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(54) **Title**: A BUILDING STRUCTURE

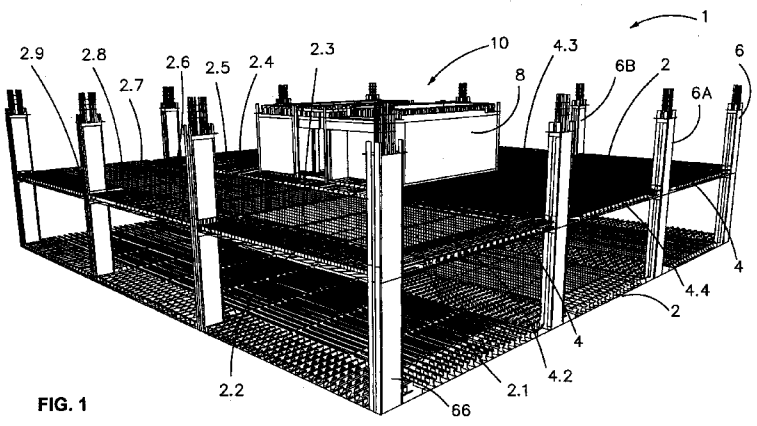


FIG. 1

(57) **Abstract**: The present invention relates to the construction of buildings as well as elements, structures and methods used in their construction. There is described a pre-fabricated formwork module (12) for a building portion. The module 12 includes two or more panels (14) each including a boundary portion (18) and one or more projecting structures (16). In the module (12) the panels are arranged such that their boundary portions (18) together define a first substantially continuous boundary for forming concrete and the projecting structures (18) project from the boundary into the concrete. The module (12) also include one or more reinforcing bars (30A) fixed, e.g. fixed to the projecting structures, in position relative to the boundary for transport and to reinforce the concrete.

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A Building Structure

Field of the invention

The present invention relates to the construction of concrete buildings as well as elements, structures and methods used in their construction. The invention will be described in relation to the construction of high rise buildings. However, single storey and low rise buildings can also be constructed using aspects of the present invention.

Background of the invention

Buildings having concrete elements are constructed using formwork to create a temporary or permanent cast into which the concrete to form the structure of the building is poured. Temporary formwork is removed after curing of the concrete, whilst permanent formwork remains as part of the structure of the building after the concrete has cured. Current methods of providing concrete formwork are very labour intensive and potentially dangerous for workers.

Traditionally, timber formwork has been used. Timber formwork is built on site by a carpenter who uses timber to create a mould into which concrete can be formed. Typically plywood boards are used to define the sides and bottom of the moulds, and more solid timber frames and bracing used to hold the plywood in place. The use of timber for formwork has certain disadvantages, e.g. timber formwork is only able to be re-used a very limited number of times, it also has the inherent dimensional and structural irregularities associated with a natural product. Moreover, because the formwork is manually installed on-site, tolerances for installation are relatively loose.

Conventional timber formwork for a vertical wall will typically consist of a pair of boards spaced apart by the thickness of the wall to be created. The boards define the opposite surfaces of the wall. The boards are supported and braced on their external sides by timber beams and other bracing to hold them in place. The boards are also tied to each other at intervals to hold the walls of the formwork from moving apart under the pressure of the concrete being poured into the formwork. The ties can be located along the edges of the board or be placed such that they project through the wall of the board to the opposite facing board.

For horizontal structures, such as a floor, the underside of the floor is defined by one or more sheets of timber (eg. made from plywood) that are supported on timber beams. For elevated floors a temporary support structure needs to be erected before the floor of the formwork can be

installed. Such installation is very time consuming and potentially hazardous, particularly when the workers are installing timber panels on the bottom of the formwork section for horizontally extending structures like floors or beams onto the support beams.

Around the edges of the timber floor, walls are erected to define a volume into which concrete will be poured. Prior to pouring concrete however, many other elements need to be laid into the formwork so that they can be cast into the concrete. Chief among these are reinforcing bars and conduits for post tensioning tendons, apertures and connections for plumbing and other services.

The placement of each of these additional elements is performed onsite after the formation of the formwork, with each additional job becoming progressively more difficult and hazardous for workers as the working area becomes more cluttered with other elements. For example, in order to install plumbing connections in a floor it may be necessary for the installer to place components between many layers of reinforcing steel or other elements of the building. These elements will also need to be carried or manoeuvred across a surface of the formwork that is criss-crossed by reinforcing bars, associated ligatures holding the steel together and other elements.

After the concrete has cured the temporary formwork then needs to be removed. This is also time consuming and potentially dangerous. In this case workers are removing supports, and structures positioned above their heads.

More recently modular temporary formwork systems have been devised. These include panels which have a frame, typically of metal, for providing structural strength. The panel surface defines the inside of the concrete mould. These systems include, corner modules, flat panels etc and the desired formwork shape can be made by joining these together. These systems can be quicker to place than conventional timber formwork because they can be clipped or bolted together and are typically able to be used many times more than conventional timber formwork, but in other respects have similar drawbacks.

One way of partly avoiding work associated with temporary formwork is the use of permanent formwork. For example steel panels can replace the floor of the formwork on horizontal surfaces. These panels are positioned in a very similar manner to that of the timber floor panels of conventional timber formwork but need not be removed afterward as they are formed into the

underside of the concrete which they have been used to create. However, in other respects these systems are similar to conventional timber formwork.

There also exists framing systems used for creating vertical walls such as the AFS system, which comprises a series of vertically extending studs to which cement sheet is attached on each side to define a wall cavity. These wall structures can be used as-is or filled with concrete to create a structural wall. If they are used as formwork the panels are first erected on site and braced. If reinforcing is needed, reinforcing bars are then inserted into the internal cavity as required. Services can be inserted through the wall before the concrete is finally poured. They can then be finished as required.

One way of ameliorating the complexity, cost and risk of using formwork as described above is to precast the concrete elements off site, but this is only viable in certain situations.

Accordingly, it is an object of the present invention to address one or more of the drawbacks of the prior art systems and/or provide a useful alternative to them.

It is not admitted that any of the information in this specification is common general knowledge, or that the person skilled in the art could be reasonably expected to have ascertained or understood it regarded it as relevant or combined it in any way at the priority date.

Summary of the invention

The present inventor has realised that structures similar to those described in the applicant's previous patent applications can be used as permanent formwork in the construction of concrete structures. For example, formwork modules for a building core, room or structure can be formed from elements similar in construction to the building units described in PCT/AU2009/001236 in the name of the Applicant. Moreover particular advantages can also be obtained if prefabricated formwork modules, e.g. formwork modules for floors, beams, band beams, walls and cores, include panel assemblies similar to that described in International patent application PCT/AU2011/000298.

