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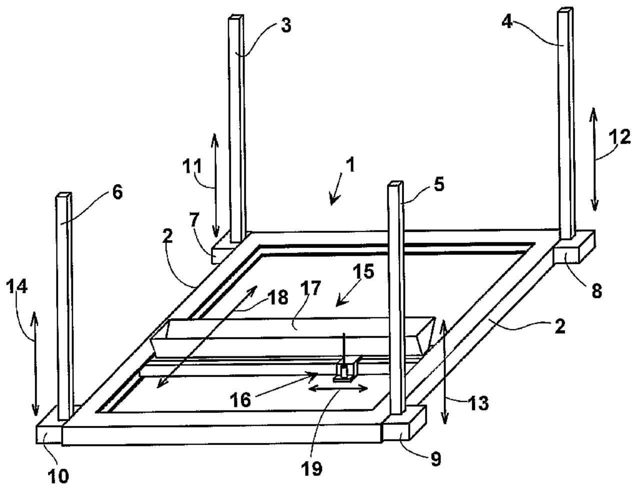
(54) Title: METHOD AND DEVICE FOR BUILDING AUTOMATICALLY CONGLOMERATE STRUCTURES



(57) Abstract: The present invention relates to the automatic construction of buildings or other heavy constructions by a method and a device suitable for reducing the construction time and for assisting its relative operations. This method comprises the steps of CAD- modelling a structure through volume or surface modelling steps, sectioning the structure computed model with horizontal parallel planes according to a predetermined pitch, prearranging an apparatus that deposits in alternation a layer of granular material and a liquid binder only in coincidence with the solid portions of said plane, within containing walls that define a closed perimeter. This method can be carried out by an apparatus having a horizontal frame (1) suitable for supporting a bridge crane (15) capable of causing and operating head to move (16) in a horizontal plane defined by said horizontal frame (1) . The frame (1) is movable along four uprights (3, 4, 5, 6) vertically (11,12,13,14), the bridge crane (15) is sliding horizontally (18) , and the operating head is sliding horizontally (19) .

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TITLE

METHOD AND DEVICE FOR BUILDING AUTOMATICALLY CONGLOMERATE STRUCTURES

Field of the invention

The present invention relates to building and, in particular to the automatic construction of buildings or other heavy constructions by a method and a device suitable for reducing the building time and for assisting its relative operations. The present invention is used also to build particularly articulated and complex structures.

Background of the invention

Many methods are known for making buildings, with different construction techniques and materials.

A well known technique uses concrete that is cast in a semi-fluid form in a formwork. With this technique volumes of concrete are obtained having the shape of the formwork used.

This technique has the drawback a complex work is required to obtain complex forms having convexities and concavities, mainly owing to the difficulty to provide formworks with shape complex and owing to the low resistance to pulling stresses of the concrete, which requires the use of steel reinforcements that must be folded to follow the shape of the formwork.

Another drawback is the cost of the manual work to make the formwork before casting the concrete and for removing the formworks after hardening.

A further drawback is the cost of the formwork material.

Another drawback of the method for construction with concrete is the waiting time necessary for hardening.

It is felt, then, the need of a method for making buildings, which is quick and not expensive, suitable for being carried out with an automatic method .

Summary of the invention

A feature of the present invention is therefore that to provide a method for making automatically buildings and other works in the building industry.

Another feature of the invention is to provide a method for making buildings obtained with volumes with even complex shape, comprising also concave or convex surfaces, and undercut portions of whichever form and size.

A further object is to provide a method suitable for providing structures resistant not only to compression, but even to pulling stresses.

Another feature of the invention is to provide an apparatus suitable for carrying out said method.

These and other objects are achieved by a method for building automatically conglomerate structures, characterized in that it comprises the steps of:

- CAD modelling a structure of building, in particular with a CAD function of surface modelling or of volume modelling, obtaining a computer file structure model;
- sectioning said computer file structure model with horizontal parallel planes according to a predetermined pitch, in order to generate a plurality of cross section planes of the structure comprising solid and empty areas, corresponding to the solid and empty parts of the structure, said planes being sorted from below towards the above;
- prearranging an apparatus suitable for depositing in alternation a layer of granular material and a liquid binder within containing walls that define a closed perimeter;
- moving said apparatus within said perimeter in

order to deposit a first uniform horizontal layer of granular inert material of thickness corresponding to said predetermined pitch;

- spraying a first layer of binder by said apparatus in order to reproduce a first plane of said cross section planes, forming a layer of inert material and of binder only at said solid areas, said apparatus having a operating head suitable for moving in a horizontal plane;
- raising vertically said apparatus according to said pitch;
- repeating the deposition step of granular inert material and repeating on it the binder spraying step as many times as are the horizontal cross sections of the structure, each time for a different and vertically next cross section plane up to complete the last layer;
- removing the inert material that has not been bond by the binder and that has accumulated within said perimeter, freeing a solid structure that repeats accurately said structure model.

In particular, said method provides a step of enveloping said structure or portion of it with a plurality of single volumes that envelope said structure.

In particular, said single volumes are selected from the group comprised of: parallelepipeds, cylinders, prisms, spheres or parts or combinations of them.

Advantageously, said single volumes have edges or vertical generatrix parallel to vertical sides of said structure and the horizontal edges parallel to the horizontal planes of said structure.

In a preferred exemplary embodiment said parallel and horizontal cross section planes are equidistant with respect to each other.

Advantageously, a CAM system is provided having graphical environment suitable for displaying said model structure file.

Always advantageously, said apparatus comprises an operating head piloted on said horizontal planes with independent motion or interpolated motion according to Cartesian or polar coordinates.

According to another aspect of the present invention, an apparatus for building automatically conglomerate structures is characterized in that it comprises:

- a closed perimeter defined by containing walls;
- a horizontal frame suitable for supporting a bridge crane capable of causing a operating head to move in a horizontal plane defined by said horizontal frame within said perimeter;
- means for actuating said operating head on said horizontal plane parallel to said bridge crane;
- a framework having at least one upright capable of supporting said horizontal frame;
- means for moving said horizontal frame in a vertical direction;
- a control unit suitable for controlling the succession of operations up to completion of said structure;
- wherein said containing walls are capable to contain said inert material in a working area larger than said conglomerate structure.

In a preferred exemplary embodiment said containing walls are vertical and define a parallelepiped or cylindrical volume on said working area.

Advantageously, a covering is provided for roofing said containing walls.

In particular, said covering is capable of stopping hermetically said volume so that a vacuum can be created inside.

Advantageously, said operating head comprises:

- at least one binder spraying nozzle operated by a controlled electro valve;
- a premixing head;
- a feeding pump;
- a reservoir;
- a washing system.

In a preferred exemplary embodiment, said operating head comprises a volumetric doser for supplying said operating head with a known amount of inert material for each stroke.

Advantageously, said operating head comprises a blade that is adapted to slide on the deposited inert material to uniform it in order to achieve a predetermined thickness, on the whole working area.

In particular, said resin is selected from the group comprised of:

- epoxy resins;
- cross linking polyurethane.

