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## (54) A modular structure

(57) A modular structure comprising a plurality of structural elements (1) of channel section made from reinforced concrete, having a layer (10) of thermally insulating material extending between two side connector portions (5, 6) of the structural element itself. The structure includes connector devices (18) of thermally insulating material each interposed between a pair of adjacent structural elements and adapted to make cooperating contact with the connector portions (5, 6) and with the layers (10) of thermally insulating material of the structural elements (1) to form therewith a substantially continuous covering layer (25) of the modular structure.

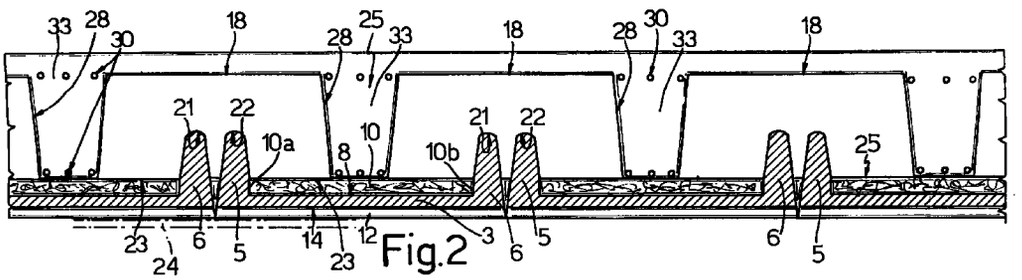



Fig.2

EP 0 810 335 A2

## Description

The present invention relates to a modular structure.

It is known in building construction to form vertical walls, for example of a load-bearing type, by casting pillars of reinforced concrete and filling the space between adjacent pillars with a curtain wall comprising prefabricated sheet-like elements or elementary modules (normally made from brick and/or concrete) connected together. These vertical walls are then finished with a layer of thermally insulating material which is normally placed in a cavity within the curtain wall or is applied to an outer face.

The creation of this cavity and, in any case, the arrangement of the thermally insulating layer, takes a long time to carry out (and this involves additional costs) and must be effected by a specialised workforce. It is also known to form horizontal platforms, such as slabs, by providing a plurality of perforated brick elements and laying them side by side on a temporary horizontal structure and casting a layer of cement mortar over these brick elements to form a flat horizontal surface which is then finished with a layer of thermally insulating material applied to one face of the horizontal platform. In a similar manner to the above, the application of the layer of thermally insulating material involves additional construction time (and hence costs) and must be carried out by a specialised workforce.

The object of the present invention is to provide a structural element which can be used in combination with other structural elements to form a modular structure usable as a vertical wall or a horizontal platform, in which the arrangement of the thermally insulating layer is carried out in a single operation with the creation of the modular structure itself.

Accordingly the present invention provides a modular structure of the type described in Claims 1 and 10. According to the present invention there is also provided a structural element for a modular structure of the type described in the Claim 17.

The invention will now be described with reference to the appended drawings which illustrate one non-limitative embodiment, in which;

- Figure 1 is a perspective view of a structural element used to form a modular structure according to the present invention;
- Figure 2 illustrates a plurality of structural elements coupled together in a modular structure forming a horizontal platform; and
- Figure 3 illustrates a plurality of structural elements coupled together in a modular structure which forms a vertical wall;
- Figure 4 is a perspective view of a vertical wall including a plurality of coupled structural elements;
- Figure 5 is a perspective view of a horizontal platform and a vertical wall both including a plurality of coupled structural elements;
- Figure 6 illustrates a modular structure including a plurality of structural elements arranged vertically, coupled together and supported by a framework;
- Figure 7 shows a cross-section of a portion of the structure of Figure 6; and
- Figure 8 illustrates an element of the framework of Figure 6.

In Figure 1 a structural element usable in building construction work for the formation of modular structures is generally indicated 1. The element 1 includes a central portion 3 comprising a flat rectagular sheet and two side connector portions 5, 6 formed as straight side walls integral with the sheet 3 and projecting from the longer sides thereof. More particularly, the structural element 1 has a channel section with the walls 5, 6 extending substantialy perpendicularly from a flat rear face 8 of the sheet 3; the walls 5, 6 have substantially the same height h and a cross-section which tapers towards a free edge (for example the walls 5, 6 may have a trapezoidal cross-section). The central portion 3 and the side connector portions 5, 6 are made from reinforced concrete. The side walls 5, 6 have respective opposite end portions 5a, 5b and 6a, 6b from which project metal elements 7 forming part of the inner reinforcement (not shown) of the reinforced cement portions. More particularly one metal element 7 may be in the form of a hook usable for engagement and lifting of the structural element 1.

The structural element 1 further includes a layer of thermally (and acoustically) insulating material 10, conveniently made from a rectangular sheet of expanded polystyrene (or other thermally insulating material), coupled to the central portion 3 in contact with the rear face 8. More particularly, the sheet 10 is rectangular with longer edges 10a, 10b located in contact with base portions of the straight side walls 5, 6. Thus the sheet 10 extends between the walls 5 and 6 over the entire width L of the rear face 8.

