

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
21 August 2008 (21.08.2008)

PCT

(10) International Publication Number  
**WO 2008/099052 A1**

(51) International Patent Classification:  
**E04B 5/40** (2006.01)

(74) Agent: **PATENTTITOIMISTO KARI PIIRHONEN OY**; P.O. Box 71, FIN-20101 Turku (FI).

(21) International Application Number:  
PCT/FI2008/000028

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(22) International Filing Date:  
18 February 2008 (18.02.2008)

(25) Filing Language: Finnish

(26) Publication Language: English

(30) Priority Data:  
20070140 16 February 2007 (16.02.2007) FI

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

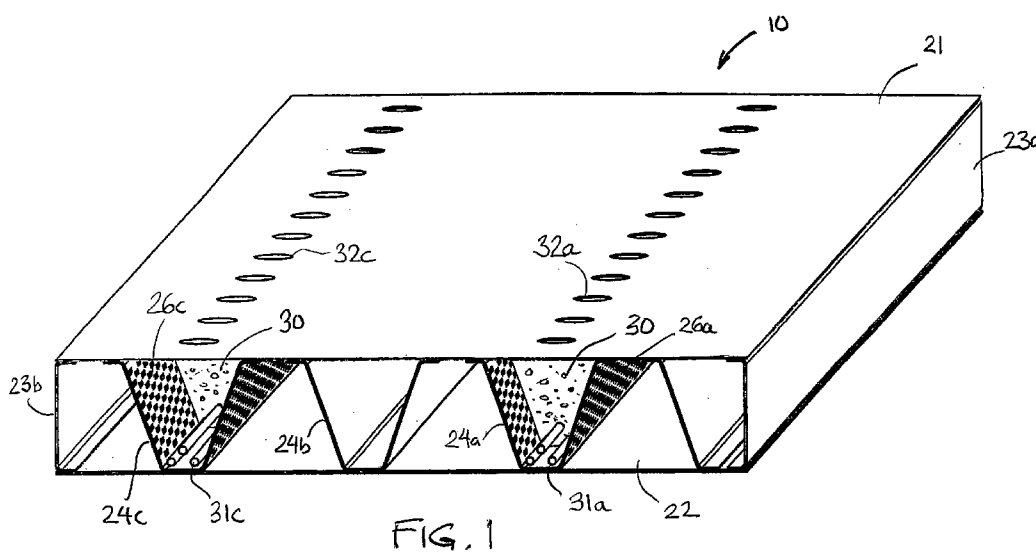
(71) Applicant (*for all designated States except US*): **HYBRI-STEEL OY** [FI/FI]; Heinäalhontie 3, FIN-24910 Halikko As (FI).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **MAARANEN, ILPO** [FI/FI]; Helsingintie 390, FIN-21500 Piikkiö (FI).  
**LUKKARI, Jorma** [FI/FI]; Kippolantie 2, FIN-90540 Oulu (FI).

**Published:**  
— with international search report

(54) Title: SLAB STRUCTURE AND FABRICATION METHOD THEREOF



(57) Abstract: A slab structure (10), and a fabrication method thereof, wherein skin sheets (21, 22) and support beams (23, 24, 25) located between the skin sheets are joined together by laser or hybrid welding. In the slab structure, at least one support beam or a space between two support beams is filled with concrete or another material, such as foamed plastic, rock wool or the like. The filling may be carried out via pouring openings (32) in an end or a skin sheet (21) in the slab structure. The slab structure may further have a surface layer (34) anchored to the steel sandwich panel by means of bonding members (33), such as studs, extending outside the skin sheet (21) via an opening (32) in the skin sheet.

## SLAB STRUCTURE AND FABRICATION METHOD THEREOF

### OBJECT OF THE INVENTION

The object of the invention is a slab structure comprising a steel sandwich panel wherein  
5 there are, between skin sheets, stiffening support members, such as section beams, bent  
from steel, the section beams most preferably being welded onto the skin sheet by means  
of laser or hybrid welding.

### PRIOR ART

10 It is known to produce slab structures from various materials such as concrete, steel and  
wood. All of the materials used have their positive and negative characteristics. For  
example, a hollow-core slab made from concrete is stiff but heavy, which may result in a  
low payload. Making slabs from steel provides a high load-bearing capacity with a light-  
weight structure, but problems may occur with vibration and sound insulation, for example.  
15 Steel sandwich panels are made from steel sheet most preferably by laser or hybrid  
welding. Hybrid welding here refers to a combination of laser welding and arc welding  
(MIG/MAG). Sandwich panels produced in this manner are strong and light in weight, and  
thus their use in various structural systems is advantageous.

20 Combinations of various materials are also used in slab structures. A frequently used  
solution is the so-called composite slab combining a steel structure and poured concrete.  
However, known composite structures require formwork for support during the pouring of  
concrete. The known structures are heavy, have a low bearing capacity, are slow to  
fabricate and install or otherwise have less than optimal technical properties.

25

### PURPOSE OF THE INVENTION

The purpose of this invention is to create a new slab structure capable of bearing even  
higher loads than known slab structures and enabling more rapid construction.

### 30 CHARACTERISTICS OF A SLAB STRUCTURE ACCORDING TO THE INVENTION

A slab structure according to the invention is characterised in that

- in the slab structure, bonding members are attached to at least one skin sheet of a  
steel sandwich panel, and
- one or more surfaces of the steel sandwich panel is coated with a surface layer, such  
35 as concrete, the surface layer bonding with the bonding members in the steel  
sandwich panel.

The sheet material used for the steel parts of the slab structure is carbon steel or stainless steel, for example. The sheet surface may be untreated or the surface may be treated by hot-dip zinc coating or paint coating, for example. The width of a typically used slab structure unit is 1,000–4,500 mm, the length 6,000–18,000 mm and height 125–500 mm.

- 5 The material thickness of the steel sheet is usually 0.7–20 mm, and various parts of the structure may be of different thickness. These dimensions are obviously only examples, as the embodiments of the invention may vary greatly.

- 10 Preferred applications for embodiments according to the invention include ground floors, intermediate floors and ceilings in buildings such as sports halls, parking buildings, commercial and industrial facilities, office buildings and apartment buildings.

- 15 The invention provides a stiff slab structure that can be used as a load-bearing slab in various structural systems. Such a slab structure has better properties than known structures, including lighter weight and higher load-bearing capacity as compared with a hollow-core slab or a concrete slab cast in-situ. A slab structure according to the invention is quicker to install, lighter to lift and can be transported more easily and effectively.

- 20 Compared with known composite slabs, a slab structure according to the invention has a higher load-bearing capacity, i.e. it enables longer spans and does not require support during the pouring of concrete. Also fire resistance, vibration damping and acoustics properties are improved.

- 25 Compared with a slab structure cast in-situ, the invention also saves materials and eliminates the dismantling of formwork. Structures of substantially lower height are also possible in buildings. Interiors with smooth ceiling surfaces without any protruding beams are also obtained.

#### EMBODIMENTS OF THE SLAB STRUCTURE ACCORDING TO THE INVENTION

- 30 A preferred embodiment of the slab structure according to the invention is characterised in that the core material in the slab structure is concrete, foamed plastic, polyurethane foam, phenolic foam, a combination of concrete and plastic, light-weight concrete, blown-in insulation wool or rock wool.

- 35 Various core materials provide different characteristics improving the structure, such as:

1) Increased bearing capacity

core material: concrete, light-weight concrete, plastic foam

- 2) Improved thermal insulation  
core material: light-weight concrete, plastic foam, blown-in insulation wool, rock wool
- 3) Improved fire resistance properties  
5 core material: light-weight concrete, blown-in insulation wool, rock wool, phenolic foam, fire-protected polyurethane
- 4) Improved acoustics  
core material: light-weight concrete, plastic foam, blown-in insulation wool, rock wool
- 10 5) Reduced vibration  
core material: concrete, light-weight concrete, plastic foam, blown-in insulation wool, rock wool

Another preferred embodiment of the slab structure according to the invention is  
15 characterised in that the skin sheet and/or support member, such as a section beam, is perforated.

This creates a so-called sound trap to improve sound insulation. The perforation also  
functions as a bonding means for the core material, such as concrete, light-weight  
20 concrete, plastic foam, blown-in insulation wool and/or rock wool.

A third preferred embodiment of the slab structure according to the invention is  
characterised in that the slab structure comprises two layers of stiffening support members  
bent from steel, the support members being welded onto each other so that a support  
25 member in the second layer is affixed to two support members in the first layer.

A fourth preferred embodiment of the slab structure according to the invention is  
characterised in that the steel skin sheet of the slab structure has one or more openings  
for feeding the core material, such as concrete or foamed plastic, into contact with the  
30 steel support member.

A fifth preferred embodiment of the slab structure according to the invention is  
characterised in that, in conjunction with a steel support member, there are concrete  
reinforcing members embedded in the core material.

35

A sixth preferred embodiment of the slab structure according to the invention is  
characterised in that

- the first end of a steel bonding member is placed in conjunction with a steel support member, embedded in the core material, in such a way that the other end of the bonding member extends outside the steel skin sheet via an opening in the skin sheet,
- there is a surface layer on the surface of the slab structure, and
- 5 - the surface layer is combined with the slab structure in such a way that the other end of the bonding member extending outside the steel skin sheet via an opening in the skin sheet remains embedded in the surface layer.

#### CHARACTERISTICS OF THE METHOD ACCORDING TO THE INVENTION

- 10 The object of the invention is furthermore a method for fabricating slab structures, according to which method one or more stiffening support members bent from steel, the support members being beams bent from steel sheet, are welded onto a steel sheet, such as a skin sheet of steel, most preferably by laser or hybrid welding.
- 15 The method for fabricating slab structures according to the invention is characterised in that
- in the slab structure, bonding members are attached to at least one skin sheet of the steel sandwich panel, and
  - one or more surfaces of the steel sandwich panel is coated with a surface layer, such
  - 20 as concrete, the surface layer bonding with the bonding members in the steel sandwich panel.

#### EMBODIMENTS OF THE METHOD ACCORDING TO THE INVENTION

- A preferred embodiment of the method according to the invention is characterised in that,
- 25 after the parts of the slab structure have been welded together, the core material, such as concrete, foamed plastic or rock wool, is introduced into a steel support member or between them via one or more openings in an end or in a skin sheet of the slab structure.

- Another preferred embodiment of the method according to the invention is characterised in
- 30 that two layers of stiffening support members bent from steel are welded onto the slab structure so that one support member in the second layer is welded onto two support members in the first layer.

- A third preferred embodiment of the method according to the invention is characterised in
- 35 that, prior to the feeding in of the core material, reinforcing members are placed in conjunction with the support member from steel, after which the reinforcing members are left embedded in the core material.

A fourth preferred embodiment of the method according to the invention is characterised in that, in the slab structure, a surface layer is placed on top of the steel sandwich panel, the surface layer being anchored to the steel sandwich panel with studs or other anchoring members.

A fifth preferred embodiment of the method according to the invention is characterised in that

- in the slab structure, the first end of a steel bonding member is placed in conjunction with a steel support member in such a way that the other end of the bonding member extends outside the steel skin sheet via an opening in the skin sheet, and
- a surface layer is placed on top of the steel blank of the slab structure, in such a way that the other end of the bonding member extending outside the steel skin sheet via an opening in the skin sheet remains embedded in the surface layer.

Generally the surface layer consists of concrete, but it may also consists of another material.

#### EXAMPLES OF EMBODIMENTS

In the following, the invention is described by way of examples with reference to the appended drawings, in which

#### LIST OF FIGURES

- Figure 1 represents an axonometric projection of a slab structure according to the invention.
- Figure 2 represents an end view of the first fabrication stage of another slab structure.
- Figure 3 represents an end view of the second fabrication stage of the slab structure in Fig. 2.
- Figure 4 represents an end view of the third fabrication stage of the slab structure in Fig. 2.
- Figure 5 represents an end view of the first fabrication stage of a third slab structure.
- Figure 6 represents an end view of the second fabrication stage of the slab structure in Fig. 5.
- Figure 7 represents an end view of the third fabrication stage of the slab structure in Fig. 5.
- Figure 8 represents an end view of the fourth fabrication stage of the slab structure in Fig. 5.