Advantageously, said resin has a viscosity set between 3 and 10 poises, and preferably between 6 and 8 poises, and is adapted to be fluid enough to penetrate between the granules of the granular material for a height corresponding to said pitch, thus reaching the layer of granular material bonded in the previous step.

In particular, said granular material has a granulometry set between 0,1 and 2 mm, and preferably between 0,5 and 1,5 mm. This way the granular material has a value of maximum effective porosity adapted to cause said binder to penetrate between the deposited granules up to reaching the layer already sprayed in the previous cycle.

Brief description of the drawings

The invention will be made clearer with the description of some of its exemplary embodiments, exemplifying but not limitative, with reference to the attached drawings wherein:

- Figure 1 shows an apparatus for building automatically conglomerate structures according to the present invention, comprising a horizontal frame sliding vertically on which a bridge crane is slidingly engaged that supports a operating head;
- Figure 2 shows an end portion of said bridge crane;
- Figures 3 and 4 show respectively a perspective view and a front view of an apparatus according to the invention and figure 5 shows a view of the operating head, relative to a first operative deposition step of an amount of granular material;
- Figures 6, 7 and 8 show the apparatus according to the invention, during a step of spreading the granular material along the exposed surface of the previously deposited layer;
- Figures 9, 10 and 11 show the apparatus at the end of a stroke of spreading the binder;
- Figures 12, 13 and 14 show the apparatus during a back stroke when the operating head sprays a binder on the layer of granular material just deposited only on the solid areas of a cross section;
- Figures 15, 16 and 17 show the final part of the spraying stroke;
- Figures 18, 19 and 20 show the repetition of the first step with a further deposition of an amount of granular material.
- Figures 21 and 22 show respectively a perspective view and an elevational view of the final steps of

completion of the building.

- Figure 23 shows a cross sectional view of a portion of a structure comprising two layers of granular material 61 and 62 deposited in two successive steps.

Description of the preferred exemplary embodiment

In the following description an example will be shown of an embodiment of an apparatus that carries out the method according to the invention.

In particular, in figure 1 an apparatus is described according to the invention suitable for making automatically conglomerate structures of buildings. it comprises a framework having four uprights 3, 4, 5, 6 capable of supporting a horizontal frame 1 movable vertically along such uprights.

Horizontal frame 1, with closed shape has at least two parallel sides 2 for slidingly engaging with two ends of a bridge crane 15 which holds an operating head 16.

Altogether, operating head 16 moves along arrow 19 perpendicular to the sliding direction 18 of bridge crane 15 and frame 1 can move vertically along arrows 11, 12, 13, 14.

In figure 2 an end portion of bridge crane 15 is shown more in detail. The bridge crane structure 15 comprises a beam 21, having at each end a couple of wheels 23 that engage with the inner part of the beams 2 of figure 1. A guide 20 is provided integral and parallel to beam 21 that slidingly holds a slide 24 of operating head 16, which is capable of spraying a liquid binder on a just deposited layer of granular material. Beam 21 supports a hopper 17 with elongated shape, which extends along the length of beam 21 and is adapted to deposit a predetermined amount of granular material at one end of the depositing plane. Along beam 21 a blade is arranged for spreading the granular material just deposited by the above described hopper 17.

Figures 3 and 4 show respectively a perspective view and a front view of an apparatus according to the invention and figure 5 is a view of operating head 16, relative to a first operative deposition step of an amount of granular material, in which frame 1 is at the position of zero (ground level), bridge crane 15 is in its first stop position and operating head 16 is in its first stop position.

The apparatus comprises four containing walls 31 that define a volume that is going to be filled with granular material following the method according to the invention.

Figures 6, 7 and 8 show the apparatus according to the invention, during a step of spreading the granular material along the exposed surface of the previously deposited layer. In this step bridge crane 15 moves towards its second limit stop, distributing and leveling the granular material deposited in the previous step, by blade 22.

Figures 9, 10 and 11 show the apparatus at the end of the previous step. Frame 1 is still at ground level, bridge crane 15 has achieved its second limit stop and is still, while operating head 16 is still at its first limit stop.

Figures 12, 13 and 14 show the apparatus in a step of back stroke when operating head 16 sprays the binder on the layer of granular material only at the solid areas of the calculated cross section. In this step frame 1 is still at the zero level, bridge crane 15 moves back and operating head 16 sprays the binder and moves along its sliding axis.

Figures 15, 16 and 17 show the apparatus at the end of the spraying step, when frame 1 is still at ground level, bridge crane 15 and operating head 16 have moved back to their first limit stop. In this position, the doser 40 of bridge crane 15 is filled with an amount of granular material to be deposited in the next step.

Figures 18, 19 and 20 show the repetition of the previous steps, in particular of the first step, on a second distribution level reached by raising frame 1 for a height equal to the pitch. In this step the amount of granular material stored in the previous step is deposited by doser 40. When frame 1 is stepped up, bridge crane 15 and operating head 16 are at the respective first limit stops.

In figure 21 the apparatus is carrying out its last step before completion of the conglomerate structure.

In figure 22 the structure of building 50 has been completed. The next steps are the evacuation of the granular material not cemented by the binder, thus leaving the cemented part and then the structure, and removing the containing walls and then the apparatus.

Figure 23 shows a cross sectional view of a portion of structure comprising two layers of granular material 61 and 62 deposited in two successive steps. The resin is selected from the group comprised of epoxy resin and cross linking polyurethane; it has a viscosity set between 3 and 10 poises, and preferably between 6 and 8 poises, and is adapted to be fluid enough to penetrate between the granules of the granular material for a height corresponding to pitch 68, thus achieving the layer 64 of granular material previously formed.

In particular, said granular material has a granulometry set between 0,1 and 2 mm, and preferably between 0,5 and 1,5 mm; this way the granular material has a maximum effective porosity adapted to cause said binder to penetrate between the deposited granules up to reaching the layer already sprayed in the previous cycle.

The foregoing description of specific embodiments will so fully reveal the invention according to the conceptual point of view, so that others, by applying current knowledge, will be able to modify and/or adapt for various applications such embodiments without further research and without departing from the invention, and it is therefore to be understood that such adaptations and modifications will have to be considered as equivalent to the specific embodiments. The means and the materials to realise the different functions described herein could have a different nature without, for this reason, departing from the field of the invention. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

CLAIMS

1. A method for building automatically conglomerate structures, characterized in that it comprises the steps of:

- CAD modelling a structure of building, in particular with a CAD function of surface modelling or of volume modelling, obtaining a computer file structure model;
- sectioning said computer file structure model with horizontal parallel planes, in particular planes that are equidistant according to a predetermined pitch, in order to generate a plurality of cross section planes of the structure comprising solid and empty areas, corresponding to the solid and empty parts of the structure, said planes being sorted from below towards the above;
- prearranging, within containing walls that define a closed perimeter, an apparatus suitable for depositing in alternation a layer of granular material and a liquid binder.
- moving said apparatus within said perimeter in order to deposit a first uniform horizontal layer of granular inert material of thickness corresponding to said predetermined pitch;
- spraying a first layer of binder by said apparatus in order to reproduce a first plane of said cross section planes, forming a layer of inert material and of binder only at said solid areas, said apparatus having an operating head suitable for moving in a horizontal plane;
- raising vertically said apparatus according to said pitch;
- repeating the deposition step of granular inert material and repeating on it the binder spraying

step as many times as are the horizontal cross sections of the structure, each time for a different and vertically next cross section plane, up to complete the last layer;

- removing the inert material that has not been bond by the binder and that has accumulated within said perimeter, freeing a solid structure that repeats accurately said structure model.