The structural element 1 further includes an outer facing layer 12 applied to a front face 14 of the rectangular sheet 3 and having a substantially constant thickness. The outer facing layer may, for example, comprise lightweight concrete, cellular concrete, hydraulic lime mixed with polystyrene, a fire-retardant material in general or an outer cladding of brick or stone.

The structural element 1 is adapted to cooperate with a connector element device 18 (Figure 2) which, in the embodiment illustrated in Figure 2, comprises a parallelepipedal block of thermally insulating material (for example expanded polystyrene) of a length at least equal to the length of the structural element 1. The connector element device 18 has two straight trapezoidalsection channels 21, 22 which extend parallel to each other in a flat face 23 of the parallelpipedal block 18.

In use, the structural element 1 may, to advantage, be used to form a horizontal platform, for example a load-bearing slab, as illustrated in Figure 2. For this pur-

pose several structural elements are located side by side with the walls 5, 6 parallel and facing each other. The rectangular sheets 3 are also located so as to be coplanar, for example by the placing of the structural elements on a flat supporting surface 24 (illustrated schematically) of a load-bearing structure (not illustrated). The end portions (not illustrated) of the structural elements 1 may also be rested on respective vertical load-bearing walls (not shown) which support the structural elements themselves. The blocks 18 are also located so as to interconnect the adjacent structural elements, the channels 21, 22 of a block 18 housing respective walls 6 and 5 of adjacent structural elements. In this arrangement, the face 23 of each block 18 is in cooperating contact with the insulating layers 10 of the adjacent structural elements so as to form therewith a substantially continuous covering layer 25 of the modular structure comprising the adjacent structural elements 1 interconnected by the connector elements 18. The adjacent parallelepipedal blocks 18 also define, with the layer 10, straight, rectangular-section channels 28 in which steel reinforcements 30 may be arranged and in which a cement layer 33 may subsequently be cast so as to form load-bearing beams when the cement has hardened.

The advantages of the modular structure described above are as follows:

- the adjacent structural elements are interconnected and a continuous thermally-insulating layer is created, extending over the entire horizontal platform, in a single operation;
- the structural elements 1 are interconnected by simple operations, without the aid of special equipment and without the need for a specialised workforce - the modular structure can thus be assembled simply and quickly; and
- modular structures may be formed of any dimensions from different numbers of structure elements.

With reference to Figure 3, the structural elements 1 may be used with connector elements 18a each comprising an elongate, substantially parallelepipedal body with a pair of parallel channels 21a, 22a in a first face 36 and a pair of parallel channels 40, 41 in a second face 46 of the body 18a opposite the face 36. The body 18a, as described for the connector element 18, has a length at least equal to the length of the structural element 1 to which it is applied.

The structural elements 1 of Figure 3 are used to form a vertical load-bearing wall. For this purpose, a first plurality of structural elements 1a is arranged alongside each other with the walls 5, 6 parallel and adjacent. The rectangular sheets 3 are then disposed vertically and in the same plane, for example with the use of an external supporting framework (described below). The blocks 18a are arranged so as to interconnect the adjacent structural elements, with the channels 21a, 22a of a block 18a housing respective walls 6 and 5 of adjacent structural elements. In this arrangement, the face 36 of each block 18a is in cooperating contact with the insulating layers 10 of the adjacent structural elements to form therewith a substantially continuous first covering layer 25a. A second plurality of structural elements 1b is arranged side by side and facing the structural elements of the first plurality, with the rectangular sheets 3 vertical and parallel to the corresponding sheets of the structural elements 1a. The blocks 18a are disposed so as to interconnect adjacent structural elements 1b, the channels 40, 41 of a block 18a housing respective walls 6 and 5 of the adjacent structural elements 1b. In this arrangement, the connector elements 18a are interposed between the connector wall portions 5, 6 of the structural elements 1a and the connector portions 5, 6 of the structural elements 1b. The connector elements 18a thus fulfil the dual function of interconnecting the adjacent structural elements 1a and 1b and separating and spacing apart the facing structural elements 1a, 1b.

In this arrangement, moreover, the face 46 of each block 18a is in cooperating contact with the insulating layers 10 of the structural elements 1b to form therewith a second substantially continuous covering layer 50 parallel to and facing the covering layer 25a.

A structural element 1a and a structural element 1b facing each other together define, with the pair of connector elements 18a which separate them, a substantially parallelepipedal cavity 55 bounded by the facing layers of insulating material 10 and the side faces of the connector elements 18a. A steel reinforcement (not shown) may be arranged in the cavity 55 and subsequently a layer of cement mortar ( not illustrated) may be cast around it so as to form, when the cement has hardened, load-bearing pillars which are firmly connected to the structural elements 1a and 1b. Pipes, connecting cables etc. may also be housed in the cavity 55.