Accordingly in its various aspects the invention provides buildings and building portions and various components and methods for building buildings.

One aspect of the present invention provides a pre-fabricated formwork module for a building portion, the module including:

two or more panels each including a boundary portion and one or more projecting structures, the panels being arranged such that their boundary portions together define a first substantially continuous boundary for forming concrete, the projecting structures projecting from the boundary to project into the concrete; and

one or more reinforcing bars fixed, e.g. fixed to the projecting structures, in position relative to the boundary for transport and to reinforce the concrete.

The projecting structures preferably include one or more receiving voids opening outwardly from the first boundary to receive one or more reinforcing bars. The projecting structures defining the receiving voids may be shaped to carry a reinforcing bar at a predetermined spacing from the boundary, or more preferably to carry at least two reinforcing bars at, at least two, different predetermined spacings from the first boundary.

Preferred forms of the module further include a retaining structure to capture the reinforcing bars in the receiving voids. The retaining structure preferably includes a plurality of apertures which in use contact the projecting structures of respective panels and through which the retaining structure is welded to the projecting structures. The retaining structure, or further structure, preferably defines a second substantially continuous boundary, for forming concrete, spaced from the first boundary.

The receiving voids are shaped such that the panels may be formed from blanks cut from a common sheet of material, said blanks being arranged on the sheet such that at least one projecting structure portion of one blank is interleaved with a similar projecting structure of a neighbouring blank and located within the receiving voids of the other blank.

The module may further include two or more spaced beam members supporting the panels.

The beams members preferably have a profiled cross section including face which is arranged to form the concrete. The profile can be, but is not limited to, an L, C or S or Z shaped profile.

Preferably at least a portion of each projecting structure spans the space between the beam members. The projecting structures can (but are not limited to having) an L, C, S or Z shaped profile.

The projecting structures may include apertures carrying the reinforcing bars. Optionally each projecting structure terminates in a hook formation for keying into the concrete. The projecting structures may further include concrete flow apertures through which the concrete may encircle a portion of the projecting structure to engage the projecting structure.

Preferably each projecting structure defines a supporting structure carrying a reinforcing bar. Optionally the supporting structure includes a channel.

Another aspect of the invention provides a pre-fabricated formwork module for a building portion; the module including:

a form defining a substantially continuous boundary for forming concrete; and

one or more projecting structures;

the projecting structures projecting from the boundary to project into the concrete and defining a supporting structure carrying a reinforcing bar.

The supporting structure may include a channel. Preferably the supporting structure and the reinforcing bar carried thereby are positioned to reinforce a lower stratum of the concrete.

Another aspect of the invention provides a floor including one or more of the modules and concrete. In floors including modules having projecting structures, the boundary portions may be positioned horizontally so that the projecting structures project upwardly and the concrete may cover an upper extent of the projecting structures.

Another aspect of the invention provides a wall including one or more of the modules and concrete there between. In walls including modules having projecting structures, the projecting structures may each be connected to a respective projecting structure of the other module to tie the modules to each other.

Another aspect of the invention provides a pre-fabricated formwork module for a building portion, the module including

one or more forms defining a void for forming concrete; and

locating structure by which the module may be located relative to a vertically adjacent like or similar module.

Optionally the locating structure includes a locating element including an engagement portion by which it is fixed relative to the forms, and a lead-in portion to locate the vertically adjacent like or similar module. Preferably the forms are complementary to the forms of the like module when mounted atop the like module. The module may further include an inner form and an outer form. The outer form may at least partly encircle the inner form to define the void about the inner form, in which case, each of the forms might be tubular whereby said defined void is tubular.

A portion of one the forms may project upwardly beyond another portion of the forms to form an inner edge of a concrete structure above the other form portion.

Another aspect of the invention provides a locating element including, an engagement portion configured to engage with a formwork module in use; and a lead-in portion to locate a vertically adjacent like or similar module in use.

The engagement portion can include, a flange insertable to engage a formwork module; and a stop portion to limit the insertion of the flange. The lead-in portion and the stop portion can form respective sides of a triangular portion. The triangular portion may be tubular.

The module preferably includes one or more reinforcing bars fixed in position relative to the forms for transport and to reinforce the concrete.

At least one of the forms may include two or more panels. Each panel may include a boundary portion and one or more of the projecting structures. Each panel is preferably at least predominantly integrally formed of sheet material. Most preferably the panels within each form are arranged such that their boundary portions together define a substantially continuous boundary for forming the concrete.

Each panel may include an edge portion of the sheet material deflected relative to the boundary portion to form a projecting structure projecting from the boundary to project into the concrete.

A region adjacent the deflected edge portion may be recessed relative to a presentation surface of the sheet to receive an edge portion of a like adjacent panel opposite the adjacent panel's deflected edge whereby the presentation surfaces of the adjacent panels substantially align.

The receiving voids can be shaped for the panels to be formed from interleaved blanks. Portions of the projecting structures defining the receiving voids can be shaped to carry a reinforcing bar at a predetermined spacing from the boundary. The portions of the projecting structures defining the receiving voids can be shaped to carry at least two reinforcing bars at, at least two different predetermined spacings from the boundary.

Each projecting structure can define a supporting structure carrying a reinforcing bar. The supporting structure can includes a channel.

Another aspect of the invention provides a building portion including the module with locating structure and concrete.

Another aspect of the invention provides a panel for a building portion; the panel including:

a boundary portion for forming concrete, and

projecting structure projecting from the boundary portion to project into the concrete and including apertures for receiving reinforcing bars; and

being at least predominantly integrally formed of sheet material.

Each projecting structure may terminate in a hook formation for keying into the concrete.

An edge portion of the sheet material may be deflected relative to the boundary portion to form the projecting structure. A region adjacent the deflected edge portion may be recessed relative to a presentation surface of the sheet to receive an edge portion of a like adjacent panel opposite the adjacent panel's deflected edge whereby the presentation surfaces of the adjacent panels substantially align.

The projecting structures preferably include concrete flow apertures through which the concrete may encircle a portion of the projecting structure to engage the projecting structure.

Another aspect of the invention provides an assembly including two or more of the panels arranged such that their boundary portions together define a substantially continuous boundary for forming the concrete.

Another aspect of the invention provides a beam for a building including one or more forms for forming concrete and concrete formed by the forms. The beam may include, and at least one of the forms be the form of, the module with reinforcing bar(s).

Another aspect of the invention provides a panel for a building portion; the panel including:

a boundary portion for forming concrete, and

one or more projecting structures projecting from the boundary portion to project into the concrete and defining one or more receiving voids opening outwardly from the boundary to receive one or more reinforcing bars.