2. Method according to claim 1, wherein said step of modelling provides a step of enveloping said structure or a portion of it with a plurality of elementary volumes, and, in particular said single volumes are selected from the group comprised of: parallelepipeds, cylinders, prisms, spheres or parts or combinations of them.

3. Method according to claim 1, wherein said single volumes have vertical edges or vertical generatrix parallel to vertical sides of said structure and have horizontal edges parallel to the horizontal planes of said structure.

4. Method according to claim 1, wherein said apparatus comprises an operating head piloted on said horizontal plane with independent motion or interpolated motion according to Cartesian or polar coordinates.

5. Method according to claim 1, wherein said resin is selected from the group comprised of:

- epoxy resins;
- cross linking polyurethane.

6. Method according to claim 1, wherein said resin has a viscosity set between 3 and 10 poises, and preferably between 6 and 8 poises, and is adapted to be fluid enough to penetrate between the granules of the granular material for a height corresponding to said pitch thus achieving the layer of granular material previously formed.

7. Method according to claim 1, wherein said granular material has a granulometry of value set between 0,1 and 2 mm, and preferably between 0,5 and 1,5 mm whereby it has a value of maximum effective porosity adapted to cause said binder to penetrate between the deposited granules up to reaching the layer already sprayed in the previous cycle.

8. An apparatus for building automatically conglomerate structures, **characterized in that** it comprises:

- a closed perimeter defined by containing walls;
- a horizontal frame suitable for supporting a bridge crane capable of causing an operating head to move in a horizontal plane defined by said horizontal frame within said perimeter;
- means for actuating said operating head on said horizontal plane parallel to said bridge crane;
- a framework having at least one upright capable of supporting said horizontal frame;
- means for moving said horizontal frame in a vertical direction;
- a control unit suitable for controlling the succession of operations up to completion of said structure;
- wherein said containing walls are capable to contain said inert material in a working area larger than said conglomerate structure.

9. Apparatus according to claim 8, wherein said operating head comprises a blade that is adapted to slide on the deposited inert material to uniform it in order to achieve a predetermined thickness, on the whole working area.

10. Apparatus according to claim 8, wherein said containing walls are vertical and define a parallelepiped or cylindrical volume on said working area.

11. Apparatus according to claim 8, where a covering is provided for roofing said containing walls.

12. Apparatus according to claim 11, wherein said covering is capable of stopping hermetically said volume so that a vacuum can be created inside.

13. Apparatus according to claim 8, wherein said operating head comprises:

- at least one binder spraying nozzle operated by a controlled electro valve;
- a premixing head;
- a feeding pump;
- a reservoir;
- a washing system.

14. Apparatus according to claim 8, wherein said operating head comprises a volumetric doser for supplying said operating head with a known amount of inert material for each stroke.

Fig. 1

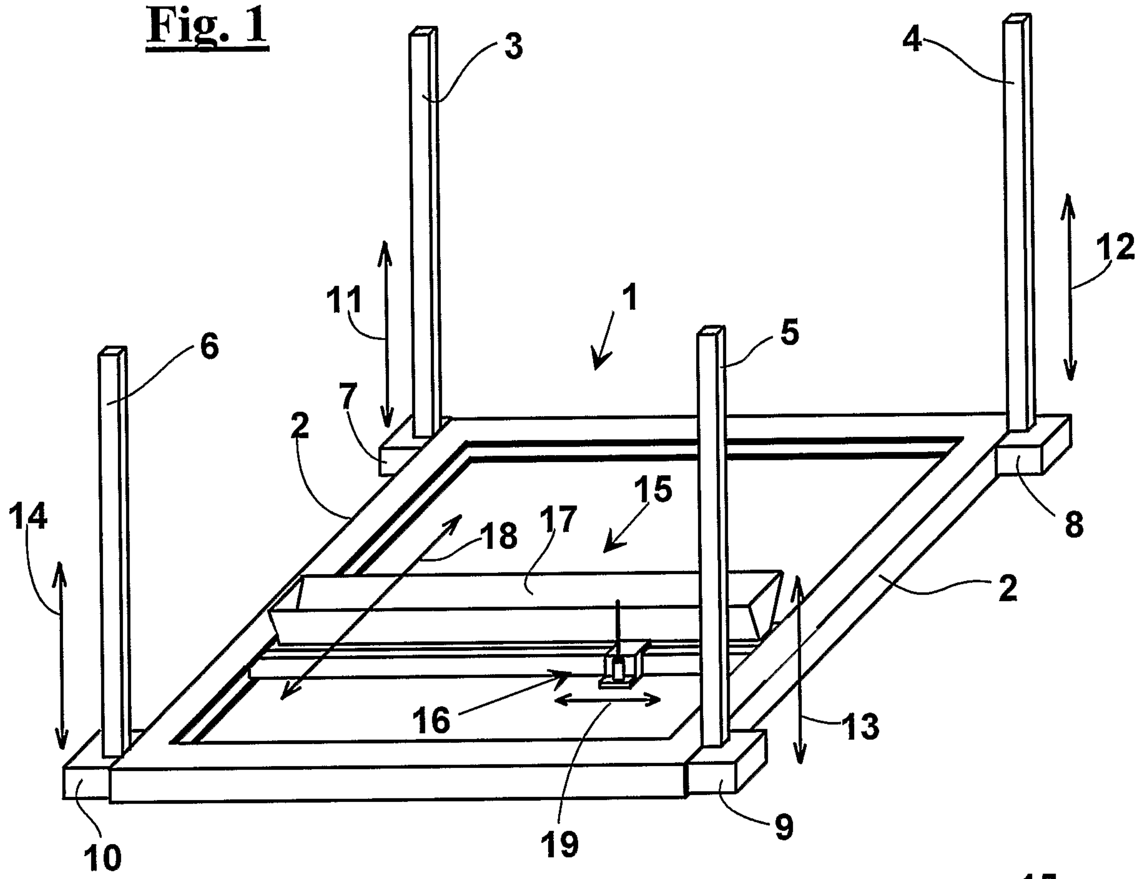
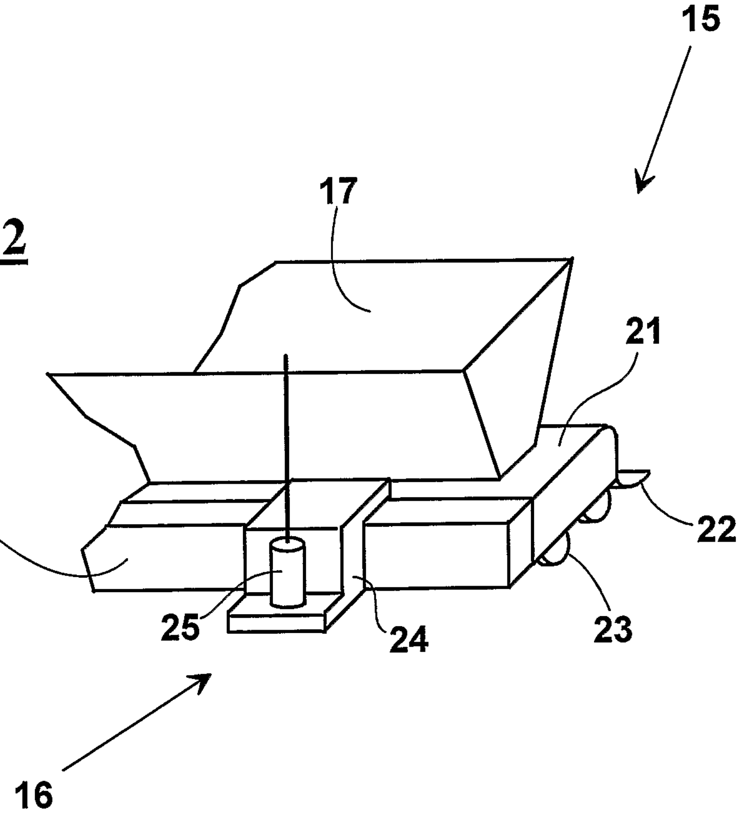