The advantages of the modular structure described above are as follows:

- the structural elements may be interconnected and the two continuous thermally-insulating covering layers, extending over the whole vertical wall, may be created by the simple operations described above;
- the modular structure with the double-layer of insulating material described above prevents the ingress of cold into the building comprising the structure itself and simultaneously prevents heat from dispersing from the building;
- the modular structure also has good sound-proofing properties;
- the presence of two facing thermally-insulating layers encapsulating an intermediate cement portion forms a modular structure having a high thermal inertia: this prevents a sharp 'meeting', within the modular structure, between the temperature outside the building and that inside the building itself (which is higher than the outside temperature). This prevents condensation forming on the surface of

the modular structure facing into the building itself;

- formwork is not required for the casting of the cement since the cavity 55 described above itself constitutes the formwork;
- both vertical load-bearing walls (when all the cavities 55 in the structure are filled with reinforced concrete) and partition walls may be formed;
- the structural elements 1a, 1b are coupled together by simple operations, without the aid of specialised equipment and without the need for a specialised workforce - the modular structure can thus be assembled quickly and simply; and
- vertical walls of any width can be made by the assemblage of any number of structural elements.

Figure 4 illustrates a plurality of first and second vertical structural elements arranged facing each other to form a vertical load-bearing wall similar to that illustrated in and described with respect to Figure 3. Rectangular apertures 60 are left open in this vertical load-bearing wall and are bounded by facing side wall portions 61, 62 of the vertical wall; each is defined by lateral portions 5, 6 of the facing structural elements and by the connector element 18 interposed between them. The aperture 60 may be closed by a rectangular panel 65 having a rectangular aperture 66 defining a doorway in the vertical wall. The lower part of the aperture 66 may be closed by a rectangular panel 67 to form a window opening in the vertical load-bearing wall. The side wall portions 60, 61 may also be faced with rectangular sheets 68, 69 having a height substantially equal to the height of the aperture 66 and adapted to support an upper L-shaped cross-beam for resting on peripheral portions of the shorter sides of the sheets 68, 69.

Figure 5 illustrates the upper portion of a vertical load-bearing wall similar to that illustrated in, and described with reference to, Figure 3. This vertical wall supports a plurality of structural elements 1 arranged horizontally and having straight end portions located so as to face upper straight portions of the vertical wall. In this position, the metal elements 7 which project from the horizontal structural elements close to the vertical wall extend into an upper region T of the vertical wall into which the metal elements 7 of the vertical wall itself also extend. Cement mortar may be poured into this region T so as to form a reinforced concrete beam which extends across the top of the vertical wall and connects the latter to the horizontal structural elements. Similarly, the horizontal structural elements disposed next to each other and in alignment have adjacent end portions from which metal elements 7 project so as to face each other across a region R. The region R extends along the adjacent portions of the structural elements 1 and is adapted to house a metal reinforcement over which cement may be poured to form a section-break, horizontal, load-bearing cross-member extending transverse the structural elements 1 and interconnecting their adjacent end portions. The cross-members do not interrupt the thermally insulating layer defined by the horizontal structural elements.

Figure 6 illustrates a framework 80 used for supporting the vertical structural elements to form a vertical load-bearing wall as described above with reference to Figure 3. The framework 3 comprises a plurality of straight connector devices 81 coupled together so as to form straight retaining structures which extend on opposite sides of the vertical wall. Each connector device comprises a rectangular plate 83 from which extend two parallel, straight tie-bars 84, 85. Each connector device 81 further includes a straight appendage 87 which projects from the opposite side of the plate 83 from the straight tie-bars 84, 85. The straight appendage 87 (Figure 7) has a hook-shaped end portion 87a which is adapted to fit into a slot 90a in a first end of a straight plate 90 extending through the connector element 18 and having a second end portion with a slot 90b coupled to the straight appendage 87 of a connector device 81 located on the opposite side of the vertical wall. Thus the plate 90 interconnects the straight appendages of two connector device 81 on opposite sides of the vertical wall, ensuring the relative positioning of the structural elements 1a and 1b facing each other. The plate 90 is withdrawn from the connector element 18 after casting in order to eliminate the thermal bridge which the plate 90 itself would form if retained within the vertical wall. Following the withdrawal of the plate 90, the insulating material constituting the element 18 expands into the slit in which the plate 90 was housed, closing this slit.

The free end portions 84a, 85a (Figure 6) of the tie-bars 84, 85 are also connected to a plate 83 of a contiguous connector device so as to be slidable axially but fixed against rotation and, hence, without the possibility of separation from the vertical wall.

Finally it is clear that modifications and variations may be made to the modular structure described without thereby departing from the protective scope of the present invention.

## Claims

1. A modular structure characterised in that it comprises:

   - a plurality of structural elements (1; 1a, 1b) each of which has at least one layer (10) of thermally insulating material and connector portions (5, 6); and
   - connector means (18; 18a) interposed between at least one pair of the adjacent structural elements and adapted to cooperate with the connector portions (5, 6); the connector means (18; 18a) including at least one piece of thermally insulating material which makes cooperating contact with the layers of thermally insulating material (10) of the adjacent structural elements (1; 1a, 1b) to form therewith a substantially continuous covering layer (25; 25,

50) of the modular structure.

2. A structure according to Claim 1, characterised in that the structural elements include at least one part (3) made from reinforced concrete.