In some examples the projecting structure(s) can be shaped so as to allow the boundary to be folded transverse to the projecting structures of the panel. To allow this, the projecting structure(s) can have notches therein. The panels (either before or after joining to a neighbouring panel) can be folded through the notches to create a recess within the panel, for example a channel shaped recess.

Another aspect of the invention provides a building portion including,

one or more panels and concrete formed by the panels;

each panel including

a boundary portion; and

projecting structure projecting from the boundary portion into the concrete.

Another aspect of the invention provides a pre-fabricated module for a wall; the module including

two spaced forms each defining a respective boundary of a void for forming concrete;

each form including one or more projecting structures projecting from the boundary into the void;

wherein the projecting structures are each connected to a respective projecting structure of the other form to tie the forms.

Another aspect of the invention provides a method of building a building portion including: installing one or more of the above modules at a building site to create at least part of a concrete formwork structure; filling the concrete formwork structure with wet concrete; allowing the concrete to cure. Another aspect of the invention provides a method of building a building portion including; installing the module with locating structure at a building site to provide a formwork structure for at least part of a building; filling the concrete formwork structure with wet concrete; installing a like module atop the module.

Preferably the concrete is allowed to at least partially cure to strengthen the building portion before installing the like module. Optionally, the module may be left in place to protect the cured concrete during the life of the building.

Another aspect the invention provides a pre-fabricated formwork module for a building portion; the module including: a form defining a substantially continuous boundary for forming concrete; and one or more reinforcing bars fixed in position relative to the form for transport and to reinforce the concrete.

The pre-fabricated formwork module preferably includes one or more projecting structures, projecting from the boundary to project into the concrete and defining a supporting structure carrying a reinforcing bar.

In a further aspect there is provided a pre-fabricated module for a wall; the module including, two spaced forms each defining a respective boundary of a void for forming concrete; at least one of the forms including one or more projecting structures projecting from the boundary into the void; wherein at least some of the projecting structures are connected to the other form to tie the forms.

The various aspects on the invention are complementary. It will be appreciate that each aspect may incorporate features described in respect of one or more of the other aspects.

As used herein, except where the context requires otherwise, the term "comprise" and variations of the term, such as "comprising", "comprises" and "comprised", are not intended to exclude further additives, components, integers or steps.

Brief description of the drawings

Preferred embodiments of the present invention will now be described by way of non-limiting example only, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a partially constructed building;

Figure 2 is a plan view of the partially constructed building of figure 1;

Figure 3 is a perspective cut away view of various portions of the building of figures 1 and 2;

Figure 4 is an exploded view of a column;

Figure 5 is a cross section view of a column;

Figure 6 is a perspective view of a pre-fabricated module for forming a floor;

Figure 7 is a perspective view of a pre-fabricated module for forming a band beam;

Figure 8A is a section view of a panel;

Figure 8B is a perspective view of an assembly of panels;

Figure 9 is a close up view of detail A from figure 8A;

Figure 10 is a close up perspective view of a portion of the building of figure 1;

Figure 11 is a longitudinal cross section view of a floor;

Figure 12 is a transverse cross section view of the floor of figure 11;

Figure 13 is a longitudinal cross section view of a band beam;

Figure 14 is a transverse cross section view of the beam of figure 13;

Figure 15 is an exploded view of a module for forming a building core;

Figure 16 is a plan view of the module of figure 15;

Figure 17 is a plan view of another module for forming a building core;

Figure 18 is a close up view of detail B of figure 16;

Figure 18B is a close up view of detail 18B of figure 18;

Figure 19 is a perspective view of a portion of the building of figure 1; and

Figure 20 is a close up perspective view of a portion of a module for forming a building core;

Figures 21 to 31 illustrate a series of steps in the assembly of a formwork module for a building core according to a further embodiment of the present invention;

Figures 32A through 32D show a sequence of steps in forming a panel according to an embodiment of the present invention from a flat sheet;

Figure 33 illustrates one arrangement of reinforcing steel in an alternative corner arrangement to that of Figures 21 to 31;

Figures 34A to 34D illustrate four steps in a process for assembling and locating vertically adjacent wall portions formed from formwork modules according to an embodiment of the present invention;

Figure 34E is an enlargement of detail 34E in figure 34A;

Figure 35 shows a side view of the protecting portion of a panel used in another embodiments of the present invention;

Figure 36 illustrates the panel of Figure 35 carrying reinforcing bars;

Figures 37A through 37F illustrate in more detail a process for forming a formwork module using the panels illustrated in Figures 35 and 36;

Figure 38 illustrates a section of a formwork module constructed in accordance with Figures 35 through 37;

Figure 39 illustrates a further alternative panel profile, which is particularly suited for use in forming a floor slab in an embodiment of the present invention;

Figure 40 illustrates a further panel profile, similar to that of Figure 39, except that it requires approximately 20% less concrete than the embodiment of Figure 39 to form a slab;

Figure 41 illustrates a portion of a module including multiple panels of the type illustrated in Figure 40;

Figure 42 is a cross section view of a portion of a slab formed using the panels of Figure 40;

Figure 43 shows the detail of a formwork assembly of two wall modules and a slab module, according to an embodiment of the present invention.;

Figure 44 illustrates a series of panels prior to being formed into formwork modules made in accordance with another embodiment of the present invention;

Figure 45 illustrates an end view of the panels of figure 44; and

Figure 46 illustrates a perspective view of part of the completed formwork module of figures 44 and 45.

Detailed description of the embodiments

Figure 1 shows a partially constructed building 1. The building will ultimately include several storeys, but in figure 1 only two are shown. In figure 1 the structure of the partial building 1 consists of a plurality of pre-fabricated modules assembled to define an external formwork structure carrying concrete reinforcing bars to strengthen the concrete once it is poured. In figure 1 the concrete is not shown. The structure of the building illustrated in Figure 1 is assembled on site, on suitable foundations (that may be constructed using a similar methodology to the upper storeys illustrated or conventionally) from a plurality of pre-fabricated formwork modules as described below.

The building 1 includes various building portions including floors 2, beams 4, columns 6, walls 8 and a central core 10. As shown in figure 2 the core 10 is made up of two core portions 10A and 10B.

As will be described, the floor portions 2 and beam portions 4 have a similar construction. As best illustrated in figure 3 the floor portions 2 and beam portions 4 together define a floor surface 2A. The beam portions 4 are deeper than the floor portions and project some distance below the underside of the adjacent floor portions 2 to structurally support the floor 2 and other portions of the building. In this example beam portions extend around the perimeter of each storey of the building and two additional parallel beams extend across the floor adjacent the core 10.