- Figure 9 represents an end view of a fourth slab structure.
- Figure 10 represents an end view of a fifth slab structure.
- Figure 11 represents an end view of the first fabrication stage of a sixth slab structure.
- Figure 12 represents an end view of the slab structure in Fig. 11 completed and in part shown as a sectional view.
- 5 Figure 13 represents a horizontal sectional view of a seventh slab structure.
- Figure 14 represents an axonometric and schematic view of the structure of an eighth slab structure.
- Figure 15 represents a side view of a fabrication stage of a ninth slab structure.
- 10 Figure 16 represents a side view and in part a sectional view of the slab structure in Fig. 15 completed.
- Figure 17a represents an end view of an object introduced into the slab structure.
- Figure 17b represents an end view of a slab structure with the object shown in Fig. 17a installed therein.
- 15 Figure 18a represents a perspective view of a tenth slab structure.
- Figure 18b represents a perspective view of an object introduced into the slab in Fig. 18a.
- Figure 19 represents an end view and in part a sectional view of a slab structure according to the invention.
- 20 Figure 20 represents an end view and in part a sectional view of another slab structure according to the invention.
- Figure 21 represents the cross section of a slab according to the invention.
- Figure 22 represents the cross section of another slab according to the invention.
- Figure 23 represents the cross section of a concrete-coated slab.
- 25 Figure 24 represents a schematic view of the locations for stud connectors in the slab structure as seen from above.
- Figure 25 represents the cross section of yet another slab.

#### DESCRIPTION OF THE FIGURES

- 30 Figure 1 illustrates a slab structure 10 comprising steel skin sheets 21 and 22, and between the skin sheets, support beams 24a, 24b and 24c bent from steel sheet. At the edges of the slab structure 10, there are also edge beams 23a and 23b bent from steel sheet. Concrete reinforcing members, such as rebars 31a and 31c, are introduced into the support beams 24a and 24c, and in this example, the support beams 24a and 24c are
- 35 filled with concrete 30a and 30c via pouring openings 32a and 32c. The reinforcing members 31a and 31c thus remain embedded in the concrete 30a and 30c. The walls of the support beams 24a and 24c are provided with perforations 26a and 26c so as to create

a good bond with the concrete 30a and 30c. When the concrete 30a and 30c has cured, the slab structure 10 in Fig. 1 is complete.

For the sake of clarity, some of the concrete 30a and 30c at the ends of the support beams 24a and 24c of the slab structure 10 has been left out so as to show the reinforcing members 31a and 31c more clearly.

Figure 2 illustrates the first fabrication stage of the slab structure 10, during which fabrication stage support beams 24a and 24b bent from steel sheet and edge beams 23a and 23b, also bent from steel sheet, have been placed on a steel skin sheet 21. These parts are welded together by laser or hybrid welding in the directions indicated by the arrows. Figure 2 shows that the flanges at the upper edge of the edge beams 23a and 23b are shorter than the flanges coming into contact with the steel skin sheet 21, making it possible to weld from above, in the direction indicated by the arrows in the figure.

The fabrication stage shown in Fig. 2 creates a blank for the slab structure 10 which includes the first skin sheet 21, and the support beams 24a and 24b and the edge beams 23a and 23b joined to the skin sheet by welding. In the position shown in Fig. 2, the blank for the slab structure 10 is upside down so that the skin sheet 21, which will be facing up in the completed slab structure, is facing down in the figure.

Figure 3 illustrates the blank for the slab structure 10 created in Fig. 2, in which blank the support beams 24a and 24b and the edge beams 23a and 23b are joined to the first skin sheet 21 by laser- or hybrid- welded joints 20. On top of this blank is added another skin sheet 22 joined to the support beams 24a and 24b and the edge beams 23a and 23b by laser or hybrid welding in the direction indicated by the arrows. After welding, the basic steelwork of the slab structure 10 is complete.

Figure 4 illustrates the basic framework of the slab structure 10 created in Fig. 3 turned right side up, so that the first skin sheet 21 of the slab structure 10, i.e. the top face of the slab structure 10, is facing upwards. When the reinforcing members 31a and 31b are put in place inside the support beams 24a and 24b, the support beams 24a and 24b can be filled with concrete 30a and 30b via pouring openings 32a and 32c in the skin sheet 21. When the concrete 30a and 30b has cured, the slab structure 10 according to the invention is complete.

Figures 5–8 show fabrication stages of the slab structure 10 similar to those of Figures 2–4, but showing another embodiment of the slab structure 10 with a two-layered support beam.

5 Figure 5 shows parts of the slab structure 10 similar to those shown above in Fig. 2, i.e. the first steel skin sheet 21, upon which have been placed skin sheet support beams 24a and 24b and edge beams 23a and 23b bent from steel sheet. These parts are joined welded together by laser or hybrid welding in the directions indicated by the arrows.

10 Fig. 5 shows that, in this embodiment, the edge beams 23a and 23b are substantially higher than the support beams 24a and 24b. The reason for this is that another layer comes on top of the first layer of support beams 24a and 24b as shown in the next figure, Fig. 6.

15 Figure 6 illustrates a blank for the slab structure 10 in which blank the support beams 24a and 24b and the edge beams 23a and 23b are joined to the first skin sheet 21 by laser- or hybrid-welded seams 20. A support beam 25 forming the second support beam layer is placed on top of the support beams 24a and 24b and joined, in the direction indicated by the arrows, by laser or hybrid welding to the lower support beams 24a and 24b forming the  
20 first support beam layer.

Figure 7 shows another skin sheet 22 added on top of the blank for the slab structure 10 created in Fig. 6, the skin sheet being joined to the support beam 25 and the edge beams 23a and 23b by laser or hybrid welding in the direction indicated by arrows. After welding,  
25 the basic steelwork of the slab structure 10 illustrated by this embodiment is complete.

Figure 8 illustrates the slab structure 10 created in Fig. 7 turned the right side up, so that the first skin sheet 21 of the slab structure 10, i.e. the top face of the slab structure 10 is facing upwards. This type of structure according to the invention with support beams 24  
30 and 25 in two layers provides the slab structure with substantially improved properties when compared with known slab structures.

Figure 9 shows a structure similar to the slab structure 10 in Fig. 8 with reinforcing members 31 placed in the space limited by the support beams 24 and 25 and the space  
35 filled with concrete 30 via a pouring opening 32 in the skin sheet 21. When the concrete 30 has cured, the slab structure 10 according to this embodiment of the invention is complete.

Figure 10 illustrates a further embodiment of the slab structure 10 according to the invention, in which embodiment the basic steelwork of the slab structure 10 is in accordance with the embodiment in Fig. 4. In the embodiment in Fig. 9, there is a surface layer 34 on top of the basic steelwork of the slab structure 10, the surface layer being  
5 anchored to the basic steelwork by bonding members 33a and 33b, such as studs.

The lower ends of the bonding members 33a and 33b shown in Fig. 10 have been placed in the concrete 30a and 30b poured into the support beams 24a and 24b. In Fig. 9, the bonding members 33a and 33b extend via openings in the skin sheet 21 upwards so that  
10 they are anchored to the surface layer 34. In this way a bond is achieved between the surface layer 34 and the support beams 24a and 24b and also with the basic steelwork of the slab structure 10, creating a continuous slab structure 10 with a surface layer 34 and strong support beams 24a and 24b.

15 The walls of the support beams 24a, 24b and 24c may be smooth or they may have some sort of embossing, perforation, additive or bonding members to provide better adhesion with the core material or to improve the acoustic properties.

The bonding perforations 26a and 26c in the walls of the support beams 24a and 24c  
20 shown in Fig. 1 and the bonding members 33a and 33b shown in Fig. 10 may also be of another type. The bonding members 33a and 33b may also be welded to the reinforcing members 31a and 31b in the support beams 24a and 24b or their shape may be designed so as to provide optimal bonding with the concrete 30a and 30b and/or with the surface layer 34.

25

The studs may also be joined by welding or wound and affixed with metal wire or a cable tie. The actual fire-rated concrete reinforcements, i.e. ribbed bars running along the duct, are also either welded to the section or held away from the steel surfaces in the duct using a steel or plastic member.

30

Figure 11 illustrates a fabrication stage of the slab structure during which beams 24a and 24b bent from steel sheet and edge beams 23a and 23b are welded to the skin sheet 22. This embodiment of the invention differs from the embodiment shown in Fig. 2 in that also the outermost beams 23a and 23b are formed from such sections in which a box section is  
35 created in the completed slab structure. This type of slab structure is assembled in the reverse order compared to Fig. 2.

Figure 12 illustrates the slab structure 10 in Fig. 11 when complete, seen from the end and in part as a sectional view. As the figure shows, the slab structure 10 is composed of a sandwich panel formed of steel skin sheets 21 and 22 and beams 23a–23b and 24a–24b made from steel sheet, to which sandwich panel core materials 30a–30d have been  
5 added, to all beams, and a surface layer 34 has been added on top of the skin sheet 21.

In the example shown in Fig. 12, the slab structure 10 is produced by first placing concrete reinforcements 31a–31d onto the bottom of steel sheet beams 23a–23b and 24a–24b. After that, concrete 30a–30d is poured via the openings 32a–32d in the skin sheet 21 so  
10 that the steel sheet beams 23a–23b and 24a–24b are filled up to the level of skin sheet 21. In connection with this, bonding studs 33a–33d have also been placed in the openings 32a–32d so that their first ends remain embedded in the concrete 30a–30d and their other ends extend out of the openings 32a–32d in the skin sheet 21. When the concrete 30a–30d has cured, a surface layer 34 is cast on top of the skin sheet 21; the surface layer may  
15 also be of concrete. The concrete layer 34 is bonded with the slab structure by means of the bonding studs 33a–33d.

Figure 13 schematically illustrates a horizontal sectional view of a slab structure 10 according to the invention. This slab structure 10 is substantially similar to the slab  
20 structure shown in Fig. 12, for example, but in addition to the previously shown longitudinal steel sheet beams 23a–23b and 24a–24b, this structure also has crosswise beams 23e and 23f at both ends of the slab. In this way the slab structure 10 is provided with greater crosswise stiffness and load bearing capacity.

For the sake of clarity, Figure 14 illustrates the structure of the slab structure 10 so that the skin sheet 21 is slightly offset from its final location. This gives a clear view of the structure of the beams 23a–23b and 24a–24c, their concrete reinforcements 31b and 31d and the concrete cores 30b and 30d. In comparison with the solutions shown in the previous figures, the solution shown in Fig. 14 additionally has stiffeners 35a–35d added to the  
25 surface of the skin sheet 21. These have been placed in the crosswise direction in relation to the slab structure 10 and welded to the skin sheet 21. By means of the stiffeners 35a–35d, the slab structure 10 is also provided with greater crosswise stiffness and load bearing capacity. The stiffeners 35a–35d may also function as joining members in the composite structure, providing a joint between the surface layer and the structure shown in  
30 Fig. 14, for example, as shown in the following figures.

Figure 15 illustrates a side view of the slab structure 10, wherein crosswise stiffeners 35 have been welded to the surface of the skin sheet 21. The crosswise stiffeners are, for example, flat bars, which increase the crosswise rigidity of the slab structure 10. The stiffeners 35 are joined with the skin sheet 21 so that they form an angle  $\alpha$  with the skin sheet 21. The angle  $\alpha$  may be  $60^\circ$ , for example, in which case the stiffeners 35 also function as joining members in the composite structure, as shown in the following Figure 16.