3. A structure according to Claim 1 or Claim 2, characterised in that the structural elements (1; 1a, 1b) include a central portion (3) and the connector portions (5, 6) disposed along opposite sides of the central portion (3); the layer (10) of thermally insulating material being coupled to at least the central portion (3).

4. A structure according to Claim 3, characterised in that the central portion (3) is substantially flat.

5. A structure according to Claim 3 or Claim 4, characterised in that the central portion (3) is substantially rectangular in plan; the connector portions (5, 6) extending along the longer sides of the rectangular shape.

6. A structure according to any one of the preceding claims, characterised in that the connector portions (5, 6) include at least two connector bodies projecting from the same side (8) of the structural element itself.

7. A structure according to Claim 6, characterised in that each connector body (5, 6) comprises a wall extending along substantially the entire length of the structural element itself.

8. A structure according to Claim 7, characterised in that each wall (5, 6) has a section which tapers towards a free edge of the wall itself.

9. A structure according to any one of the preceding claims, characterised in that each connector means defines at least two contiguous seats (21, 22; 21a, 22a, 40,41) each of which is adapted to house a connector portion (5, 6) of a respective structural element.

10. A modular structure according to any one of the preceding claims, characterised in that the structural elements comprise:

- a first plurality of first structural elements (1a) each of which has at least one layer (10) of thermally insulating material and connector portions (5, 6);
- a second plurality of second structural elements (1b) each of which has at least one layer (10) of thermally insulating material and connector portions (5, 6); the second structural elements (1b) being arranged facing the first structural elements (1a) and separated therefrom by the connector means (18a) interposed between connector portions (5, 6) of first and second structural elements (1a, 1b) facing each other;
- the thermally insulating portion (18a) being in cooperating contact with the layers (10) of thermally insulating material of the first structural elements (1a) to form therewith a first substantially continuous covering layer (25a) of the modular structure and being in cooperating contact with the layers (10) of thermally insulating material of the second structural elements (1b) to form therewith a second substantially continuous covering layer (50) of the modular structure extending in a position facing the first covering layer (25a).

11. A structure according to Claim 10, characterised in that each connector means defines at least two first contiguous seats (21a, 22a) each of which is adapted to house a connector portion (5, 6) of a respective first structural element (1a) and two second contiguous seats (40, 41) each of which is adapted to house a connector portion (5, 6) of a respective second structural element (1b).

12. A structure according to Claim 11, characterised in that the connector means comprise a block of insulating material having a first pair of adjacent channels (21a, 22a) adapted to house respective connector portions (5, 6) of first structural elements (1a) and a second pair of adjacent channels (40, 41) disposed on the opposite side from the first channels (21a, 22a) and adapted to house respective connector portions (5, 6) of second structural elements (1b).

13. A structure according to any one of the preceding claims, characterised in that the structural element (1; 1a, 1b) includes an outer facing layer (12) located on the opposite side from the layer (10) of thermally insulating material.

14. A Structure according to any one of the preceding claims, characterised in that the structural elements include at least one portion (3) made from reinforced concrete; the structural element having opposite end portions (5a, 5b; 6a, 6b) from which project metal elements (7) forming part of an inner reinforcement.

15. A structure according to Claim 14, characterised in that at least one metal element (7) is shaped as a hook usable for the engagement and lifting of the structural element (1).

16. A structure according to Claim 10, characterised in that it includes a framework (80) comprising a plurality of straight connector devices (81) coupled

together so as to form straight retaining structures which extend on opposite sides of the modular structure; each connector device including an interconnecting element (83) from which project two straight, parallel tie-bars (84, 85) and a straight appendage (87) projecting from the interconnecting element (83) on the opposite side from the straight tie-bars (84, 85); the straight appendage (87) having an end portion (87a) adapted to couple with a first end of a straight plate (90) extending through the connector element (18) and having a second end portion for coupling with a straight appendage (87) of a connector device (81) located on the opposite side of the modular structure; the free end portions (84a, 85a) of the tie-bars (84, 85) also being connected to an interconnecting element (83) of a contiguous connector device (18) so as to be slidable axially but fixed against rotation.

**17.** A structural element for a modular structure, characterised in that it comprises:

- a central portion (3) having at least one layer (10) of thermally insulating material; and
- at least two side connector portions (5, 6) located along opposite sides of the central portion (3) and adapted to cooperate with connector means (18; 18a) interposed between at least one pair of adjacent structural elements; the connector means (18; 18a) including at least one piece of thermally insulating material which is in cooperating contact with the layers (10) of thermally insulating material of the adjacent structural elements (1; 1a, 1b) to form therewith a substantially continuous covering layer (25; 25,50) of the modular structure.

**18.** A structural element according to Claim 17, characterised in that the structural element has a channel section and the layer of thermally insulating material extends between the connector portions.