The floors 2 are formed from a plurality of pre-fabricated floor modules corresponding to floor portions 2.1 to 2.9. Similarly the beams 4 are formed from a plurality of pre-fabricated beam modules corresponding to beam portions 4.1 to 4.4. The core portions 10A and 10B are formed of separate pre-fabricated formwork modules and are separated by a beam module 4. The columns e.g. 6A to 6C are also formed from individual pre-fabricated formwork modules. Although not illustrated in figure 1, the external perimeter or the whole floor, defined by the outer edges of the beam modules, includes an upstanding edging to contain concrete within the formwork. Concrete can be poured into the formwork created by the assembly of the modules to create the final structure of each floor. The concrete can be poured into the whole floor at once or in a plurality of sections.

The process for constructing a portion of a building of this type runs generally as follows:

1. Pre-fabricate formwork modules that are needed for the building. The formwork modules will typically include all or a majority of the concrete reinforcing members needed for the completed construction pre-located in them. Ducting to carry other elements, e.g. post tensioning tendons etc. that need to extend through or along the final concrete form are preferably pre-installed in the pre-fabricated formwork modules. Apertures or fittings that extend through the final concrete forms are also preferably pre-placed in the formwork modules during manufacture.

2. Transport the modules to the site. For efficiency, delivery will preferably take place in the order of installation.

3. Place the formwork modules on-site to construct the required formwork structure. Installation may require some temporary propping of formwork modules.

4. Connect formwork modules to neighbouring modules if required. Connections can be made by welding, bolting or other suitable mechanical fastening, alternatively neighbouring modules can be configured to interlock sufficiently well to not need additional fastening prior to concrete being poured. As will be described, certain modules are design to cooperate to be permanently interlocked by a continuous phase of concrete.

5. Connect reinforcing, services, ducts or other elements between abutting modules if required.

6. Pour concrete into the assembled formwork either section by section or for an entire floor at a time; and finish concrete as required;

7. After sufficient curing of the concrete, remove temporary props.

As will be appreciated other steps in the construction of a building will run in a generally conventional manner.

In the example of the building of figure 1, after fabricating the formwork modules for the lower floor they can be assembled on-site. This begins by placement of modules for the lower band beams 4 and cores 10. Floor formwork modules 2.1 to 2.9 are laid between the band beams to finish the floor formwork. Concrete for at least the floor slab can then be poured. Lower column modules 6 may then be installed. It may be advantageous to also pour the columns and core of the lower level at this point or wait until the upper floor slab is poured.

On top of the core and column formwork already in place the band beam formwork modules of the floor above are next mounted thereto. These may need propping from below during curing of the concrete. The floor formwork modules can be placed between the beams to complete the floor formwork for the upper floor. The floor formwork may also need temporary propping. Concrete can then be poured into the upper floor formwork and lower columns and core formwork. This process can continue to create additional levels.

The construction of an exemplary floor module 12 is illustrated in figures 6, 8A, 8B and 9. Each module 12 includes a plurality of, in this case a pair of, transversely spaced beams 28 extending

in a longitudinal direction. A plurality of panels 14 extend transversely to span the space between beams 28. As will be described the panels 14 sit adjacent each neighbouring panel to present a substantially continuous boundary for forming concrete, i.e. there are no significant holes or gaps through which concrete may escape. In this embodiment the panels are formed from roll formed galvanised steel in the vicinity of 1.6mm thick and neighbouring panels are connected. As will be described the module 12 is left in place to form a permanent part of the building structure. It is contemplated that the panels 14 might be formed of the thicker material to strengthen the permanent structure. In a preferred form, the pre-fabricated formwork module is generally similar to the panel assembly described in PCT/AU2011/000298. However this structure is modified to facilitate the flow of concrete and to support and locate reinforcing steel within the module.

The panels can be formed using any suitable technique, e.g. roll-forming, pressing, bending or moulding etc. Moreover the panels could be initially formed so as to have the deflected shape, e.g. by moulding or extruding, or may be formed initially from planar material that is subsequently bent to form the deflected shape, e.g. in a press brake or roll forming operation.

In this embodiment the panel 14 is roll formed to include a planar boundary portion 18 and a projecting structure 16. The projecting structure 16 runs along one of the long edge portions of the panel 14. In the assembled module the panel is placed such that the projecting structure 16 projects into the concrete. Each projecting structure 16 includes a vertical (i.e. perpendicular to the boundary portion 18) web 16A extending from the boundary portion 18 to a horizontal flange portion 16B projecting away from the boundary portion 18. The horizontal flange 16B terminates in a short downward return 16C. The flange16B and return 16C together constitute a hook formation.

The boundary portion 18 includes 3 stiffening ribs 20 running along the length of the panel 14. Each rib 20, in this embodiment, is a shallow depression (i.e. deformation toward the concrete side of the panel 14) about 50mm wide by about 2mm deep. The stiffening ribs 20 serve to stiffen the boundary portion 18 and resists drumming.

The boundary portion 18 includes a presentation surface 18A on the non concrete side of the panel 14. In this embodiment the presentation surface 18A is relatively flat and only includes minor deformations in the form of the small recesses associated with the ribs 20.

As best shown in figure 9 the panel 14 includes an engagement region 22 that extends along the length of the panel 14 and is located immediately adjacent to the projecting structure 16. The engagement region 22 is recessed by about 2mm. The recess is about 50mm wide and is adapted to receive a corresponding length tail portion 24 of a like adjacent panel. Using such a structure, when a plurality of similar panels are overlapped such that the tail of one lies in the engagement region of another, the presentation surfaces 18A of the panels substantially align. A panel assembly 26 having three panels 14 arranged in this manner is illustrated in figure 8B. Within the assembly 26 adjacent panels 14 are connected to each other and held in relative disposition, eg. by spot welding along the elongated region of overlapping material 22, 24.

It will be appreciated that the panels 14 of the assembly 26 together present an attractive common presentation surface. In a completed building this surface can be left as-is or receive various surface treatments as required.

The projecting structure 16 of each panel 14 constitutes a purlin integrally formed with the panel 14 to strengthen the panel against bending about an axis transverse to its length (i.e. about an axis parallel to the length of the module 12). The panels 14, and the assembly 26, is therefore relatively strong in this direction. The projecting structure 16 is ideally dimensioned such that it provides sufficient strength to the panel so that a formwork module which incorporates the panel 14 can be self supporting.