Figure 16 illustrates a surface layer 34 cast on the slab structure 10 of Fig. 15, the surface layer being, for example, concrete. The figure shows that the stiffeners 35 tilted in opposite directions function as joining members of the concrete 34 and the steelwork. The stiffeners 35 can also be arranged on the surface of the skin sheet 21 in another way, for example so that every other flat bar is tilted to the left in Fig. 16 and every other to the right.

Figure 17a illustrates an end view of an elongated object 30 which can be fitted into the box beam 24 in the slab structure 10 shown in Fig. 17b. The object 30 may, for example, consist of hard or soft rock wool, foamed plastic, such as polyurethane foam, phenolic foam, a combination of concrete and plastic, light-weight concrete. When inserted into the box beam 24, the object 30 forms a structure damping sound and/or other vibrations in the slab structure 10.

Figure 18a illustrates a perspective view of yet another slab structure 10, wherein the steel sheet beams 23a–23d are similar in the centre and at the edges of the slab structure 10. The boxes remaining between the steel sheet beams 23a–23d are filled with objects 30 as shown in Fig. 18b. The objects 30 may be solid or formed, for example, from two or more superimposed sheets 30a and 30b.

In the slab structure 10 shown in Fig. 18a, the steel sheet beams 23a–23d are U channels, known as such. They may also be beams of another shape, such as known C channels or Z sections. This kind of light-weight slab structure shown in Fig. 18a is preferably applicable to a wall structure, for example.

Figure 19 illustrates a slab structure 10 consisting, similar to Fig. 1, of steel skin sheets 21 and 22, with between them, support beams 24a, 24b and 24c bent from steel sheet. However, this embodiment does not include concrete reinforcements inside the support beams 24a and 24b, as the support beams 24a and 24b have been left empty. This is a light steel hollow-core slab 10 coated with a concrete layer 34. The concrete layer 34 is

bonded with the steelwork by means of stud connectors 33 welded to the surface of the skin sheet 21. The stud connectors 33 are placed in rows parallel to the support beams 24a and 24b, substantially at the joints 20 between the support beams 24a and 24b and the skin sheet 21. Thus the stud connectors 33 are in highly advantageous locations in the  
5 slab structure 10 in terms of its strength. Embedded in the concrete layer 34, there may also be a concrete reinforcing mesh 36, known as such.

Figure 20 illustrates a slab structure 10 differing from the structure in Fig. 19 in that this is a heavy steel hollow-core slab 10. In this embodiment, the skin sheet 21 is formed of  
10 several parts which are elongated sheet strips 21a, 21b and 21c parallel to the support beams 24a and 24b. The edges of the skin sheets 21a, 21b and 21c are joined to the edge flanges of the support beams 24a and 24b by welded joints 20 in such a way that the top portions of the support beams 24a and 24b most preferably remain open across the entire length of the support beams 24a and 24b. Upward directed stud connectors 33 are also  
15 welded onto the edges of the skin sheets 21a, 21b and 21c in rows, substantially at locations on the joints of the skin sheets 21a, 21b and 21c and the edge flanges of the support beams 24a and 24b.

In the slab structure 10 in Figure 20, concrete reinforcements 31 are additionally placed in  
20 the lower portions of the support beams 24a and 24b and a concrete reinforcing mesh 36 is placed on the skin sheets 21a, 21b and 21c, after which a concrete layer 34 is cast on top of the slab structure 10. Thus the concrete mass also enters the support beams 24a and 24b, making it possible cast both the concrete parts 30a and 30b of the support beams 24a and 24b and the surface layer 34 in the slab structure 10 in a single casting  
25 operation.

Figure 21 illustrates a slab structure 10, wherein the skin sheets 21 and 22 and the edge beams 23a and 23b form a structure closed on all four sides. As the ends of the slab 10 are furthermore closed by welded end sheets not shown in Fig. 21, a closed, water-tight  
30 box is obtained, which box can be used as a pier pontoon, for example. Similar to a conventional pier, wooden beams 37 and wooden decking 38 can be fixed on top of such a box. The pier box may be empty, i.e. filled with air, but it can also be filled with some floating material, such as foamed polyester plastic (EPS) or polyurethane foam.

35 Figure 22 illustrates a slab structure 10, the slab structure being, similarly to Fig. 21, a box closed both at its sides and ends and filled completely or partially with floating material 30, such as foamed polyester plastic (EPS) or polyurethane foam. Similarly to Fig. 19, stud

connectors 33 are welded and a concrete reinforcing mesh 36 added to the surface of the skin sheet 21 of the slab structure 10, after which a concrete layer 34 is cast on top of the skin sheet 21. This advantageously creates a pier pontoon with a concrete deck.

- 5 Figure 23 illustrates yet another closed, slab structure 10 made of steelwork, the slab structure being enclosed entirely in a concrete layer 34. For this, purpose, stud connectors 33 are welded onto the skin sheets 21 and 22 of the steelwork and there is a concrete reinforcing mesh 36 on top of the steelwork. There may also be floating material, such as plastic foam, inside the steelwork.

10

Figure 24 illustrates a schematic view of the locations of stud connectors 33 in the slab structure 10. As the figure shows, the stud connectors 33 are welded onto the surface of the skin sheet 21 so that the stud connectors are in rows parallel to the support beams 24a and 24b at the points where the support beams 24a and 24b are welded onto the skin  
15 sheet 21.

- Figure 25 illustrates a slab structure 10 wherein the skin sheets 21a and 21b are wider than in the solution shown in Fig. 20, and thus the upper skin sheet 21 covers one or more support beams 24 so that the support beams do not remain uncovered at their top. In such  
20 a case most preferably only every second or third support beam 24 is filled with concrete 30. This solution could be called a medium-heavy steel hollow-core slab because the properties of the structure are, in a way, between those of the light steel hollow-core slab 10 shown in Fig. 19 and those of the heavy steel hollow-core slab 10 shown in Fig. 20.

25 **ADDITIONAL NOTES**

It is obvious to a person skilled in the art that the different embodiments of the invention may vary within the scope of the claims presented below.

## LIST OF REFERENCE NUMBERS

|    |     |                           |
|----|-----|---------------------------|
|    | 10  | Slab structure            |
|    | 20  | Welded joint              |
| 5  | 21  | Skin sheet                |
|    | 22  | Skin sheet                |
|    | 23  | Edge beam                 |
|    | 24  | Support beam              |
|    | 25  | Support beam              |
| 10 | 26  | Bonding perforation       |
|    | 30  | Core material             |
|    | 31  | Reinforcing members       |
|    | 32  | Pouring opening           |
|    | 33  | Bonding member            |
| 15 | 34  | Surface layer             |
|    | 35  | Stiffener                 |
|    | 36  | Concrete reinforcing mesh |
|    | 36b | Concrete reinforcement    |
|    | 37  | Wooden beam               |
| 20 | 38  | Wooden decking            |