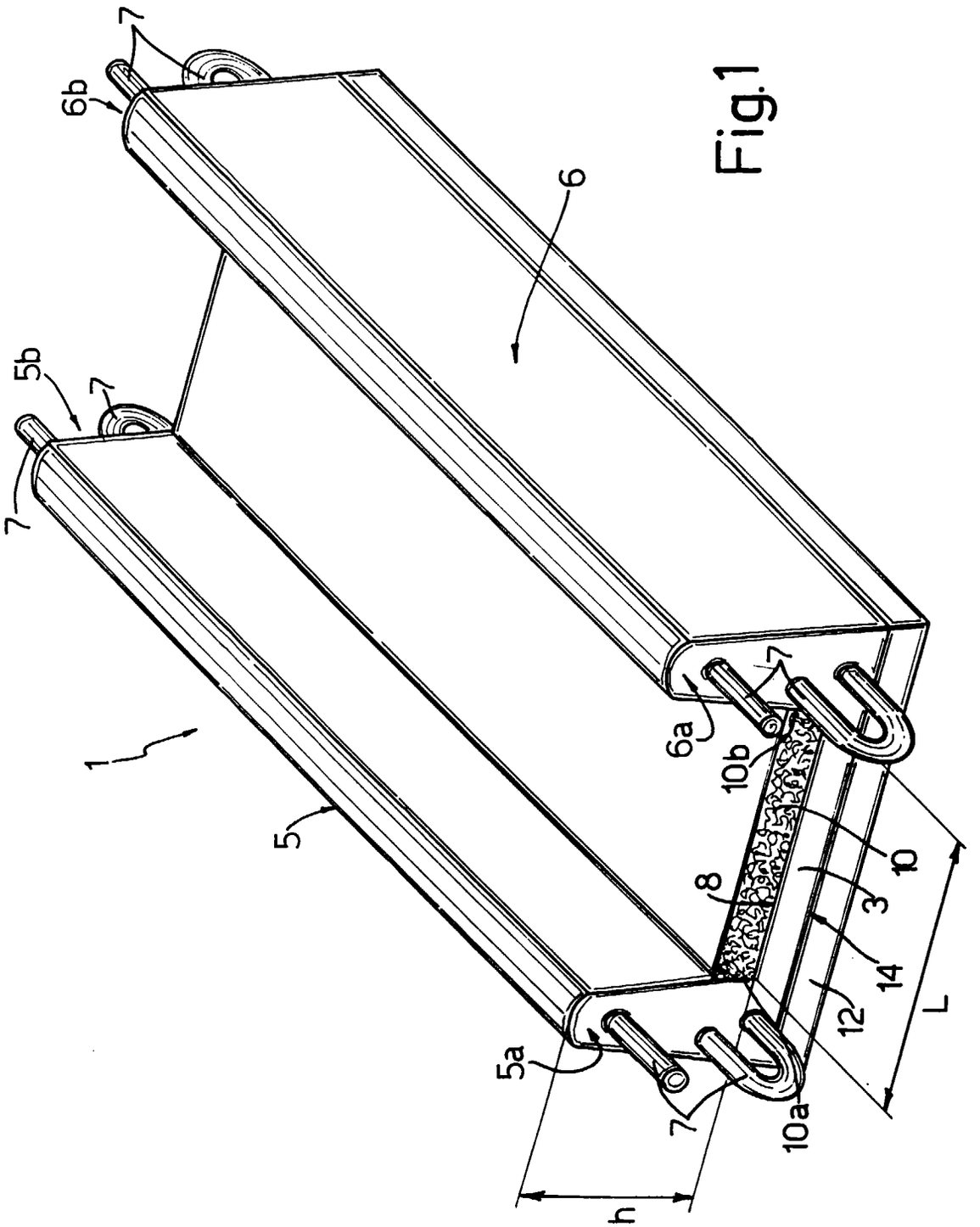
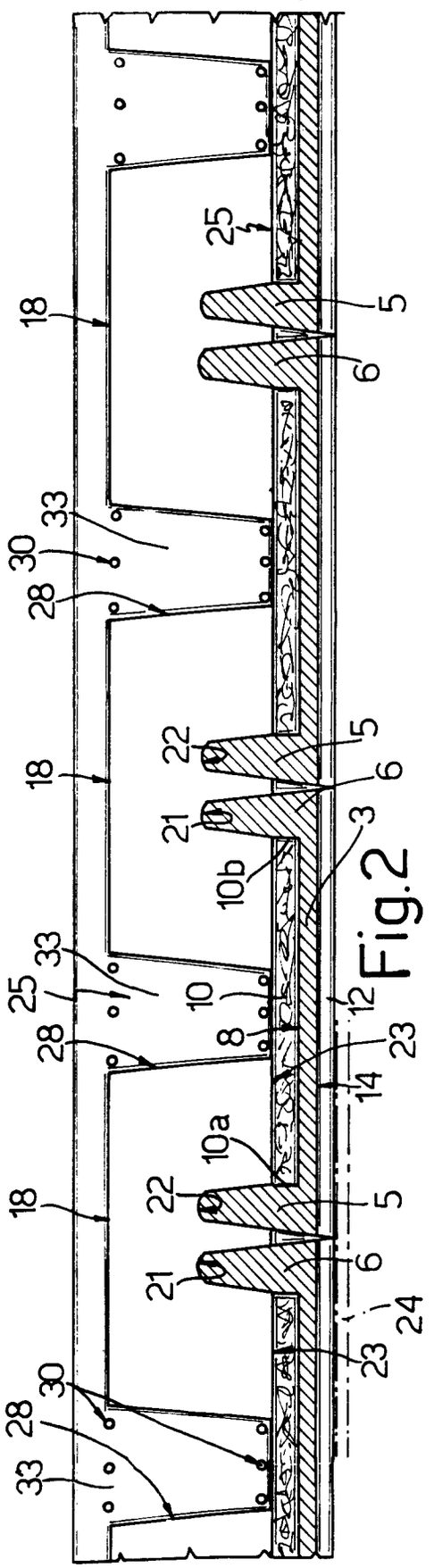