Returning to figure 6, within the module 12 the pair of longitudinal beams 28 carries the free ends of the panels 14. The beams 24 are formed of L-shaped section (i.e. in cross section the beam has a pair of perpendicular arms). One of each beam's arms underlies the panels 14 to provide support whilst the other arm of each beam projects upwardly to about the same height (i.e. projection in the concrete direction) as the projecting structure 16.

The beams 28 perform a dual role. They strengthen the module by resisting bending about an axis transverse to the module and provide an edge to form concrete, as will be described in more detail below. Figures 11 and 12 are cross section views of a floor 2 incorporating the module 12 and concrete 34. The variant of module 12 illustrated in these figures does not include returns 16C.

Each web 16A includes a series of apertures 30 spaced along its length (i.e. across the module 12). Each aperture 30 carries a respective reinforcing bar 30A. Thus the position of the apertures 30 of the projecting structure 16 dictates the location of the reinforcing bars 30A

within the concrete 34. As illustrated, within the floor 2 the apertures 30 are positioned low down on the web 16A so that the reinforcing bars 30A are carried towards the bottom of the concrete 34 to resist tensile forces associated with a weight carried on the floor 2.

A series of concrete flow apertures 32 are arranged along the length of the web 16A. In this embodiment the concrete flow apertures 32 are spaced at the same pitch as the apertures 30 and are inter-leaved therewith. The apertures 32 each have a triangular form the apex of which is downwardly directed. As such the apertures 32 are relatively narrower thereby leaving more material in the lower portions of the web 16A about the apertures 30. The concrete flow apertures are relatively large to permit wet concrete to flow therethrough and to form a continuous phase of solid concrete when cured. Thus the concrete flow apertures 32 allow stress to be transmitted between portions of concrete floor through the web 16A and allow a portion of the projecting structure 16 to be encircled by a continuous phase of concrete to interlock the concrete and the projecting portion 16. The horizontal flange portions 16B of the variant at Figure 11 and the hook formations 16B, 16C of the variant of figure 8A also enhance the engagement of the projecting structure 16 with the concrete 34. It should also be noted that reinforcing bars can be mounted to the panels via intermediate members, or in some cases rested and retained on the projecting structures, rather than (or additional to) being retained in apertures formed therein.

As has been described the underside of the floor 2 presents a reasonably attractive presentation surface 18A forming a ceiling for a lower floor of the building.

The module 12 is pre-fabricated, i.e. is manufactured at a manufacturing facility and is transportable to the site of the building. In this embodiment the reinforcing bars 30A are fixed relative to the panels 14 for transport by virtue of the fit with the apertures 30. The apertures 30 are about 1mm per side larger than the external diameter of the reinforcing bar 30A. Whilst this would usually be regarded as a rather loose fit, by virtue of the rough textured nature of reinforcing bar and the tolerances on its straightness, when a reinforcing bar engages with multiple apertures 30 along the length of the module 12 there is found to be a sufficient fixation between the bars 30A and the panels 14 for the module 12 to be transported on site with an acceptable degree of movement of the bars 30A. If slippage of the reinforcing bar is excessive they can be tied to one or more of the projecting portions 16 of the panels using wire, in the manner in which reinforcing bars are conventionally tied to other such bars or ligatures. Other bar fastening structures are also contemplated.

The engagement between the reinforcing bars 30A and the apertures 30 also serves a function in use. As the reinforcing bars 30A are located at multiple points along their length, they are restrained against buckling outwardly when placed under compression. As such the apertures 30 replace the time consuming ligatures associated with prior art reinforcing structures.

The floor 2 is formed by supplying the module 12, including its panels 14, bars 30A and beams 28 to the building site as a pre-assembled unit. The module 12 is placed in situ. For larger spans, such as within the building 1 of figure 1, further structural supports might be provided to the module 12. By way of example one or more struts or props might be placed between an underside of the module 12 and the floor below to temporarily support the module 12. The end portions of module 12 might be capped by a separate piece of formwork, or as will be described might cooperate with another formwork module. The concrete is then poured into the module 12 to a depth somewhat deeper than the height of the projecting structures 16 so that the surface 2A of the finished concrete is desirably unblemished by projecting formwork and so that the reinforcing bars have the required coverage for durability. In this embodiment the projecting structures 16 are about 100mm high and the concrete 34 is about 130mm deep so that the upper extent of the projecting structures 16 is about 30mm below the surface 2A.

It will be appreciated that the panel structures of preferred versions of the invention can form a protective skin about the concrete. In particular, the skin can be relatively impermeable and thereby help to guard against degradation of the concrete over time, for example, by reducing the penetration of moisture into the concrete. Another advantage is that the metal skin can prevent moisture loss from the concrete and reduces the shrinkage normally associated with concrete structures.

The beam module 12' of figure 7 is similar to the floor module 12, however It has different dimensions to provide additional strength. It's projecting structures 16' are somewhat deeper than those of the floor module. In this embodiment the projecting structure 16' are about 300mm deep. As best illustrated in figures 13 and 14 the concrete flow apertures 32 take the form of relatively large hexagonal apertures spaced along the length of the web 16A'. Reinforcing bar apertures 30' are spaced along both upper and lower portions of the web 16A'. The lower reinforcing bar apertures carry reinforcing bars in the same manner as the apertures 30 of the wall module. The upper reinforcing bar apertures also 30' carry reinforcing bars, which are located in the upper strata of concrete to resist a tension in this region.

Unlike the L shaped beams 28 of the floor module 12, the beam module 12' includes more complex "Z- shaped" beams 28' running along each of its sides. Each beam 28' includes an L shaped portion arranged in a similar fashion to the L shaped beams 28, and also includes a horizontal flange portion 28A' which projects outwardly on either side of the module 12'. The horizontal flanges 28A' are arranged at a height somewhat below the upper extent of the projecting structures 16'. The flanges 28A' constitute structure co-operable with another module such as the floor module 12.

In use a floor module 12 may be arranged in a direction transverse to the beam module 12' with its end seated upon one of the flanges 28A'. As such the open concrete receiving area of the floor module 12 opens into the open concrete receiving area of the beam module 12'. When filled with wet concrete the concrete is able to flow between the modules to form a continuous concrete phase. The relative heights of projecting structures 16 and 16' and the flanges 28' is selected so that the upper extent of the projecting structure 16 and 16' is at about the same height when installed and both are buried about 30mm under the surface 2A of the concrete.

Figure 10 is a cut away view illustrating multiple floor modules 12 and arranged to co-operate with a beam module 12'. As can be seen each of the floor modules 12 spans between two adjacent beam modules 12' and is supported on tops of the of the flanges 28' of the beam modules 12' in the manner described above.

Figures 15 to 20 illustrate exemplary modules for forming the core of a building.