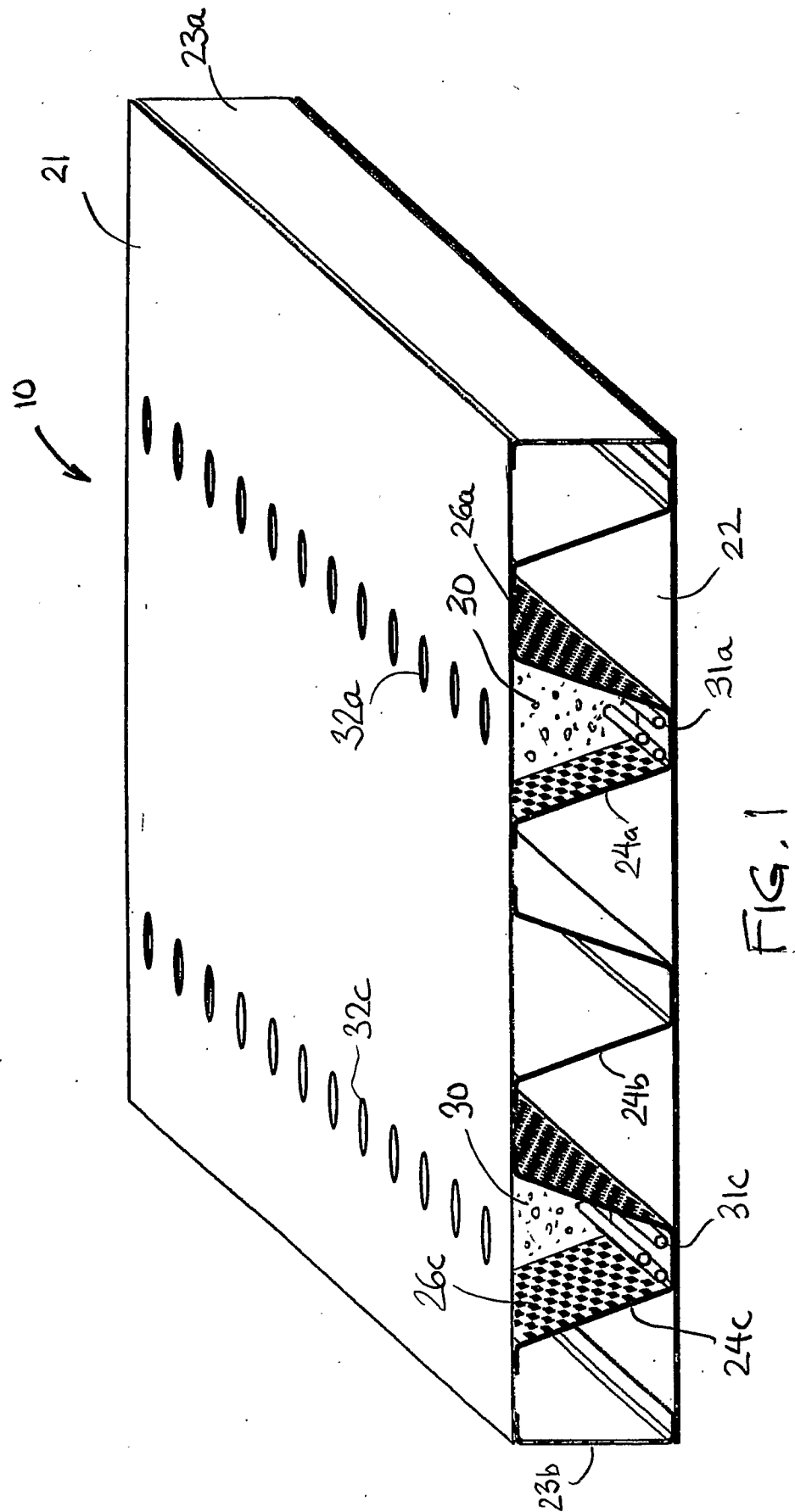
## CLAIMS

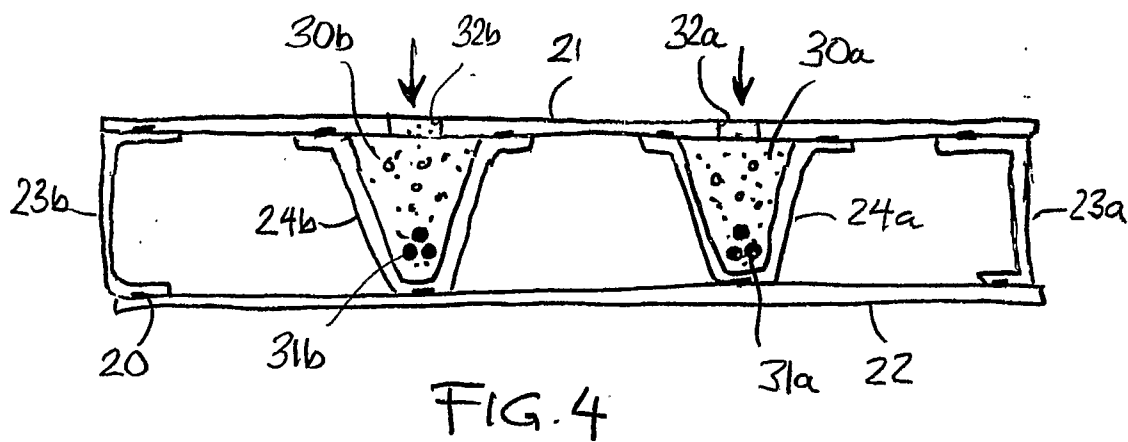
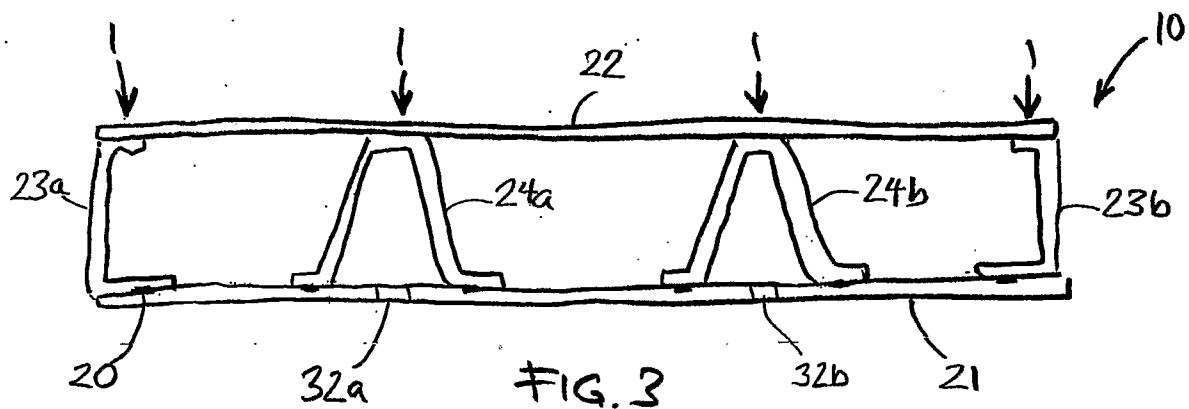
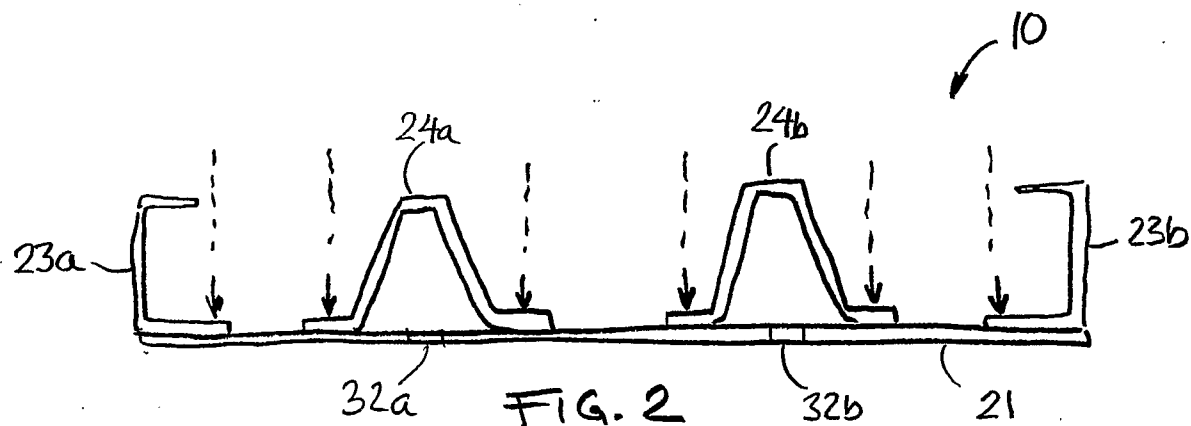
1. A slab structure (10) comprising a steel sandwich panel wherein there are, between skin sheets (21, 22), stiffening support members bent from steel, such as section beams (23, 24, 25), the section beams most preferably being welded onto the skin sheet by laser or hybrid welding, c h a r a c t e r i s e d in that
  - bonding members (33) are provided at least on one skin sheet (21, 22) of the steel sandwich panel in the slab structure (10), and
  - one or more surfaces (21) of the steel sandwich panel is coated with a surface layer (34), such as concrete, the surface layer bonding with the bonding members (33) in the steel sandwich panel.
2. A slab structure (10) according to claim 1, c h a r a c t e r i s e d in that the slab structure (10) has one or more spaces formed by a section beam or spaces remaining between section beams, the space(s) being filled with a core material (30), the material being most preferably concrete, foamed plastic, polyurethane foam, phenolic foam, a combination of concrete and plastic, light-weight concrete, blown-in insulation wool or rock wool.
3. A slab structure (10) according to any one of claims 1 or 2, c h a r a c t e r i s e d in that the skin sheet (21, 22) and/or the support member (23, 24, 25), such as a section beam, is perforated in order to improve the sound insulation and/or bonding of the core material.
4. A slab structure (10) according to any one of claims 1, 2 or 3, c h a r a c t e r i s e d in that the slab structure (10) comprises two layers of stiffening support members (23, 24, 25) bent from steel, the support members being welded together in such a way that a support member (25) in the second layer is affixed to two support members (24a, 24b) in the first layer.
5. A slab structure (10) according to any one of claims 1–4, c h a r a c t e r i s e d in that the steel skin sheet (21) of the slab structure (10) has one or more openings (32), or there are spaces between elongated sheet strips (21a, 21b and 21c) for feeding the core material (30), such as concrete or foamed plastic, into contact with the support members (23, 24, 25).

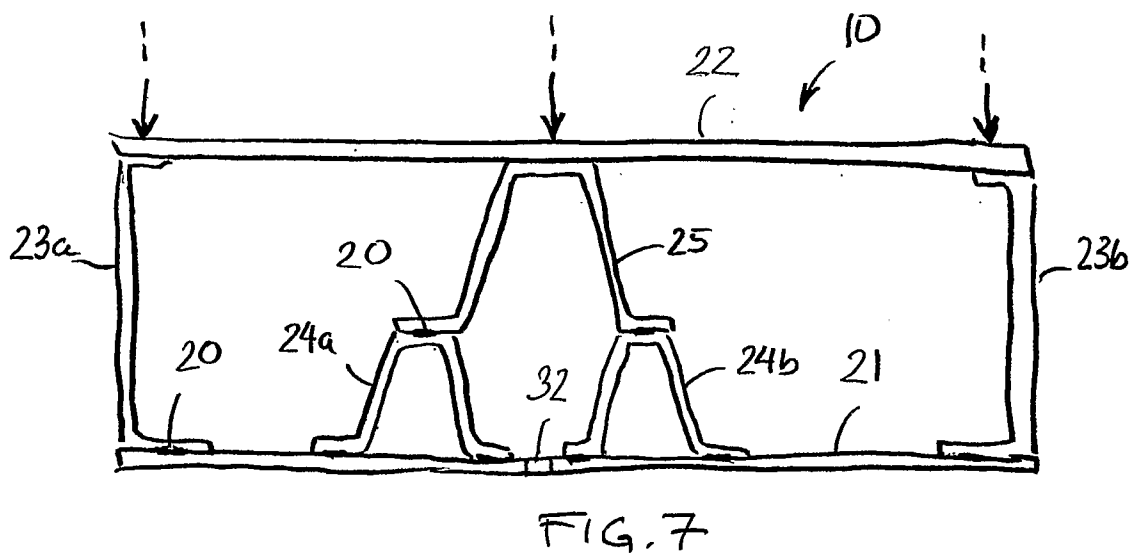
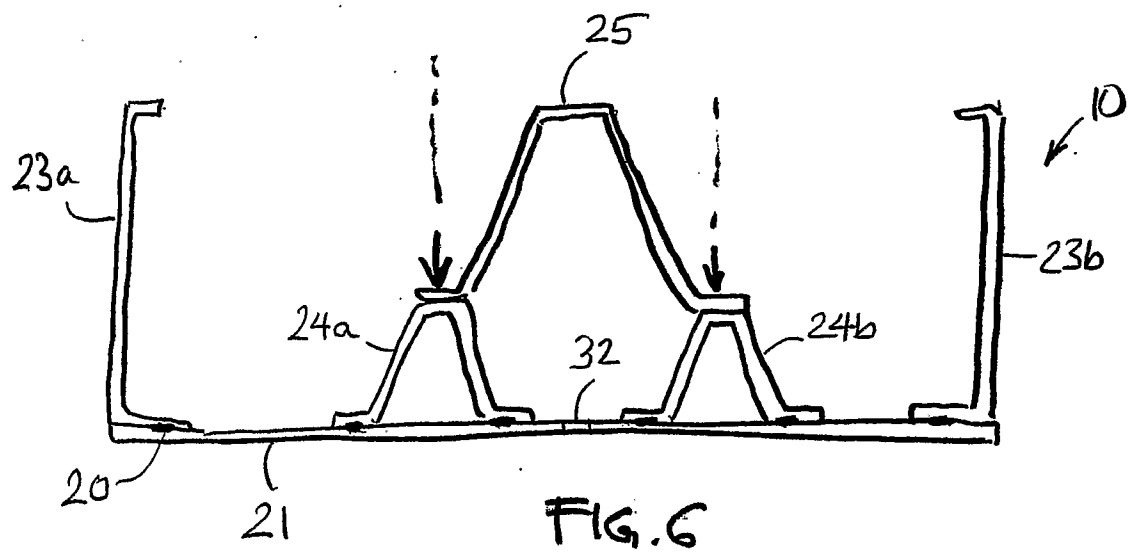
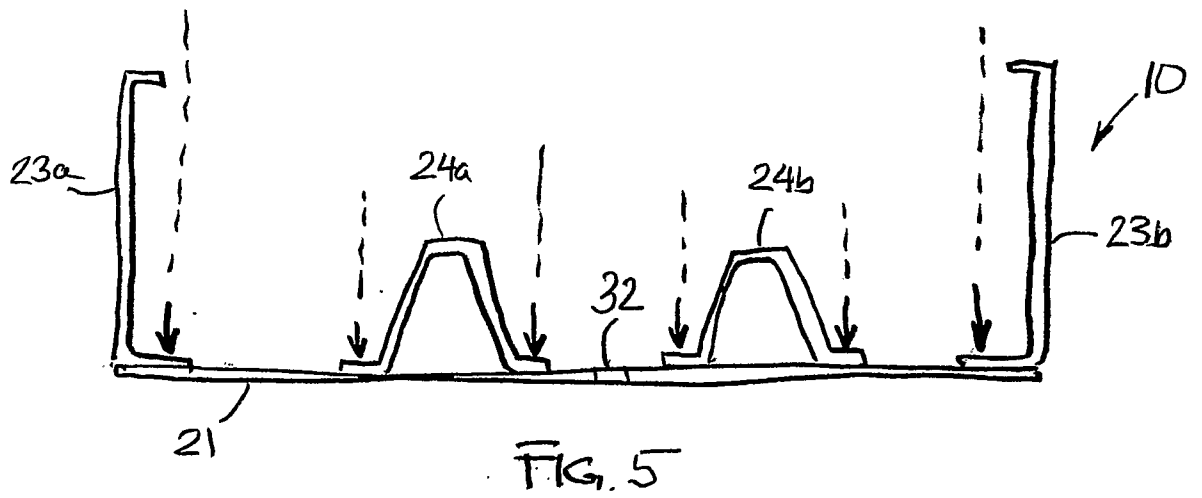
6. A slab structure (10) according to any one of claims 1–5, characterised in that the slab structure (10) has, in conjunction with the support members (23, 24, 25), concrete reinforcing members (31) embedded in the core material (30).
- 5 7. A slab structure (10) according to any one of claims 1–6, characterised in that
- the first end of an anchoring or bonding member (33) made of steel, such as a stud, is placed in conjunction with a steel support member (23, 24, 25), embedded in the core material (30), in such a way that the other end of the bonding member extends outside the skin sheet (21) via an opening (32) in the skin sheet,
  - 10 - there is a surface layer (34) on the surface of the slab structure (10), and
  - the surface layer (34) is placed in conjunction with the slab structure (10) in such a way that the other end of the bonding member (33) extending outside the steel skin sheet (21) via an opening (32) in the skin sheet, remains embedded in the surface layer.
- 15 8. A fabrication method of the slab structure (10), according to which method one or more stiffening support members (23, 24, 25) bent from steel, which members are beams bent from steel sheet, are welded onto a steel sheet (21, 22), such as a steel skin sheet, most preferably by laser or hybrid welding, characterised in that,
- 20 - in the slab structure (10), bonding members (33) are attached to at least one skin sheet (21, 22) of the steel sandwich panel, and
  - one or more surfaces (21) of the steel sandwich panel is/are coated with a surface layer (34), such as concrete, the surface layer bonding with the bonding members (33) on the steel sandwich panel.
- 25 9. A fabrication method of the slab structure (10) according to claim 8, characterised in that,
- in the slab structure (10), a surface layer (34) is placed on top of the steel sandwich panel (21, 22, 23, 24, 25), the surface layer being anchored to the steel sandwich panel by means of studs (33) or other bonding or anchoring members, and
  - 30 - in the slab structure (10), one or more support members (23, 24, 25) made from steel, or the space between them, is filled with a core material (30).
10. A fabrication method of the slab structure (10) according to claims 8 or 9,
- 35 characterised in that, after the parts (21, 22, 23, 24, 25) of the slab structure (10) are welded together, a core material (30), such as concrete, foamed plastic or rock wool, is