Fig.1


18
25
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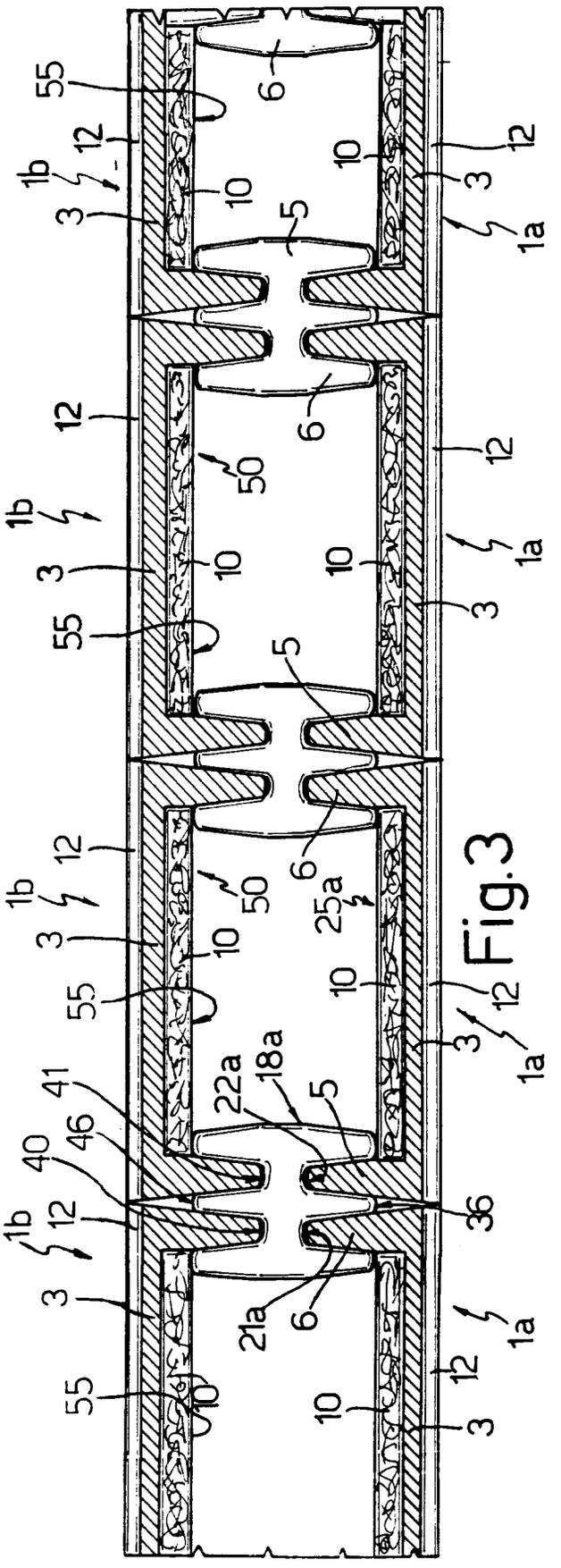
6
33
30
28
22
21
10b
3
10
12
8
23
14
10a
24

Fig.2


55
1b
12
3
10
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6
1a
50
25a
41
40
46
22a
18a
36
21a