Figure 15 illustrates the general construction of the core modules. The modules 36 includes an inner formwork structure 36A encircled by an outer formwork structure 36B to define a tubular void 40 (see figure 16) between them for receiving concrete. When filled with concrete the modules forms a tubular wall which constitutes a portion of the building's core 10A. This tubular wall has a height corresponding to 1 building level and can for example define the building's lift wells, fire escapes or other core structure. Doors, windows or other apertures can also be formed through the formwork structure by providing suitable walls in the formwork. The inner formwork 36A and outer formwork 36B structures are formed from a plurality of panel assemblies similar to those used in the floor's formwork modules held to each other by vertically extending corner angles. Although it will be appreciated that other attachment means could be used.

Figure 18 illustrates the details of two wall portions of the module 36 and how they come together at a corner. The portion 38 includes a pair of opposed panel assemblies 26' defining a void 40 between them for receiving concrete. The projecting structures 16" of the panel assemblies 26' project into the void 40. In this embodiment each projecting structure 16" projects half way into the void 40 and abuts a corresponding projecting structure 16" of the other panel assembly 26'. The abutting projecting structures 16" are connected to each other to tie the panel assemblies 26' to resist outward bulging caused by the weight of wet concrete within the void 40.

As best illustrated in figure 18B, the projecting structures 16 may be connected with the aid of a clip 42 in the form of a simple extruded C section embracing the return flanges 16C" of the respective projecting structures 16'A'. Clip 42 may engage with one or both of the flanges 16B" or returns 16C". A range of other forms of connection are possible.

It is also contemplated that the extent of projection of the projecting structures into the concrete on each of the panel assemblies 26' could vary, along with a complementary variation in the corresponding dimension of its paired projection 16", so that the relative location of the connection between the paired projecting structures 16" varies from pair to pair. In this way weaknesses associated with the connection do not align along the length of the wall. As in the previous embodiments the projecting structures of one or both wall structures forming the core module can have apertures for carrying reinforcing bars.

Figure 18 also illustrates vertical L shaped beams 48A and 48B, also referred to as corner angles, connecting the panel assemblies 26' of the inner form 36A and outer form 36B respectively.

Figure 17 illustrates a second pre-fabricated formwork structure 50 for a core portion of a building. In this case the module 50 is used to construct a stair well, e.g. as a fire escape. As can be seen in addition to the outer tubular structure the core similar to the core module 36 of figure 16, the module 50 includes internal walls e.g. 52. These walls are formed as part of the core module, or may be provided by stand-alone wall modules. In either case the formwork components for forming a wall includes complementary pairs of panel assemblies 26' tied to each other in some fashion, eg. by connecting respective pairs of projecting structures in the manner described above.

Stand alone wall formwork modules may or may not incorporate pre-assembled reinforcing bars. Wall modules could be configured to form a simple planar wall, or might form part of a more complex structure such as the module 50 for forming a core of a building. Curved walls are also able to be made using non-planar wall portions of the formwork structure.

Figure 20 shows a top portion of a core formwork module in situ. The inner form 36A extends higher than the outer form 36B. Structure, for cooperating with other modules, in the form of horizontal flange 28A" extends horizontally outwardly from the top of the outer form 36B. The flange 28A" is configured to cooperate with a formwork module of the floor above, typically a beam module 12', in a manner analogous to the co-operation between the flange 28A' of the module 12' with the floor module 12 described above. In use a beam module 12' is seated on the flange 28A" so that its open concrete receiving area opens into the void 40 of the module 36 so that the beam module 12' and the module 36 may be simultaneous filled with wet concrete which when cured defines a continuous phase of solid concrete intimately connecting the walls of the building core 10A with the beam 4 formed by the module 12'. The form 36A thereby defines an inner extent of the beam 4.

In this embodiment the upper extent of the inner form 36A terminates in location structure 46 about its upper periphery. The location structure 46 in this embodiment takes the form of a portion outwardly flared at an angle to define a lead in for guiding to an aligned position a similar module that is placed on top of it. The lower extent of the inner form 36A of the like module 36 will have a correspondingly shaped lead in such that when the top core module is lowered it is urged into alignment with the module 36. The void 40 defined by the module 36 complements, as in co-operates with, the void formed by the upwardly adjacent like module 36. In this embodiment the voids co-operate to form a continuous tubular structure about the lift wells.

Figure 19 shows the building module 36 in place and spaced from another building module 50 which defines the stairwells 54. The module 36 is spaced from a module 50 to define a corridor 52. A beam 4' defines a ceiling of the corridor 52, a portion of the floor structure of an upwardly adjacent building level and structurally inter-connects the core portions 10A and 10B respectively defined by modules 36 and 50.

Figures 4 and 5 illustrate a preferred form of column formwork module 58. The column includes an upwardly projecting cage 56 of reinforcing bars surrounded by the sleeve like module 58.

The cage 56 includes vertically extending reinforcing bars 57 embraced by a set of ligatures 59. The vertical bars 57 are tied to the ligatures 59 in conventional fashion to resist outward buckling.

The sleeve structure 58 includes a pair of sleeve wall portions 12''' analogous to the floor module portions 12 excepting that the relative positioning of the apertures within the web 16 have been reversed to move the reinforcing bars of the module 12''' towards the centre of the column 6. The module 58 further includes a pair of narrow elongate panel assemblies 26''' which co-operate with extended L shaped portions of the module portions 12''' to form a continuous sleeve carrying reinforcing bars. Note that the apertures of the webs and the reinforcing bars of the module 58 are not shown in figure 4.

The cages 56 have a height corresponding to the height of a building level but are off-set at half a pitch so that the join between vertically adjacent cages occurs about mid-way between the floor and ceiling of each respective building level corresponding to a mid point of the sleeve so that weakness associated with joints between cages are offset from weakness associated with joints between vertically adjacent modules 58. As such when the floor of each building level is formed a portion of cage 56 projects upwardly from below.

It will be observed in figure 3 that the upper extent of module 58 terminates in outward extending flanges closely analogous to the flanges 28A described in respect of other modules. Which flange is configured to co-operate with the beam modules forming the floor above so that the column 6 and the floor above are integrally formed with a continuous phase of concrete.