Fig. 2



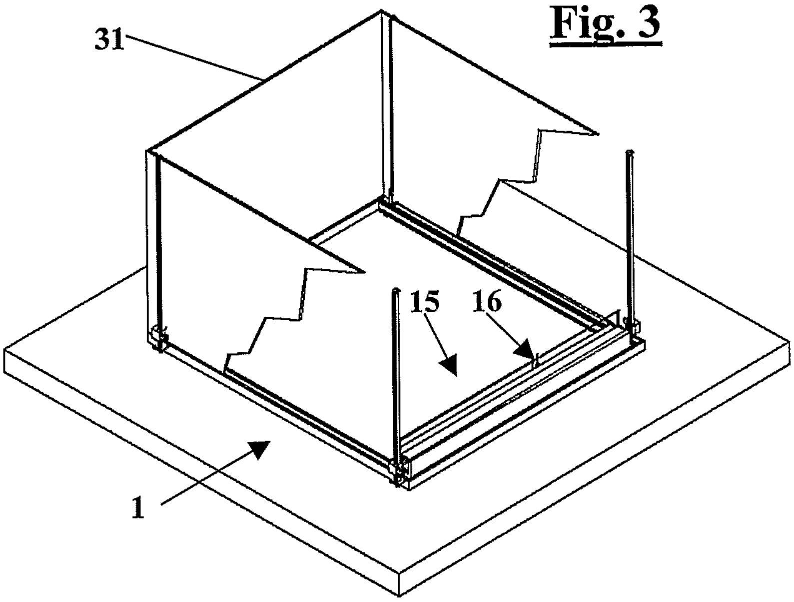


Fig. 3

Fig. 4

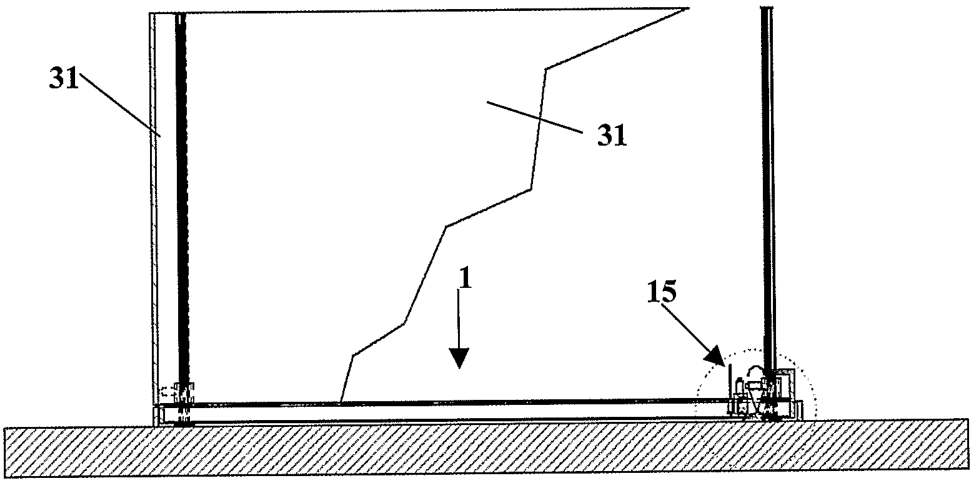


Fig. 5

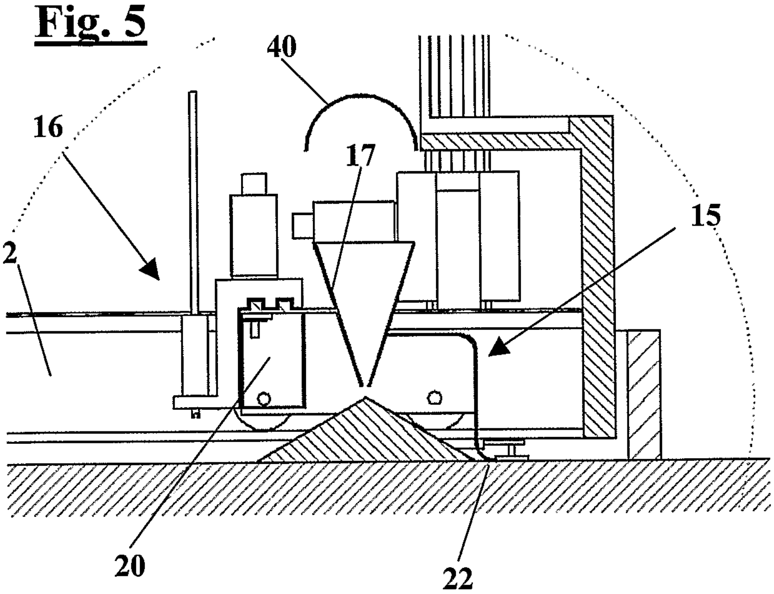


Fig. 6

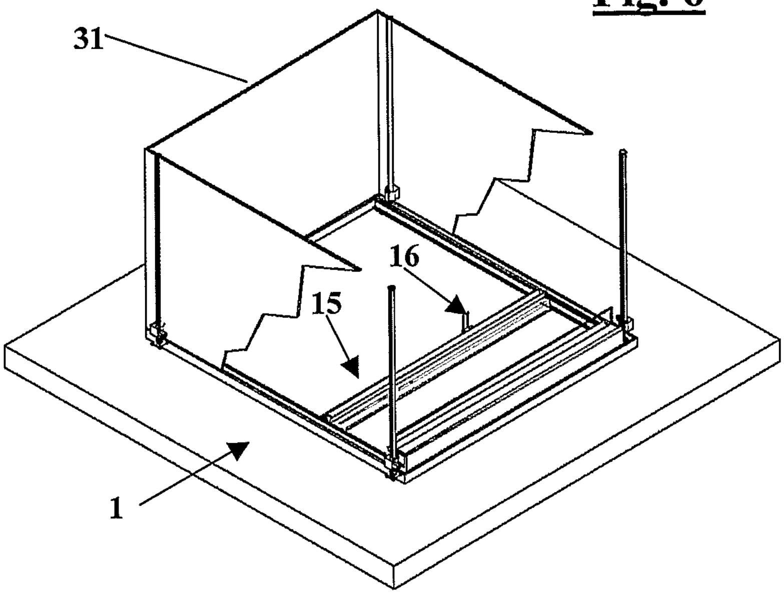
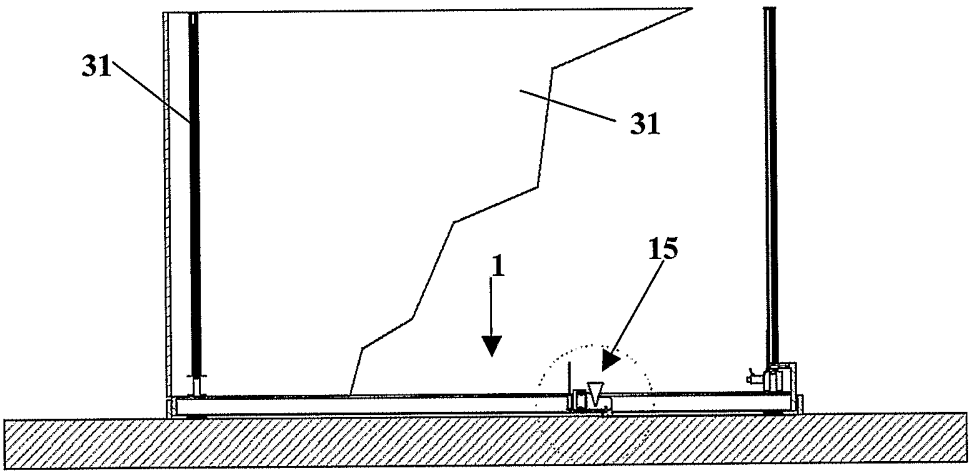