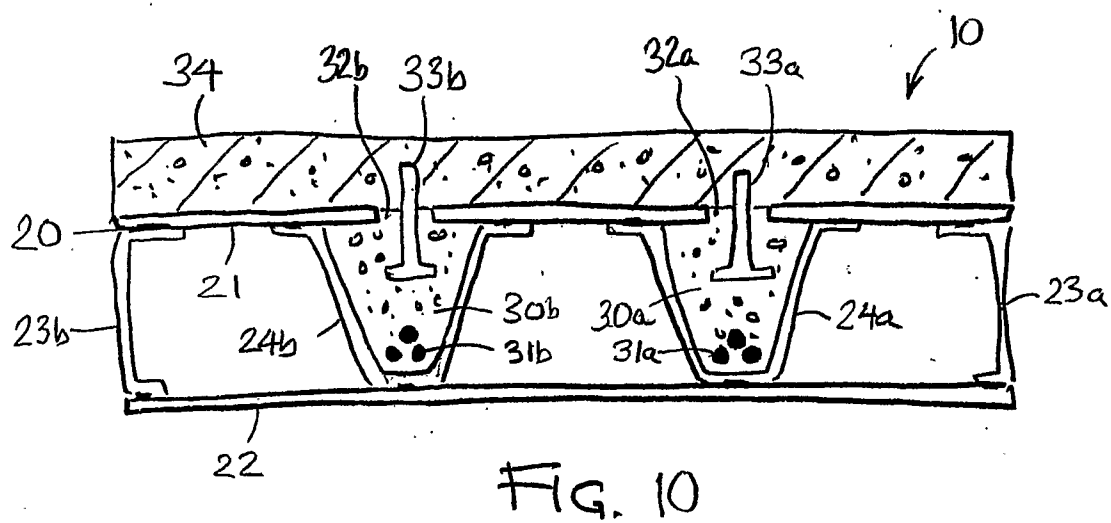
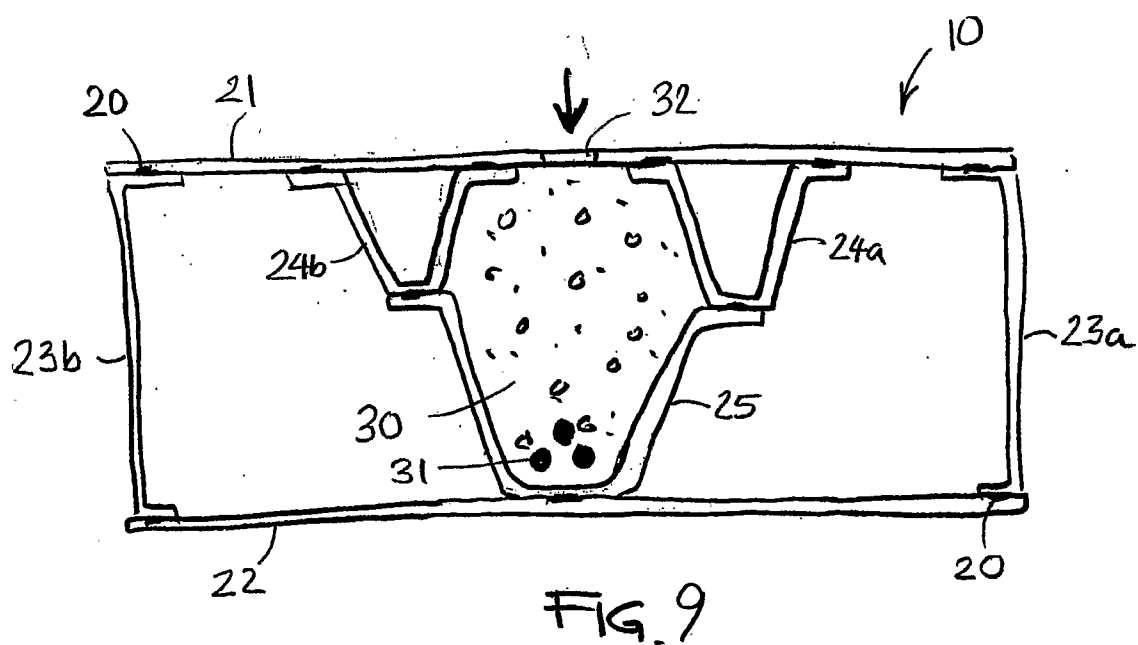
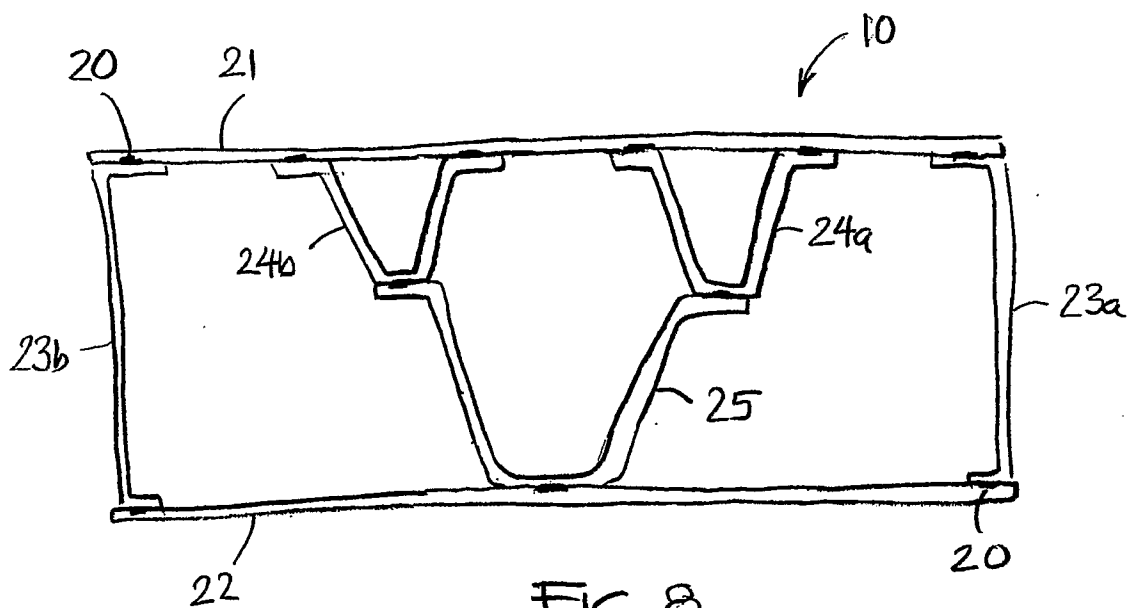
introduced into the steel support members (23, 24, 25) or into the spaces between them via one or more openings (32) in an end or in a skin sheet of the slab structure.

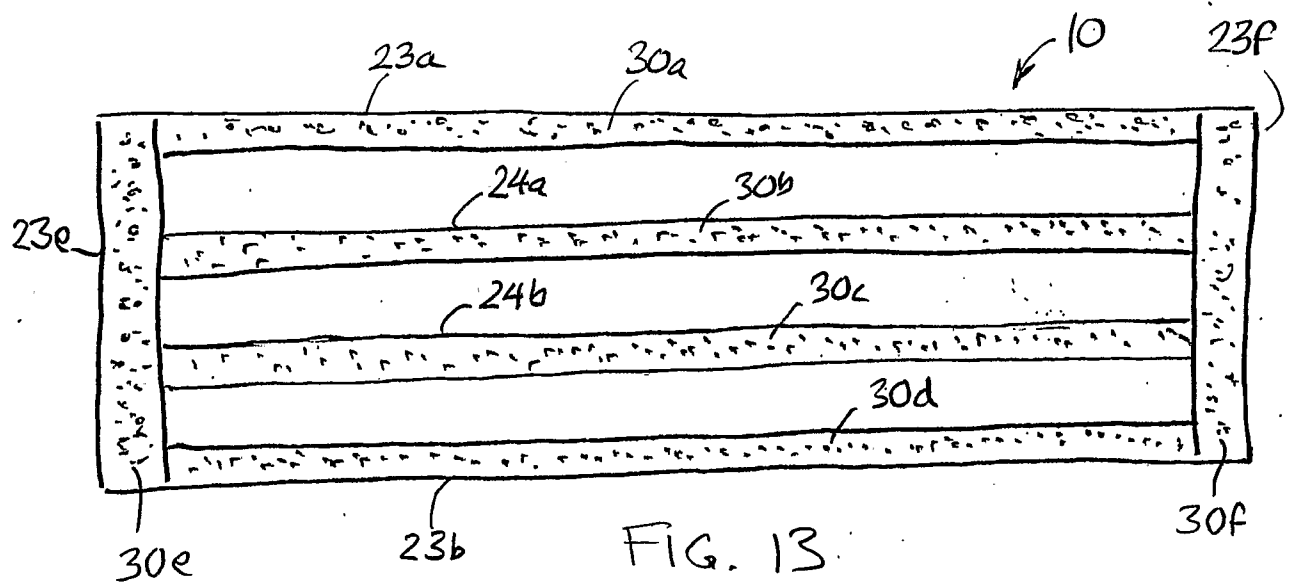
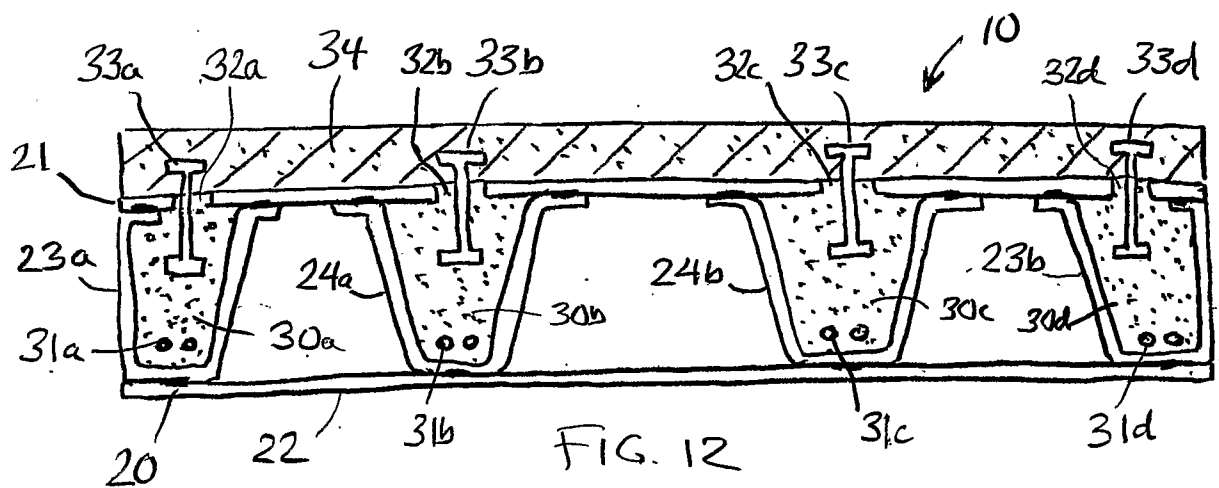
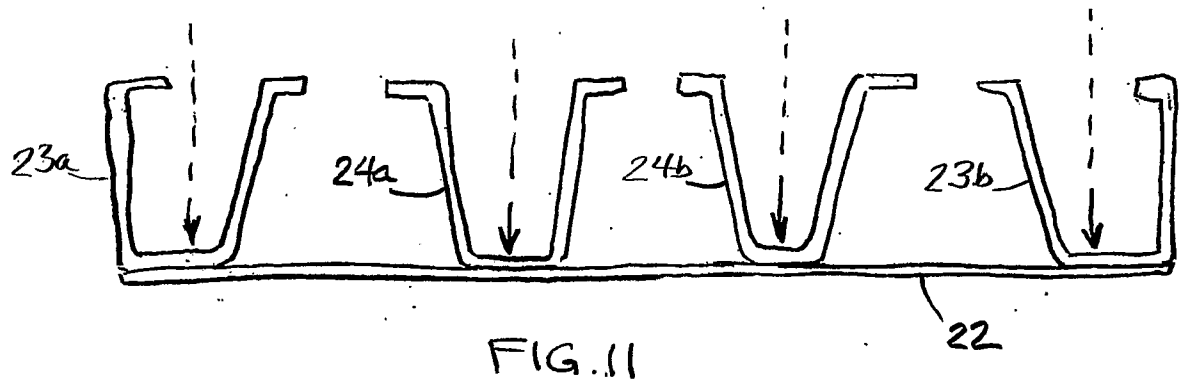
- 5 11. A fabrication method of the slab structure (10) according to any one of claims 8, 9 or 10, characterised in that two layers of stiffening support members (23, 24, 25) bent from steel are welded onto the slab structure (10) in such a way that one support member (25) in the second layer is welded onto two support members (24a, 24b) in the first layer.
- 10 12. A fabrication method of the slab structure (10) according to any one of claims 8–11, characterised in that, prior to the feeding in of the core material (30), concrete reinforcing members (31) are placed in conjunction with the steel support member (23, 24, 25), after which the concrete reinforcing members are left embedded in the core material.
- 15 13. A fabrication method of the slab structure (10) according to any one of claims 8–12, characterised in that,
- in the slab structure (10), the first end of an steel anchoring or bonding member (33) is placed in conjunction with a steel support member (23, 24, 25) in such a way that the other end of the bonding member extends outside the skin sheet (21) via an opening (32) in the skin sheet,
  - a surface layer (34) is placed on top of the steel blank (21, 22, 23, 24, 25) for the slab structure (10), as a result of which the other end of the bonding member (33), which extends outside the steel skin sheet (21) via an opening (32) in the skin sheet,
  - 25 remains embedded in the surface layer.