Figure 21 shows a further embodiment of a panel 2100 which may be used to form a portion of a wall or other structure of a building. The panel 2100 is similar to that of the previous embodiments however, rather than having receiving voids in the form of holes or apertures in its projecting portion into which reinforcing bars are inserted during manufacture, the projecting structure of the panel 2100 include open ended receiving voids to enable the transverse insertion of reinforcing bars into the building module. As can be seen panel 2100 includes a generally planar boundary portion 2102 and a projecting structure 2104. The projecting structure 2104 includes a plurality of upstanding projecting portions (e.g. 2106 and 2108). The projecting structure 2104 is deflected substantially at right angles to the boundary portion 2102 of the panel 2100. In use, projecting structure 2104 will be surrounded by the concrete poured into the formwork. As will be apparent from further description below, the projecting structure

portions, e.g. 2106 and 2108, are shaped to define a pair of notches 2110, 2112 which, in use are used to hold and locate reinforcing bars.

Figure 22 illustrates a plurality 2200 of panels 2100 which have been joined together to form an elongate boundary structure that can form part of a formwork module. As described in the previous embodiment, the panels 2100 are preferably joined to each other by welding. The projecting structure portions e.g. 2108 and 2106 of the panels are aligned with the corresponding projecting structure portion of each other panel to provide an aligned row of projecting structure portions for supporting reinforcing bars as illustrated in Figure 23. In Figure 23, a partially assembled formwork module 2300 is shown.

The assembly 2300 includes the plurality of panels 2200 from Figure 22 and additionally includes reinforcing steel in the form of a mesh 2302 of reinforcing rods. The rods of reinforcing mesh 2302 are pre-welded into a mesh structure 2302 which can be inserted transversely between neighbouring projecting structure portions e.g. 2106 and 2108, and lowered such that the reinforcing mesh 2302 is hung on the projecting structure portions 2106, 2108. Preferably, the reinforcing mesh 2302 can be welded to the panel structure 2200 to hold it in correct position relative to the module. As will be appreciated, rather than using a pre-welded mesh, individual reinforcing bars can be inserted at appropriate places in the panel structure 2100.

Figure 24 shows structure 2400 comprising the assembly 2300 of Figure 23 and a similar formwork structure 2402 placed next to each other. The two panels 2300 and 2402 form the inside walls of a right angled, corner shaped, formwork module. Two structures 2300 and 2402 can be welded together down their abutting vertical edges at 2404. The reinforcing bars held by the two formwork panel sections 2300 and 2402 can be effectively joined to each other using sections of L shaped reinforcing bars e.g. 2500, as shown in Figure 25. As will be appreciated by those skilled in the art the L shaped reinforcing bars 2500 are placed relative to the reinforcing mesh of the panels 2300 and 2402 are such that they overlap to an extent required by building codes. When forming a wall, it may be necessary to have multiple layers of reinforcing bars set at predefined spacings from the boundary portions of the formwork structure. Figure 26 shows a more complete structure 2600, which additionally includes a second layer of reinforcing steel 2602. This is hung in the outermost notches in the projecting structure portions of the panel structures 2300 and 2402 again, as illustrated in Figure 27, the reinforcing bars 2602 of the two panels 2300 can be joined by L shaped corner pieces of reinforcing steel 2700 as illustrated in figure 27.

Next, when forming a wall it is necessary to provide second boundary portion or skin to the formwork module. An initial phase of this process is illustrated in Figure 28. In Figure 28 the partly assembled formwork module 2800 is shown having a first flat sheet 2802 applied to a section of the panel 2402. The sheet 2802 is rectangular and generally planar in structure and has a plurality of apertures or holes 2804 formed in it. Each hole 2804 lines up with a corresponding flange of a respective projecting structure portions of a panel to which it will be mounted. During assembly, the projecting structure portions of the panel structure 2402 are welded to the inside edges of the apertures 2804 to mechanically connect the sheet 2802 to the panel structure 2402. This process is repeated, and as illustrated in Figure 29, an outer skin on the formwork module is thereby provided. The sheets 2802 can be positioned such that they overlap in a region along the longitudinal edges e.g. 2900. To facilitate this the panels e.g. 2802 can be provided with a small 2mm step along the overlapping edge to allow overlapping of neighbouring panels such that a substantially planar outer surface results.

Next, as illustrated in Figure 30, the corner of the module 3000 can be completed by welding on a corner panel 3002. This corner panel generally speaking is simply an L shaped panel for covering the corner of the adjoining panel structures.

Figure 31 shows a completed of formwork module 3100, which may be used for a stairwell or similar portion of a building. The building formwork module 3100 includes a double skinned wall using the structure illustrated in connection with Figures 21 to 30 and carries reinforcing steel between two skins. As illustrated with the previous embodiments, doors and other holes through the wall structure can be provided in such formwork modules. This is typically done by providing suitably shaped panels for the framing the aperture.

Figures 32A through 32D illustrate four stages in forming a panel similar to that used in figures in the embodiment of Figures 20 to 31. In an initial step, shown in Figure 32A a flat sheet 3200, e.g. made of steel, is provided. Next, two panel blanks 3202 and 3204 are punched from each sheet 3200. The panel blanks 3202 and 3204 are identical and are shaped such that the projecting portions of one of the panels 3202 sit within the open receiving voids of the other panel 3204. In this way, two panels 3202 and 3204 can be formed from a single sheet of material 3200 with minimal wastage. Each panel blank e.g. 3206 shown in Figure 32C is extracted from the pair and the profiles projecting portion is folded as illustrated in Figure 32D. The panel is folded along the junction between the projecting portion 3208 and the boundary portion 3210 of the panel blank 3208 and also to form an overturned flange 3212 on the distal end of the projecting portion 3208. The folding process can be performed using either a press

brake, pan break, press or similar folding equipment or alternatively may be formed with a roll-forming machine. In an alternative embodiment at least some of the folding operations may be performed prior to separation or punching of the individual blanks 3206 from the panel 3200.

Figure 33 illustrates the detail of a corner of two walls, similar to that illustrated in Figure 31. However, the portion of the formwork module 3300 illustrated in Figure 33 differs from the previous corner design described in that the reinforcing steel layout is different. The formwork portion 3300 includes an outer skin 3302 which defines a first boundary for forming concrete, an inner skin 3304 which forms another boundary for forming concrete. The skins 3302 and 3304 are formed from a plurality of panels similar to that described above. The inner skin 3304 includes a plurality of projecting structures e.g. 3306, 3308, 3310 etc, on which reinforcing bars 3312, 3314, 3316 and 3318 are supported. The corner is reinforced using a pair of substantially U-shaped reinforcing bars 3322. The U-shaped bars overlap at their bend portions at the corner. Together, these reinforcing portions 3320 and 3322 define a loop 3324, into which a vertically extending reinforcing bar 3326 can be inserted. The reinforcing bars are tied to adjacent reinforcing bars in a manner that will be known to those skilled in the art. As will be appreciated by those skilled in the art, a range of additional reinforcing bar configurations can be used in embodiments of the present invention.