Fig. 7



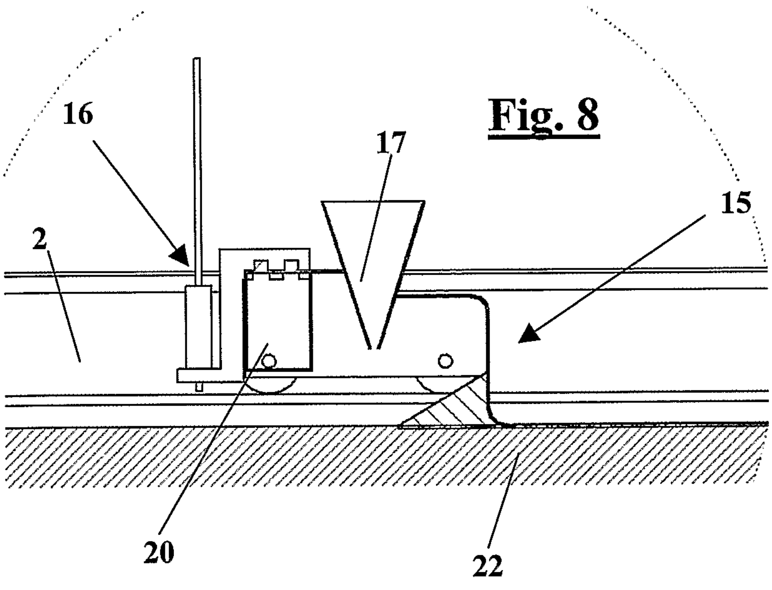


Fig. 8

Fig. 9

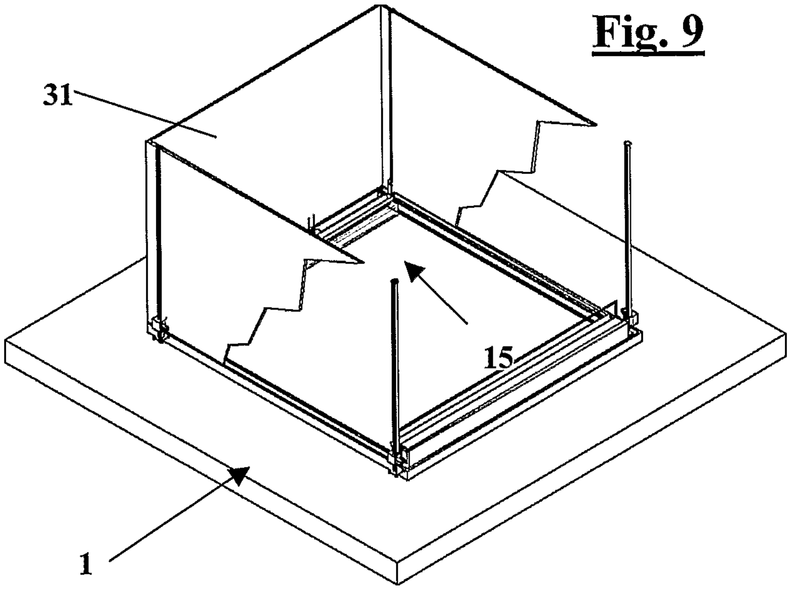


Fig. 10

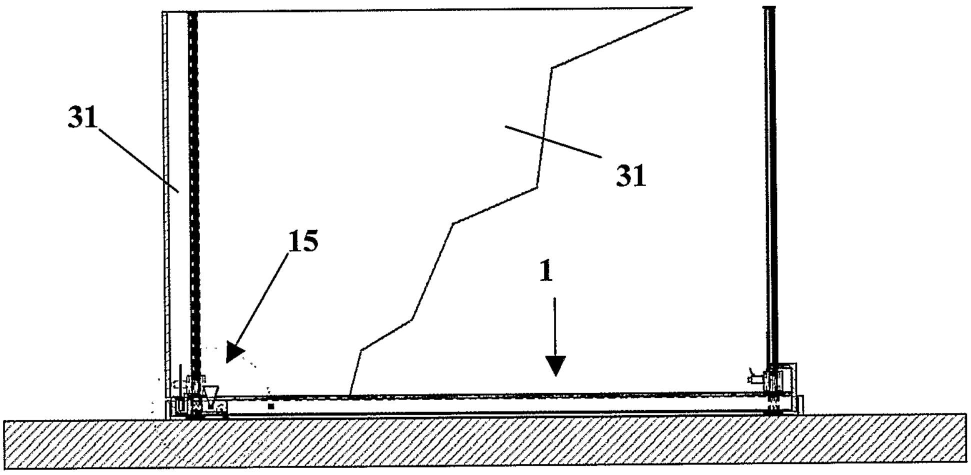


Fig. 11

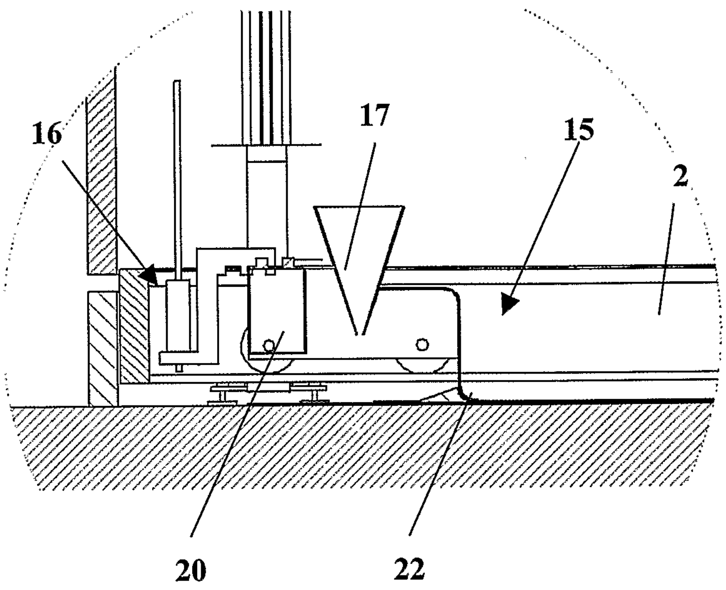


Fig. 12

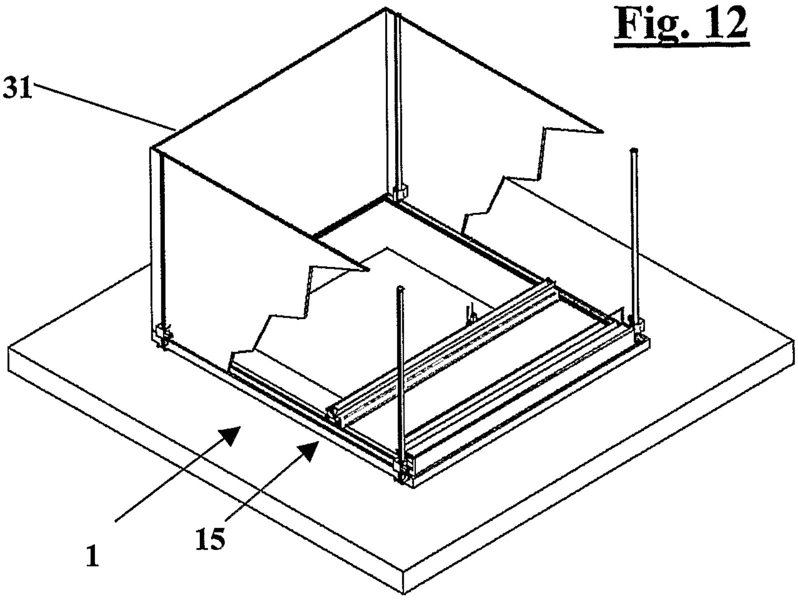


Fig. 13

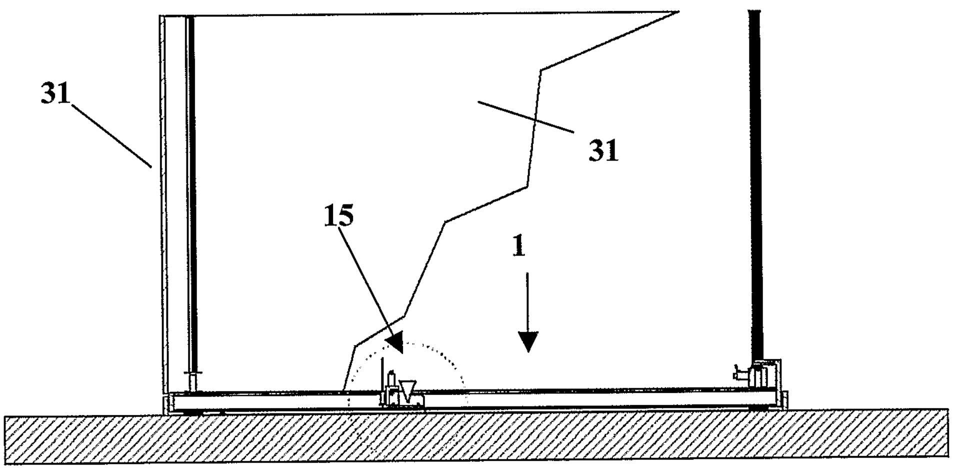
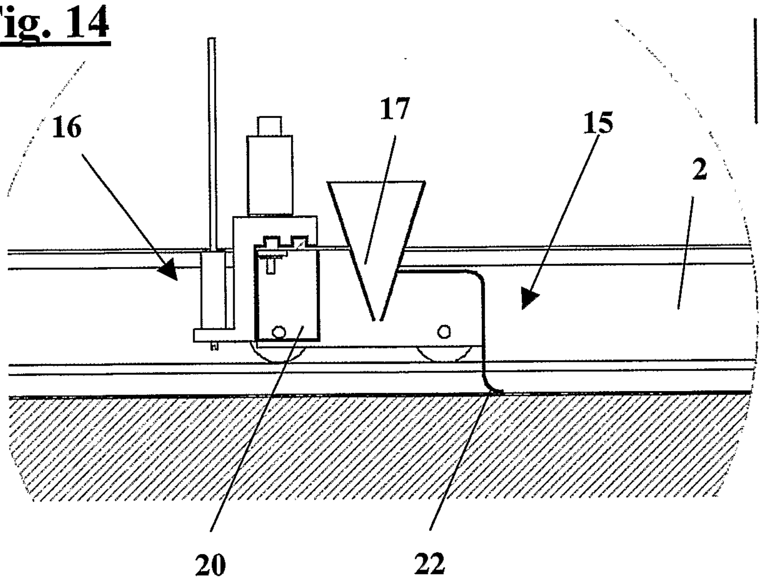