Fig.3

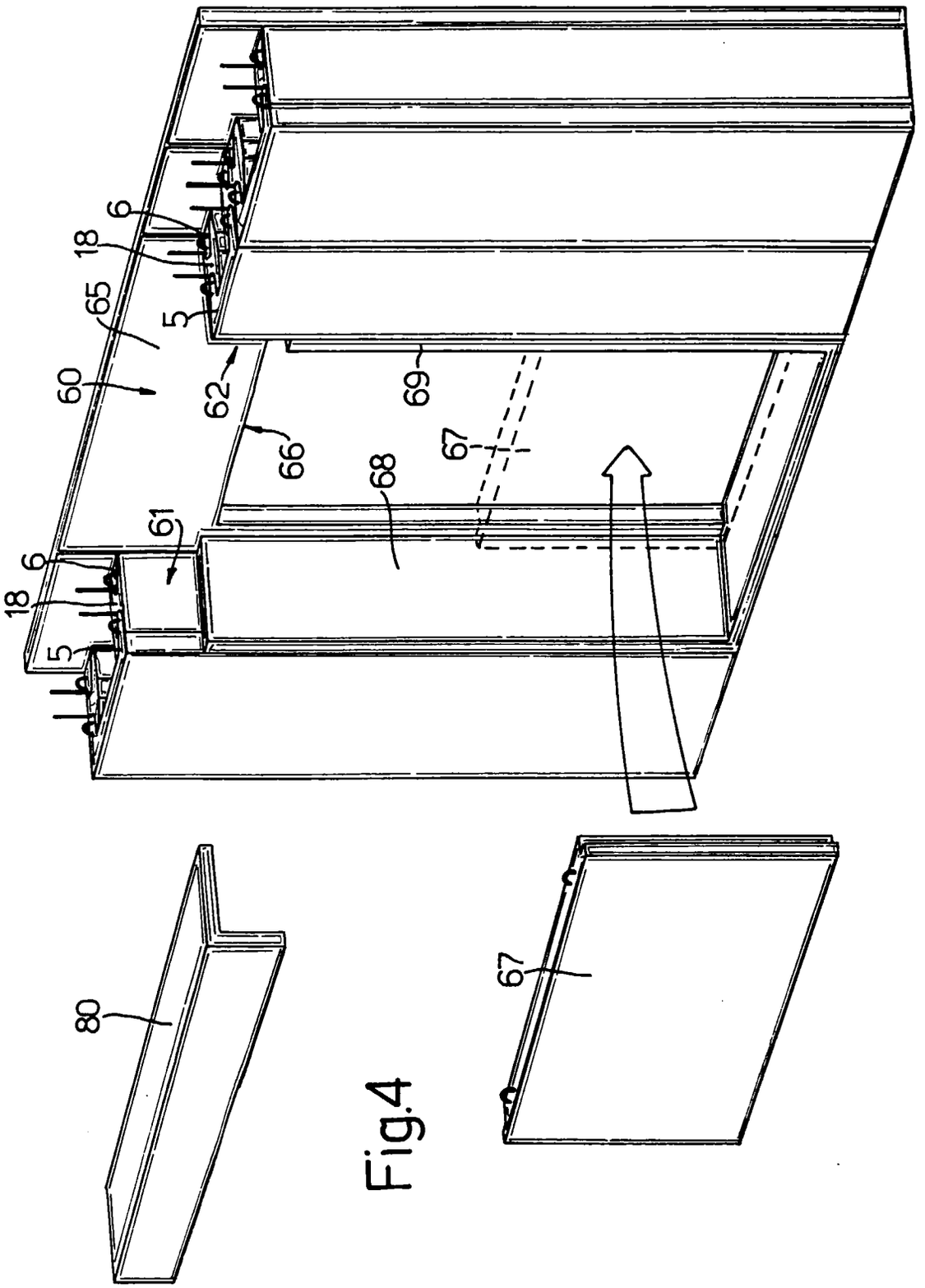


Fig.4

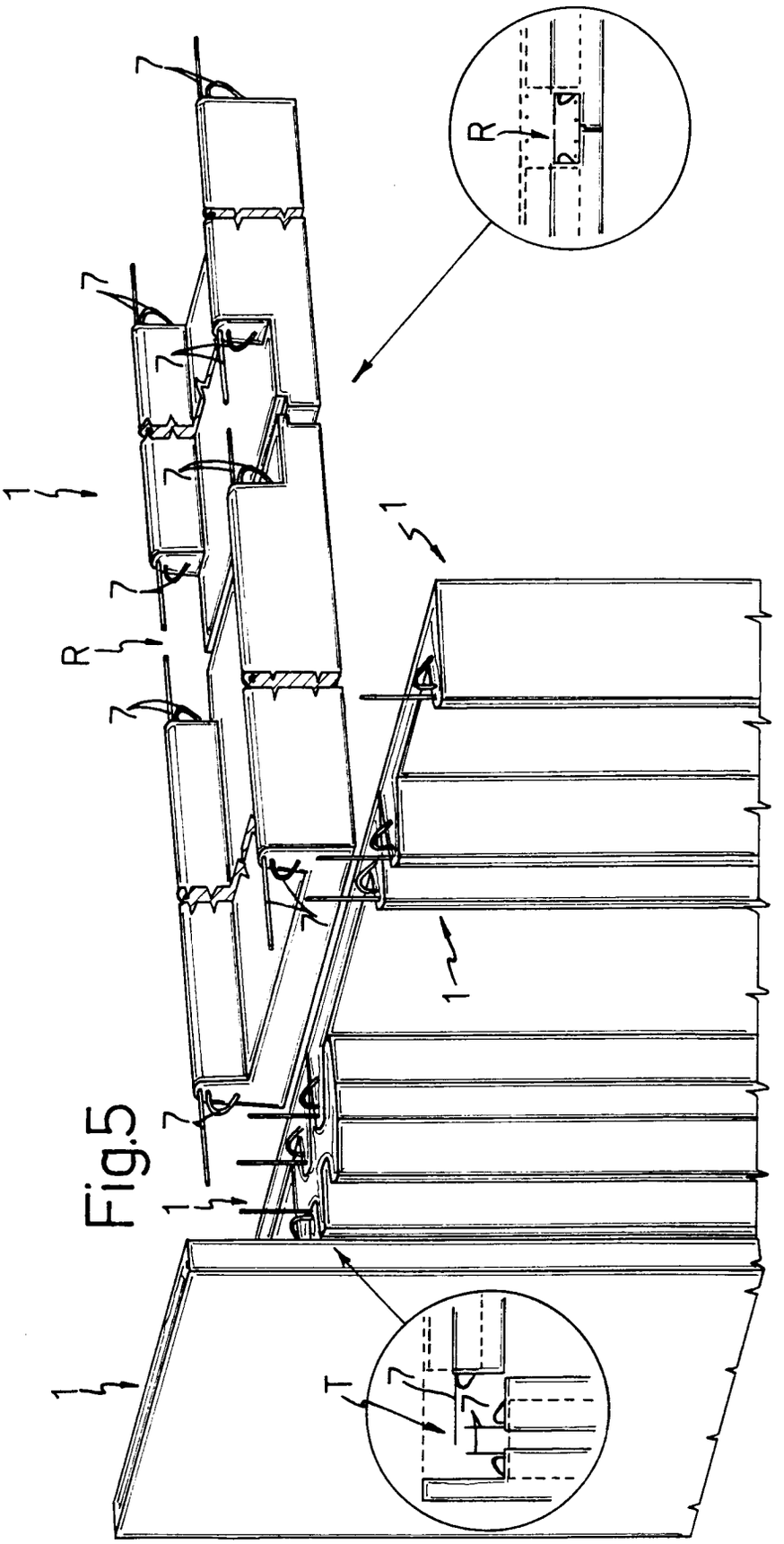


Fig.5