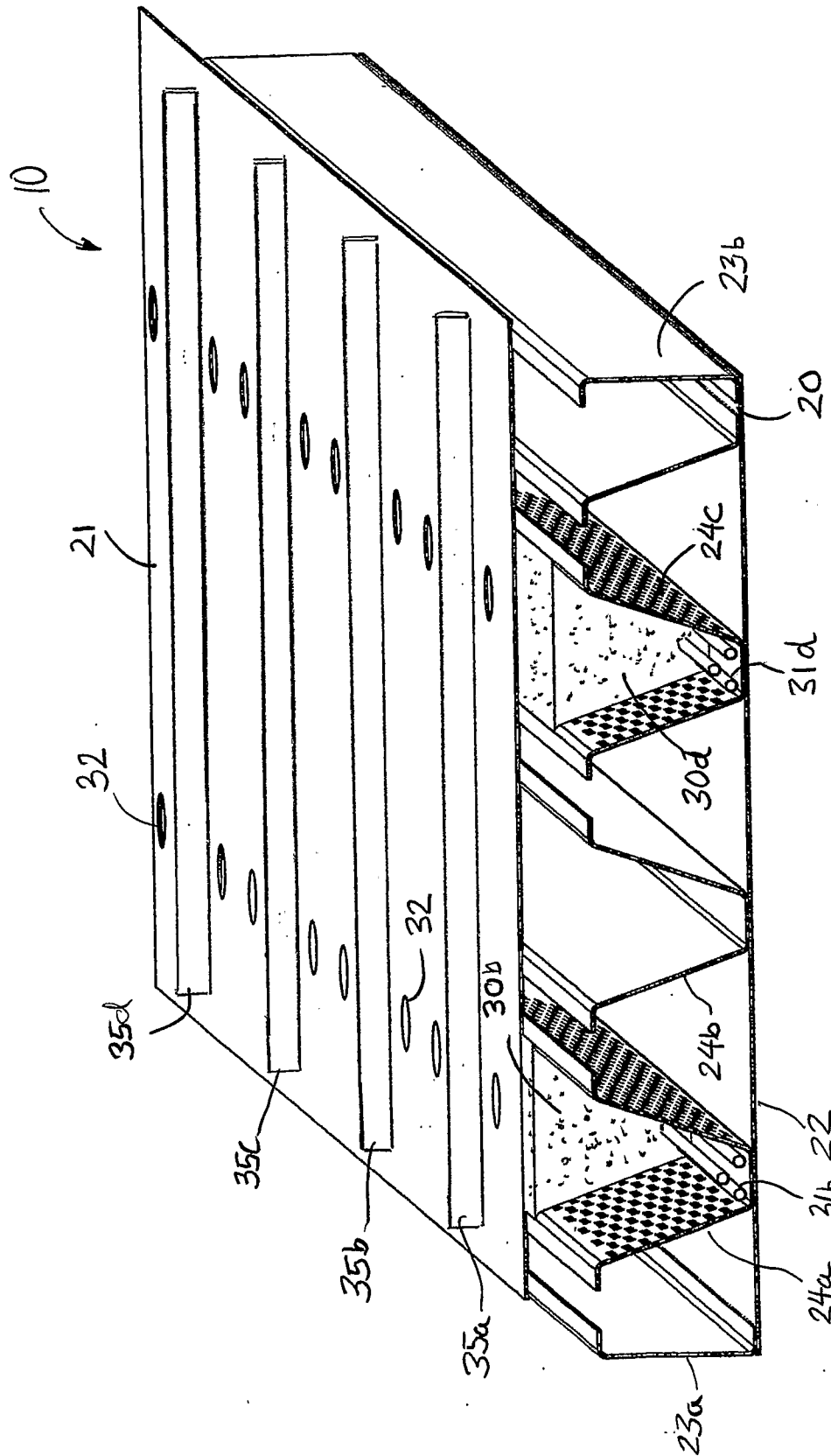
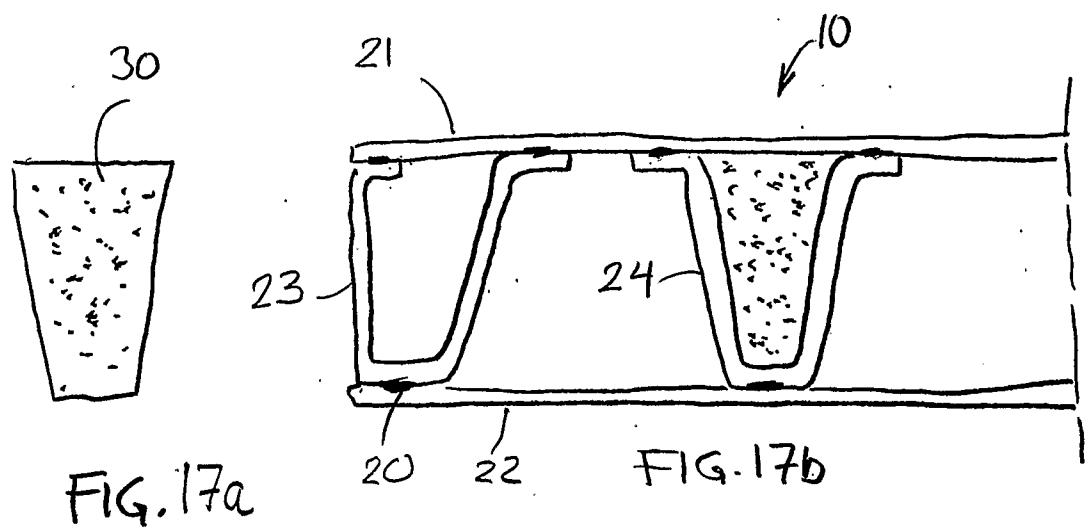
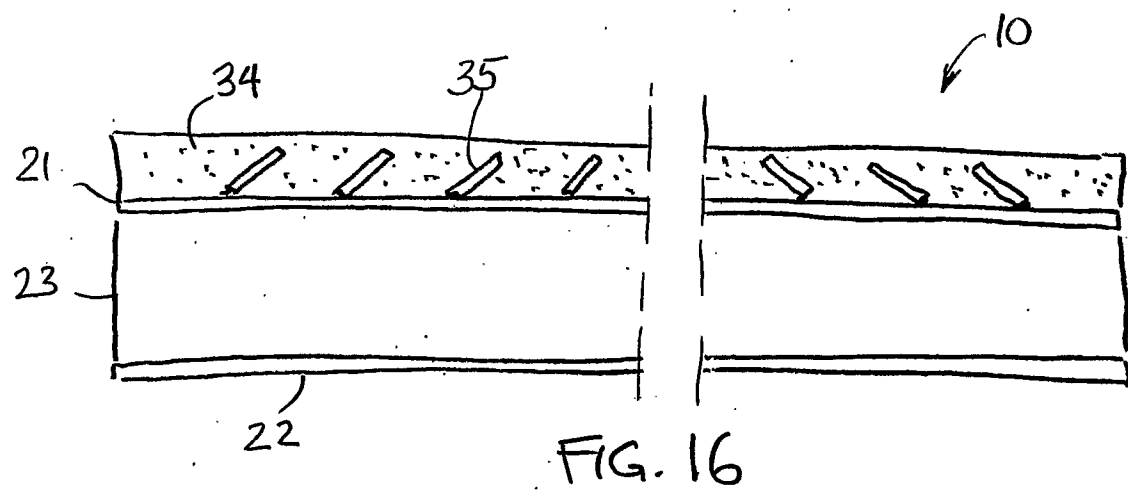
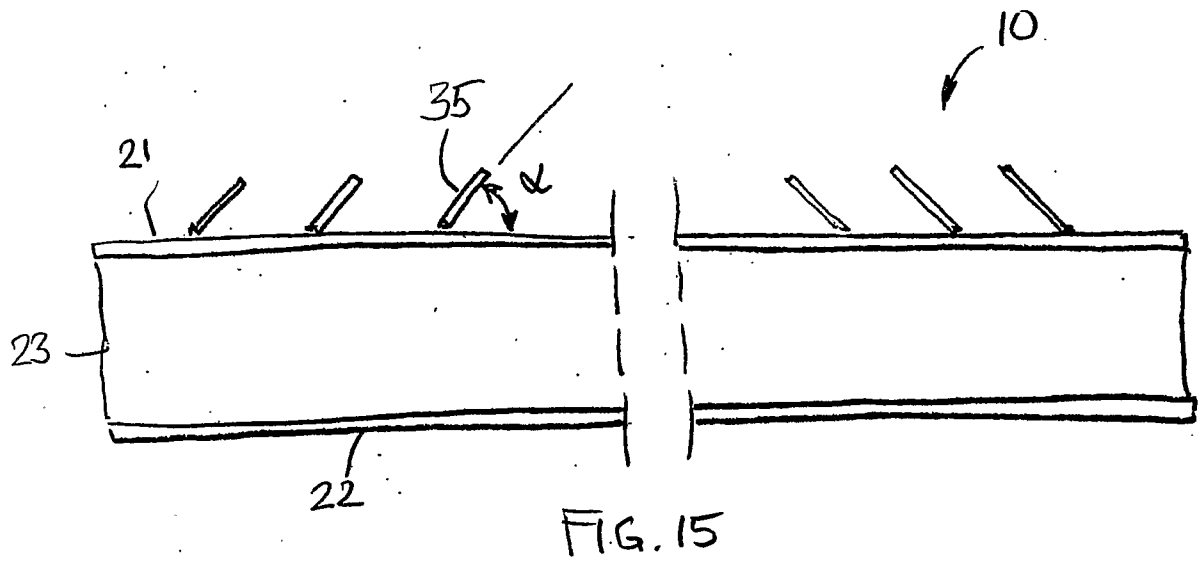
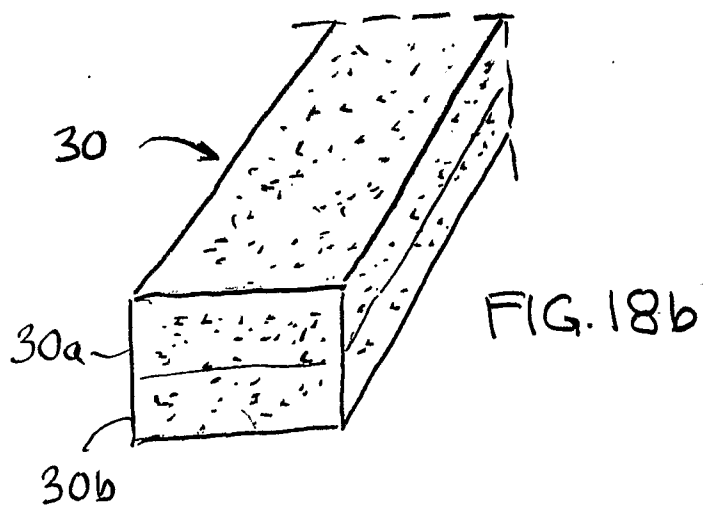