Fig. 14



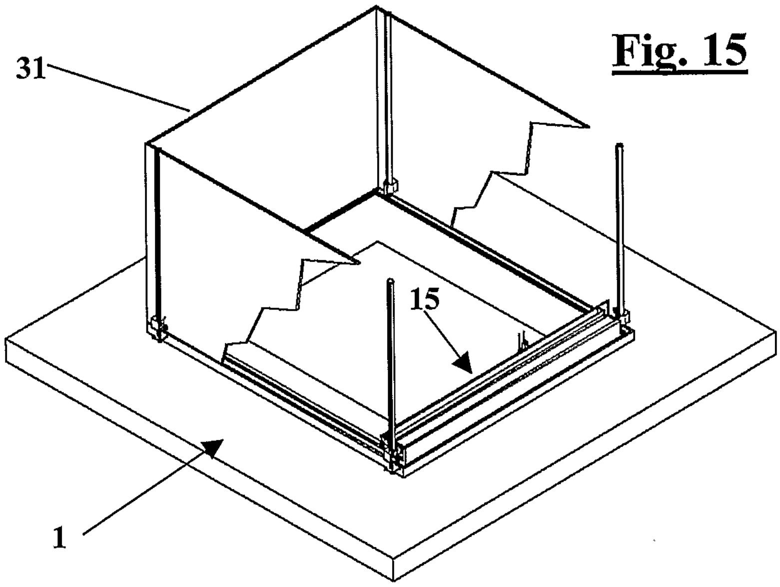


Fig. 15

Fig. 16

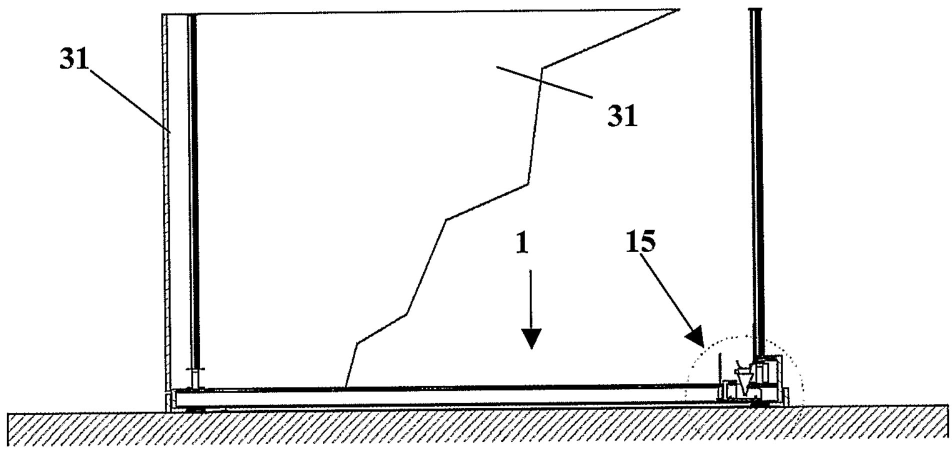
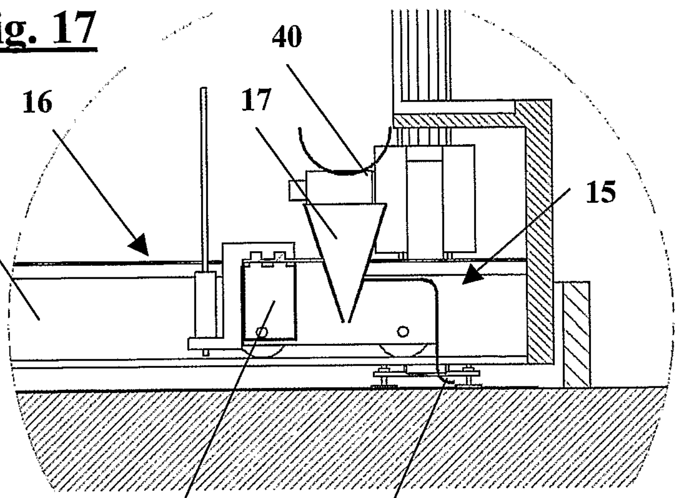