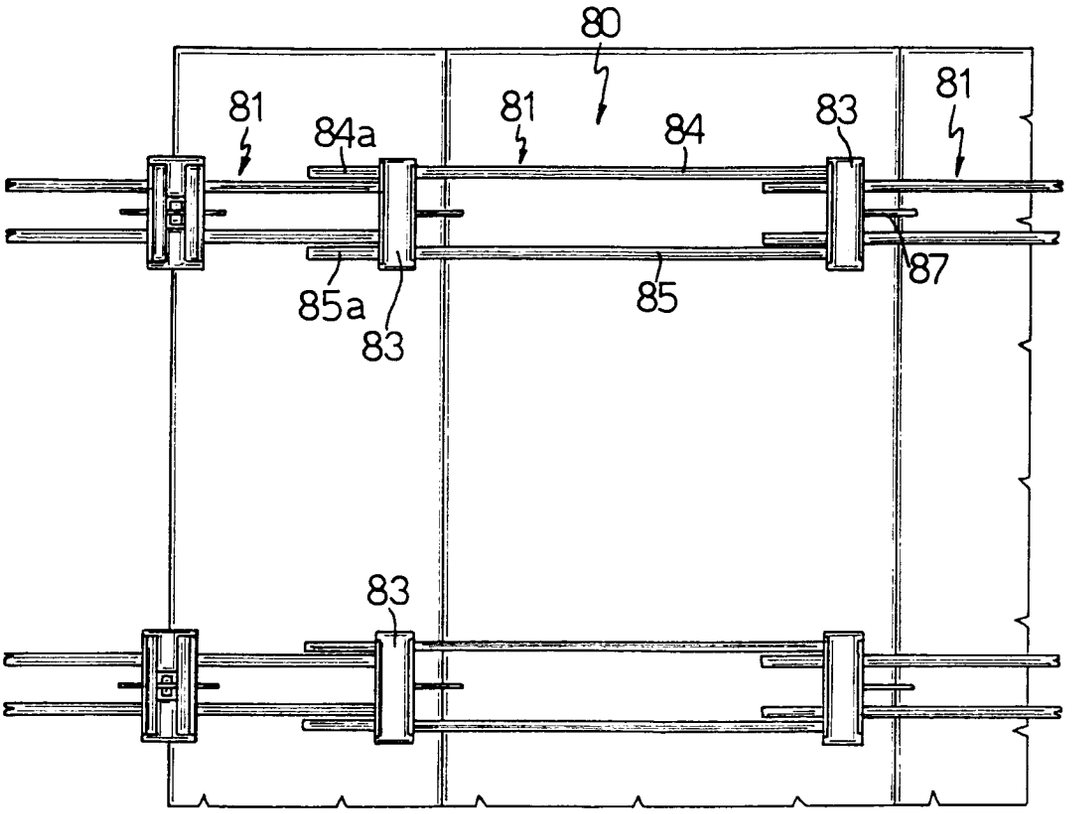


Fig.6

Fig.8

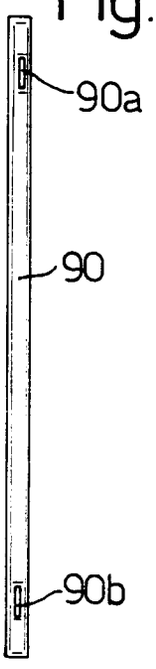


Fig.7