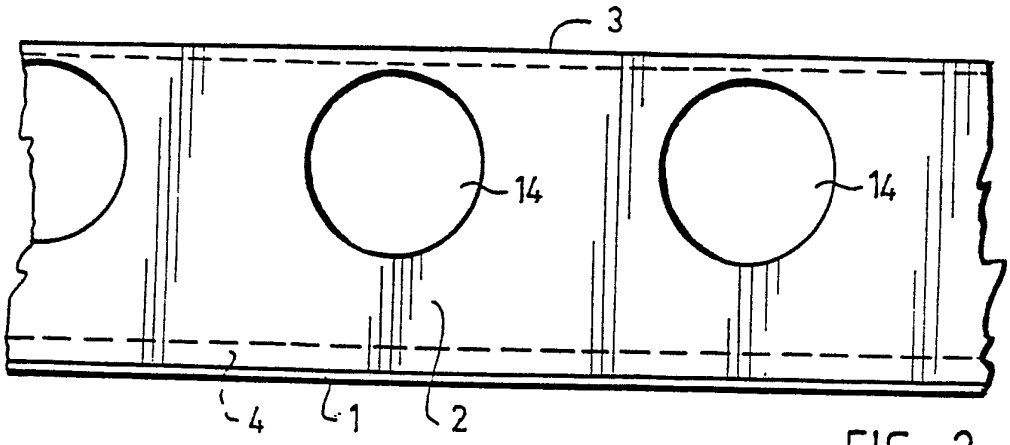


FIG. 2

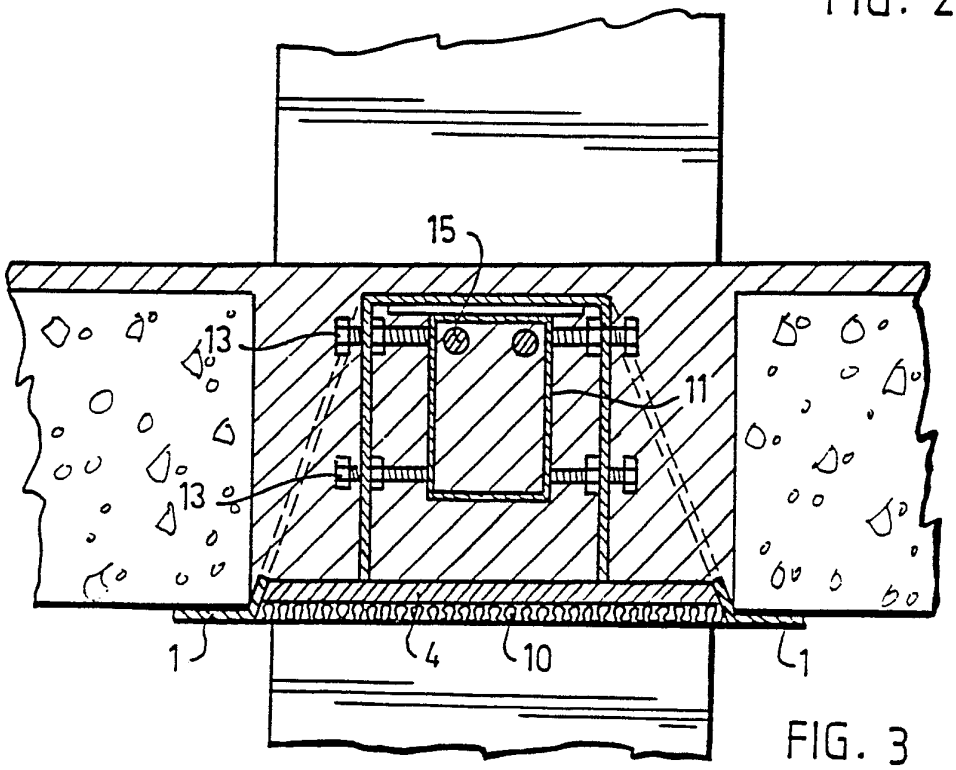


FIG. 3

FIG. 4

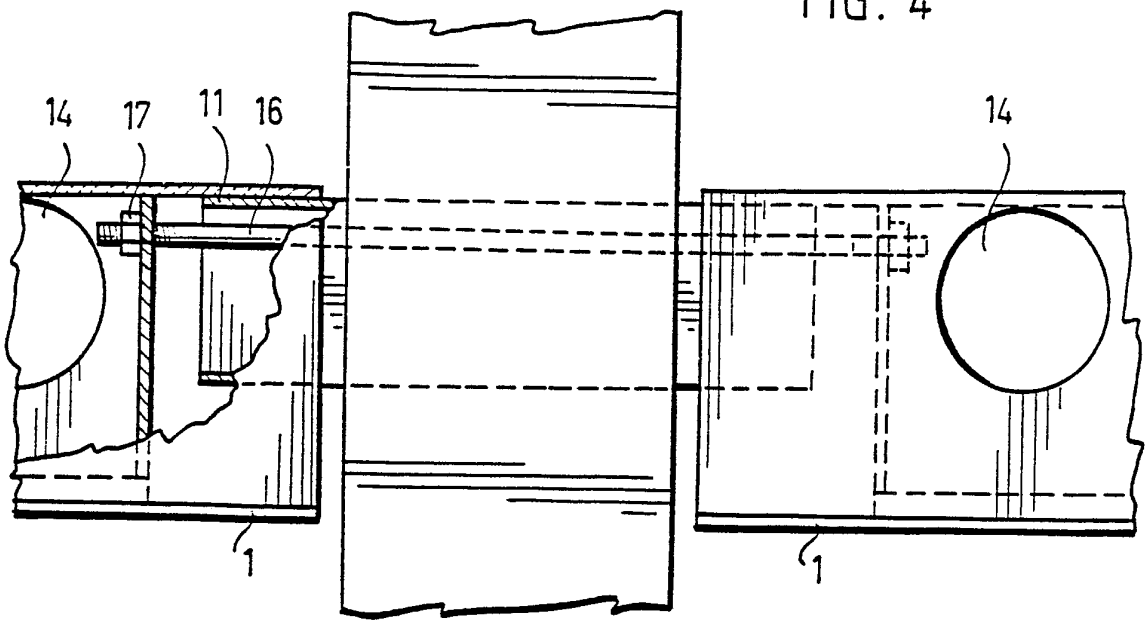
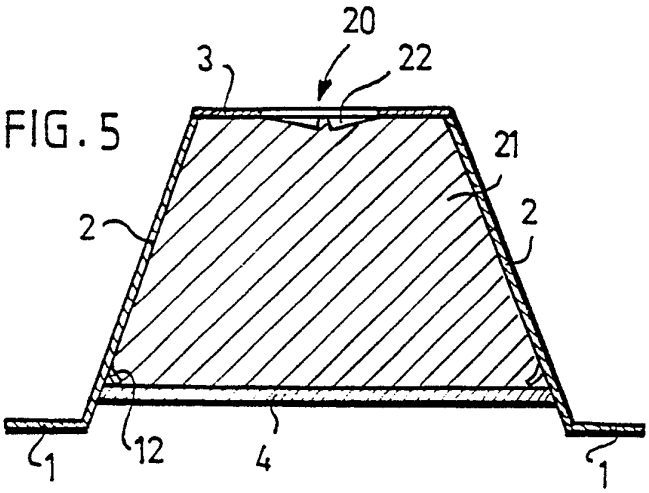


FIG. 5



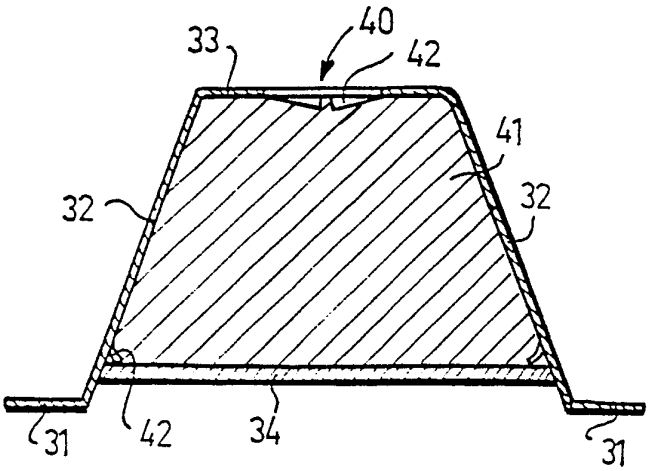


FIG. 7

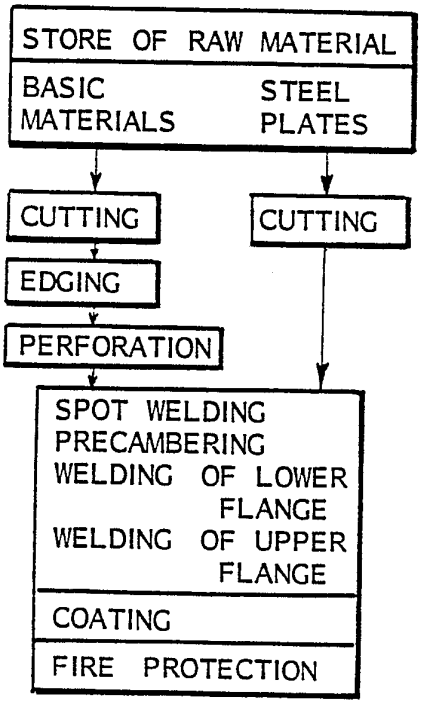


FIG. 6

INTERNATIONAL SEARCH REPORT

International Application No PCT/FI 90/00091

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: E 04 C 3/293, E 04 B 5/29

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	E 04 B; E 04 C

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	DE, B2, 2339638 (SOWA, W) 22 June 1978, see column 2, line 20 - column 3, line 6; column 3, line 36 - column 6, line 4; figures 1-10 --	1,3-5
X	DE, A1, 2431913 (SOWA, W) 22 January 1976, see the whole document --	1,3-5
A	EP, A2, 0292449 (THOR, J) 23 November 1988, see column 1, line 34 - line 53; column 3, line 5 - column 4, line 28; figures 1-5 --	1-6
A	US, A, 3397497 (SHEA, Y.R ET AL) 20 August 1968, see column 2, line 48 - line 70; column 3, line 61 - line 72; figures 1-4 --	1-6
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* **Special categories of cited documents:** [10]

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"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
8th June 1990	1990 -07- 13
International Searching Authority	**Signature of Authorized Officer**
SWEDISH PATENT OFFICE	Ingemar Hedlund

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.PCT/FI 90/00091

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the Swedish Patent Office EDP file on 90-05-07
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
DE-B2- 2339638	78-06-22	AT-B-	339554	77-10-25
		BE-A-	818458	74-12-02
		CH-A-	582801	76-12-15
		FR-A-B-	2239570	75-02-28
		GB-A-	1469478	77-04-06
		NL-A-	7410421	75-02-06
		SE-B-C-	407602	79-04-02
		SE-A-	7409878	75-02-05
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		FR-A-B-	2239570	75-02-28
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US-A- 3397497	68-08-20	NONE		