Fig. 17



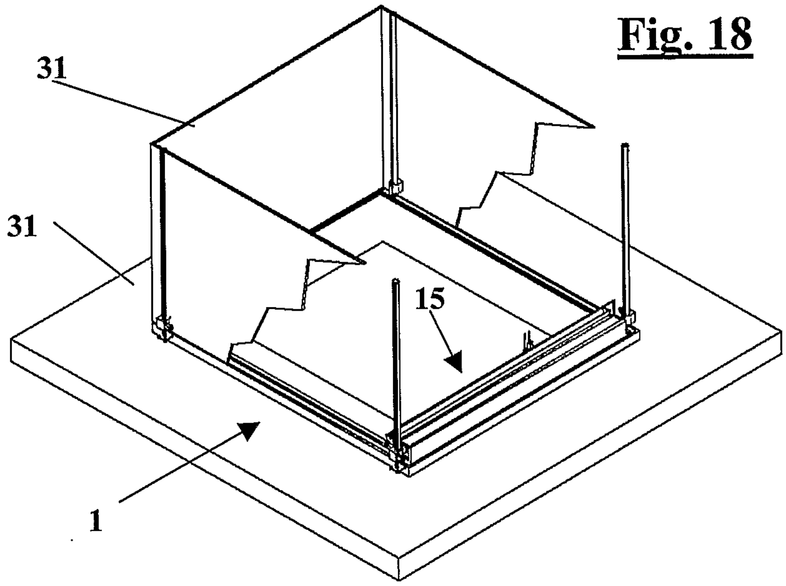


Fig. 18

Fig. 19

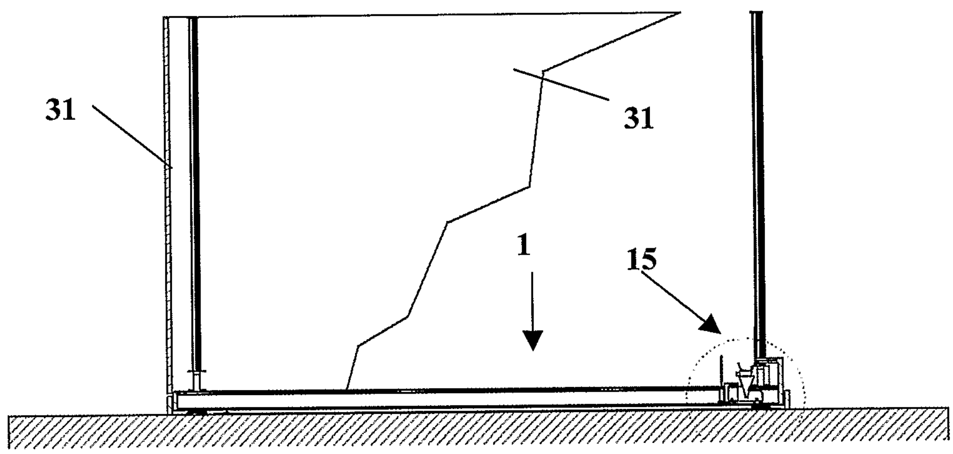


Fig. 20