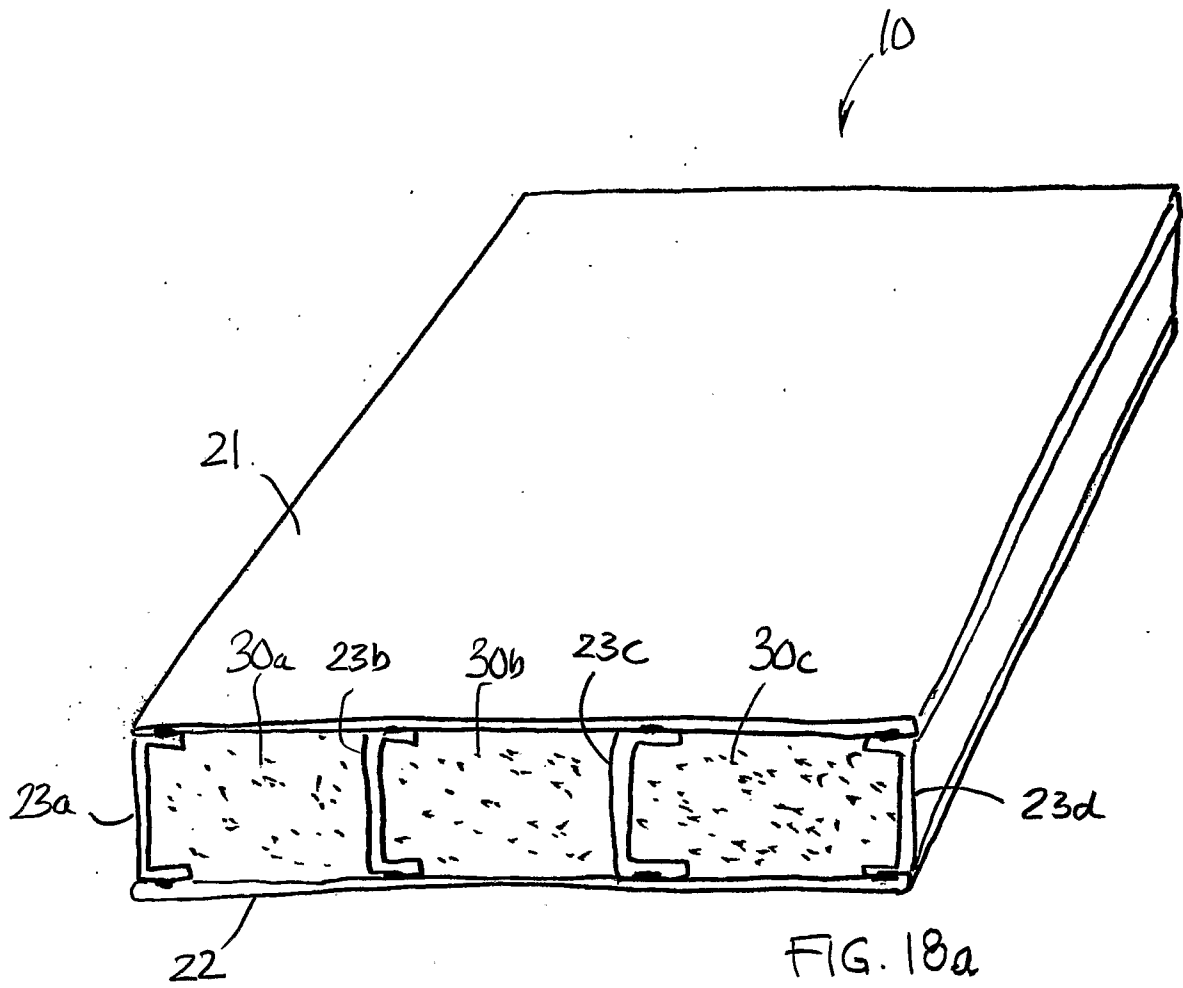
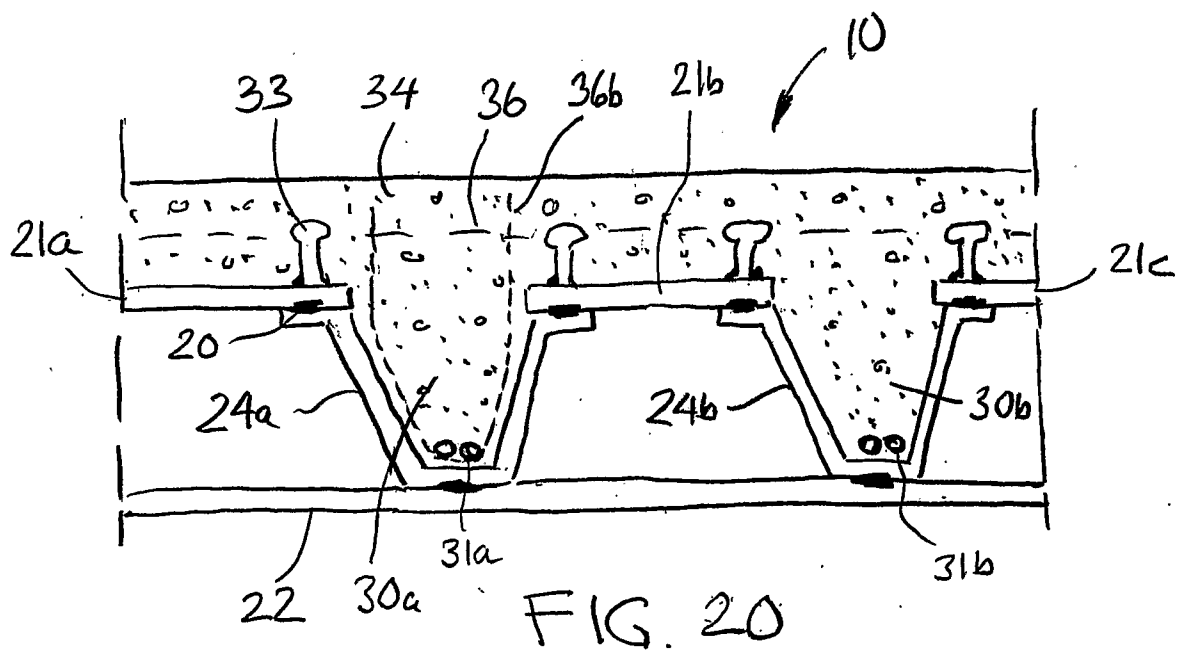
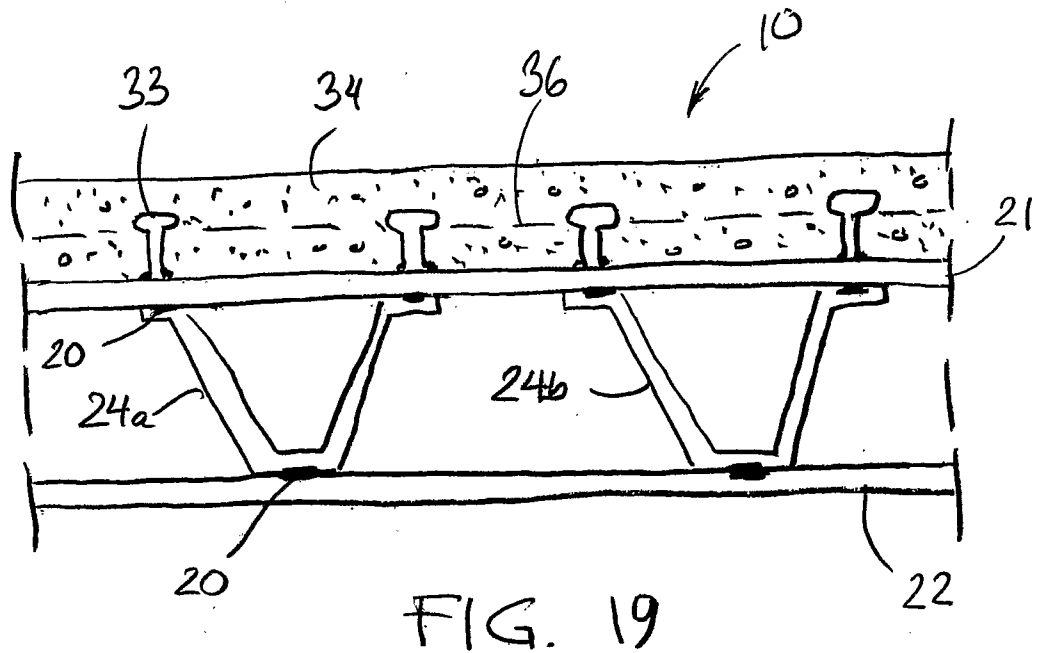
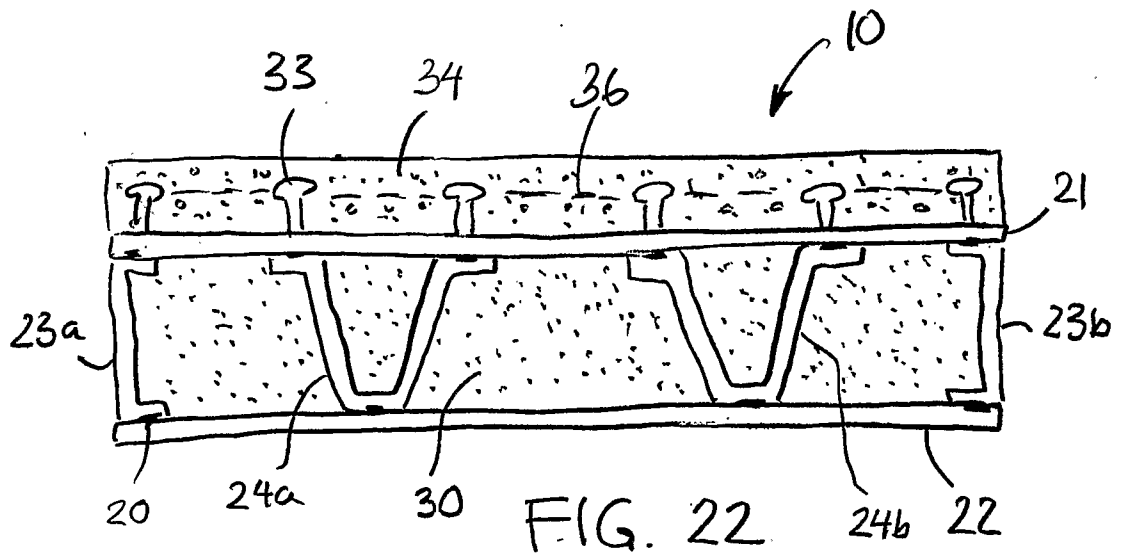
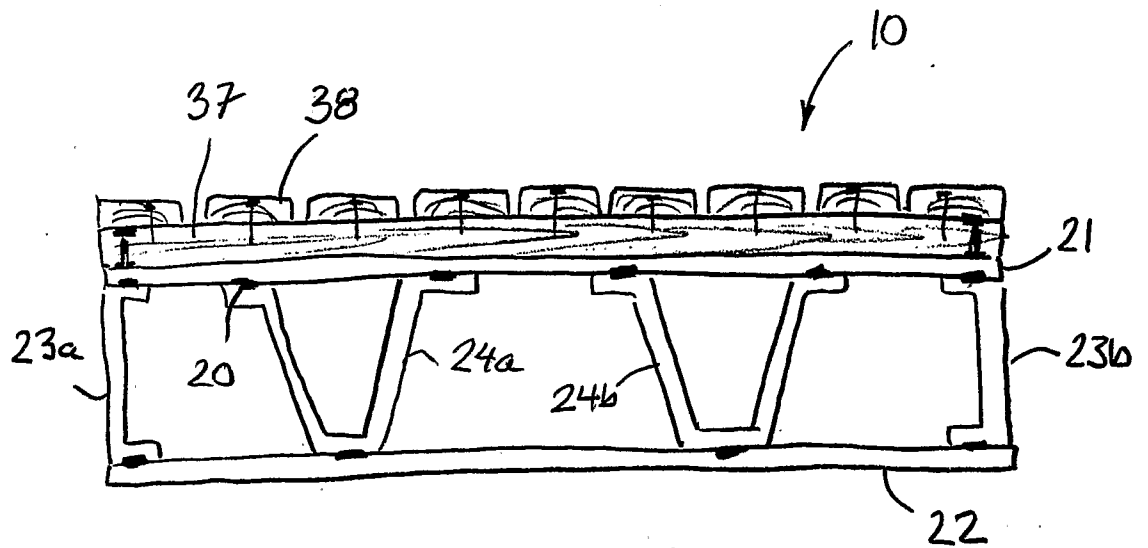