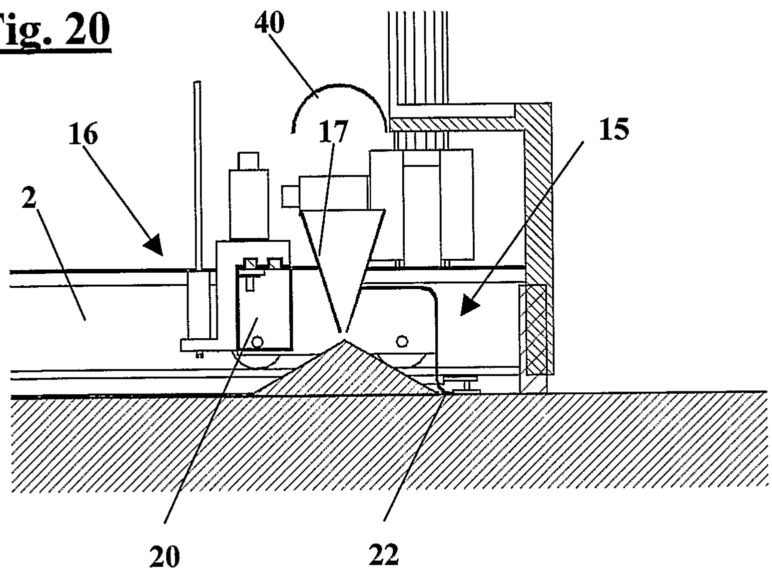


Fig. 21

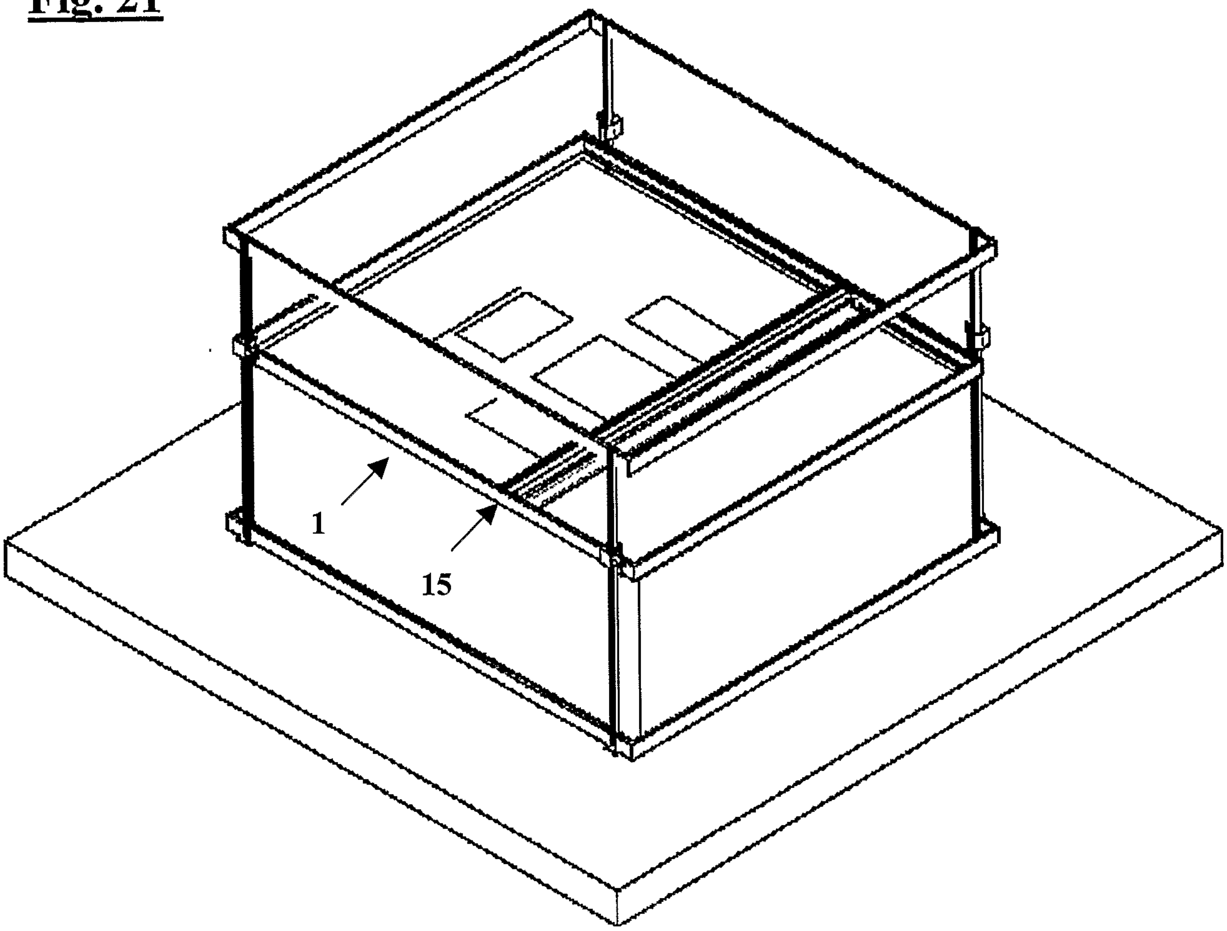


Fig. 22

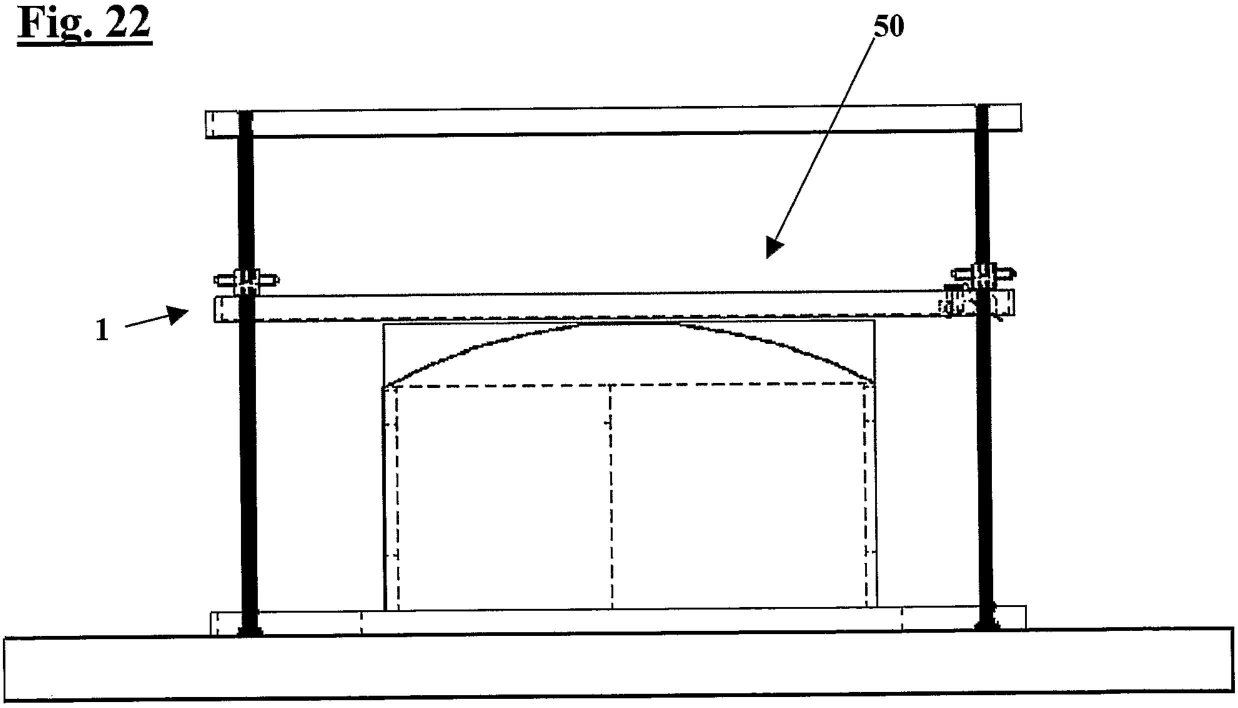


Fig. 23