FIG. 14









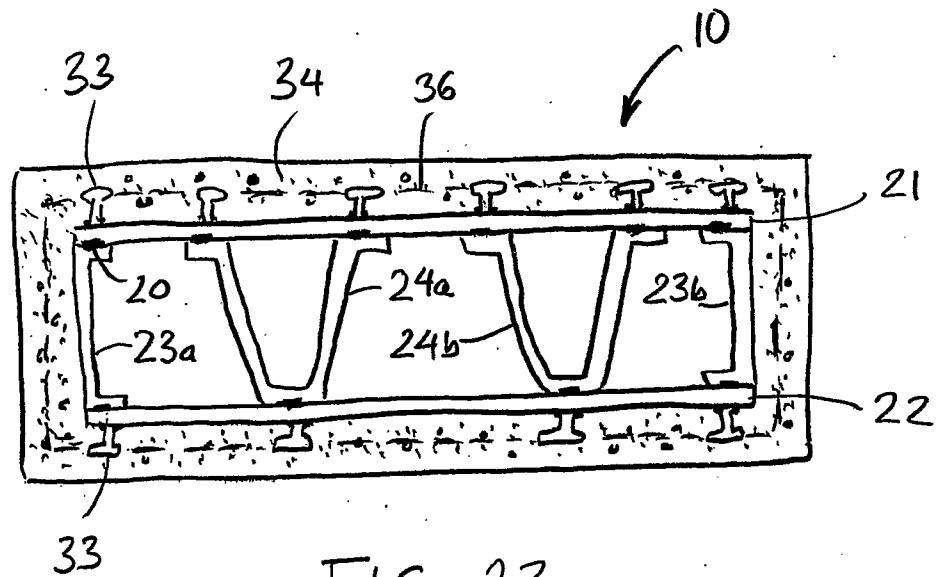


FIG. 23

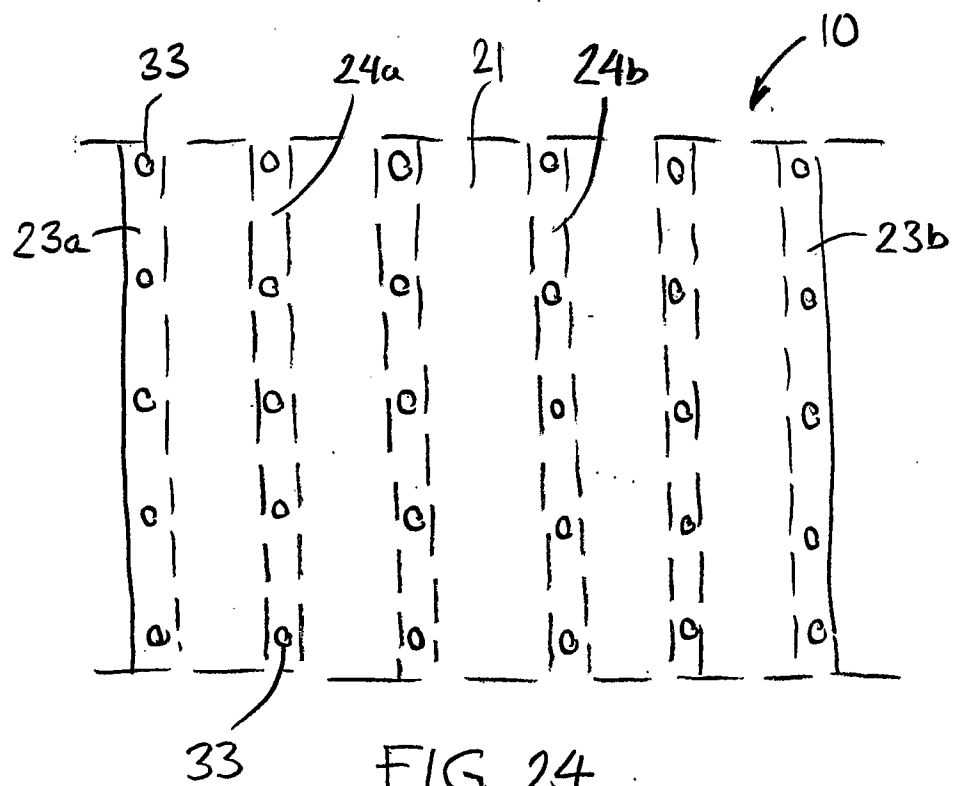
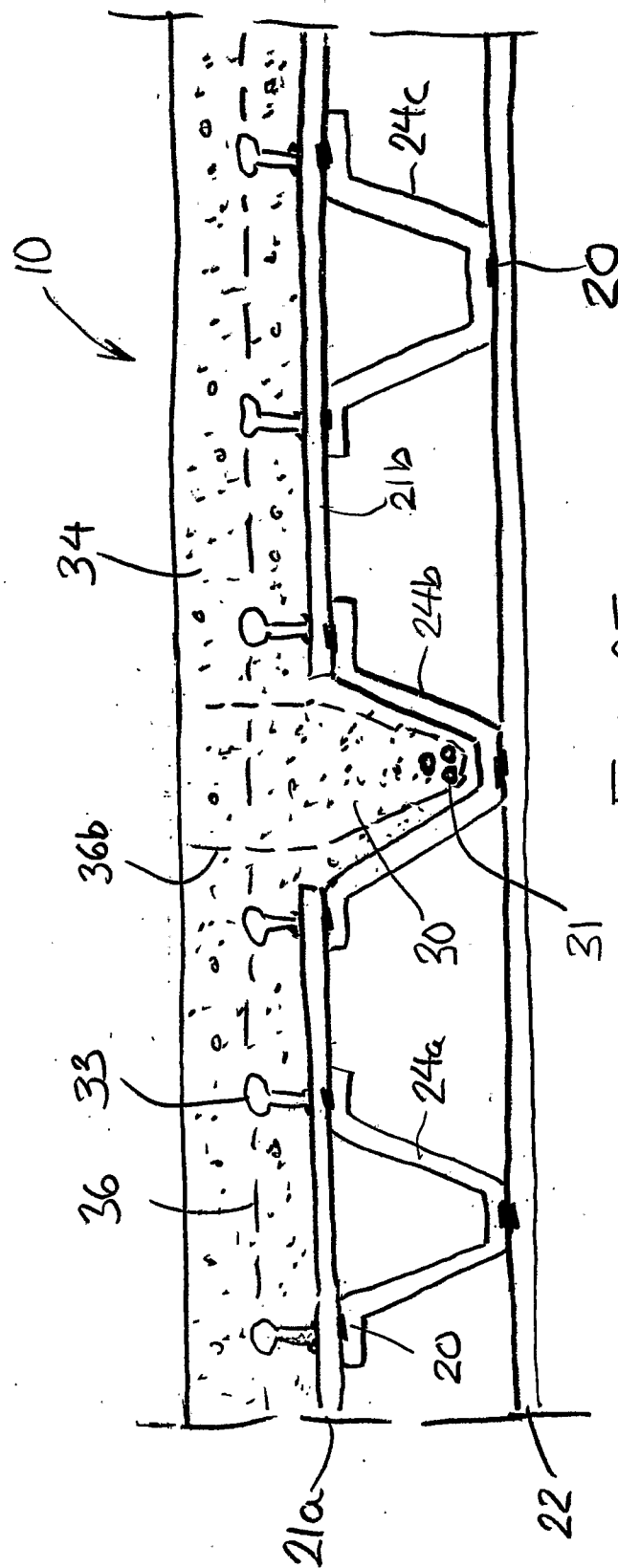


FIG. 24



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2008/000028

## A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC8: E04C, E04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-internal, WPI

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                | Relevant to claim No. |
|-----------|-------------------------------------------------------------------------------------------------------------------|-----------------------|
| Y         | JP 2001107317 A (NKK CORP) 17 April 2001 (17.04.2001), (whole document; particularly EPO abstract; FIGS. 1 and 2) | 1-13                  |
| Y         | Oy MIZAR Ab. Product brochure: "Mizar Laser Welded Sandwich Panels". 2003, pages 1-8. , (whole document)          | 1-13                  |
| Y         | WO 8902959 A1 (SELVAAGEBYGG AS) 06 April 1989 (06.04.1989), (whole document; particularly pages 4-7; FIGS. 1-3)   | 1-13                  |



Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

27 May 2008 (27.05.2008)

Date of mailing of the international search report

02 June 2008 (02.06.2008)

Name and mailing address of the ISA/FI  
National Board of Patents and Registration of Finland  
P.O. Box 1160, FI-00101 HELSINKI, Finland

Facsimile No. +358 9 6939 5328

Authorized officer

Veli-Pekka Autio

Telephone No. +358 9 6939 500

International application No.  
PCT/FI2008/000028

Form PCT/ISA/210 (patent family annex) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2008/000028

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.

**E04B 5/40** (2006.01)