Figures 34A through 34D show how vertically adjacent walls comprising formwork modules can be stacked upon each other in use. Generally speaking, the Figures 34A to 34D illustrate the following components:

a lower formwork module 3400

an upper formwork module 3402

a pair of like locating elements 3404 and 3406.

The formwork modules 3402 and 3400 are similar to each other, as will usually be the case when forming a building with multiple storeys. As described in the previous embodiments, the formwork modules have first and second skins e.g. 3400A and 3400B. Each module additionally includes projecting structures e.g. 3400C which extend, in this case all the way across the concrete forming void within the formwork module and are adapted to carry reinforcing bars in the manner illustrated in Figures 34B through 34D. The top edge of the uppermost projecting structure 3400D includes slots 3400E and 3400F into which a respective

downwardly extending flange of each of the locating elements 3404 and 3406 can be inserted. The bottom edge of the lowermost projecting structure 3402A of the upper formwork module 3402, includes a pair of grooves 3402B and 3402C, which are shaped to receive an upwardly extending lead-in portion of the locating elements 3404 and 3406.

Locating element 3404 is shown in more detail in Figure 34E. The locating elements 3404 and 3406, are designed to be located in one of the two modules and provide a tapered lead-in portion to assist in locating an adjacent module when they are brought together. In this example, the locating elements are formed of a plastic or metal material and are elongate in structure and additionally assist in forming a seal between the vertically adjacent formwork modules so that concrete does not leak out between the junctions between the adjacent formwork modules.

Turning now to Figures 34B which shows the upper formwork module 3402 being lowered down towards the lower formwork module 3400. In this illustration, the formwork modules 3400 and 3402 are illustrated carrying reinforcing bars 3402D and 3400G. The locating elements 3404 and 3406 are inserted into the grooves 3400E and 3400F of the lower formwork module 3400. As illustrated in Figure 34C, in the event that the formwork modules 3402 and 3400 are brought together out of alignment, the lead-in portions 3404A and 3406A of the locating elements 3404, 3406 bear against the angled surfaces of grooves 3402B and 3402C of the upper formwork module 3402 and bring the two formwork modules 3402 and 3400 into alignment as they are brought together. Their final aligned and connected position is illustrated in Figure 34D.

Figures 35 through 38 illustrate a further example of a panel structure usable in a formwork module according to an embodiment of the present invention.

Figure 35 shows an alternative profile shape useable in the panel according to an embodiment of the present invention. The panel 3500 has generally the same construction as in previous embodiments however, the projecting structure has a profile which is adapted to receive and hold reinforcing bars at a plurality of spacings from the boundary portion of the panel. In this regard, the projecting structure 3502 have a generally crenellated profile and includes a plurality of substantially square projections with recesses 3508 therebetween. At the top end of the projections e.g. 3502 there is located notches 3504 and 3506. These notches are adapted to receive reinforcing bars in the manner described below. The recesses 3508 and the profile between adjacent projections e.g. 3502 is also adapted to receive reinforcing bars at a first separation from the boundary portion of the panel

Figure 36 illustrates an example placement of reinforcing bars using a panel of the type described in Figure 35. As can be seen in this example, upper and lower layers of reinforcing bars 3600 and 3602 are supported by the panel 3500. Transversally extending reinforcing bars 3604 and 3606 can also be attached to the panels, and reinforcing bars 3602 to complete the reinforcing structure. In the present example, the reinforcing bars 3602 and 3604 may be pre-formed into a mesh prior to insertion into the panel structure. However, they may alternatively be placed as individual rods. Similarly, rods 3600 and 3606 may be formed into a mesh or placed individually. In one form, the rods 3604 and 3606 are welded to the profile 3500 and serve as retaining means to retain the orthogonally extending reinforcing rods 3602 and 3600 within the formwork module.

The formwork module formed using a panel described in connection with Figures 35 through 37 may be particularly advantageously used in forming beams of a concrete building. As will be known to those skilled in the art, beams of different depths may be required within a building and accordingly, the height of the projecting portions e.g. 3502 may be longer than that illustrated in the present embodiment. Also, the separation between projecting portions may differ, depending on the requirements of the building portion to be formed with the formwork module.

It should be noted that the lower reinforcing bars 3600 and 3606 are located at a position within the formwork module such that they will be at the bottom of the building portion formed with the formwork module. This means that these reinforcing bars will typically be under tension in the building. Depending on the thickness of the beam being formed, the upper reinforcing bars 3602 and 3604 may also be in tension. Clearly, additional levels of reinforcing bars could be provided by changing the profile shape to some degree.

Figures 37A to 37F illustrate six stages in the fabricating a formwork module using panels of the type illustrated in Figures 35 and 36. Initially, in Figure 37A there is shown a sheet 3700 from which two panels can be formed. Next, in step 37B the flat sheet 3700 is cut into complementarily shaped blanks 3702 and 3704. The blank 3702 is illustrated in Figure 37C. Next, in Figure 37D the blank 3702 is formed by folding the blank to its desired shape to provide an upstanding projecting portion and other structure in the panel 3702. Next, as illustrated in Figure 37E a plurality of panels are welded together (in the manner described elsewhere herein) to form a panel structure 3706. One or more sides of the panel structure 3706 will typically be bordered by side walls, in the manner illustrated elsewhere herein to provide sides for forming concrete. Finally, in Figures 37F the panel structure 3706 is loaded with reinforcing bars, in the

form of upper and lower reinforcing meshes 3708 and 3710. These can be attached to the module via welding or other mechanical fastening means.

Figure 38 shows a larger section of formwork module 3800 made in a manner described in connection with Figures 37A through 37F. However, in this example the reinforcing steel is placed as individual bars. In this regard bars 3802 are arranged in a lower layer to be in a lower stratum of concrete. Next, an upper layer of reinforcing bars e.g. 3804 are provided. As can be seen these rest in the notches at the top of the profile of the projecting portions of the panels. Finally, transverse reinforcing bars 3806 are provided which overlie the upper layer of reinforcing bars 3804 and assist to retain them within the module 3800. Also, as illustrated, one side of the module is provided with the wall 3808 to form concrete along one side of the module in use.

Figure 39 illustrates a further panel profile in cross section, which may be used in embodiments of the present invention. For example, a panel having a profile illustrated in the present form may be particularly advantageously used in forming a slab portion of a building. As described in the previous embodiments the panel 3900 includes a boundary portion 3902 for forming concrete and a projecting portion 3904, which, in use, extends upward into the concrete forming void of the formwork module and serves to retain reinforcing bars. In this example, the projecting portions 3904 include a supporting structure 3906, which in this case is a horizontally directed indentation in the upwardly extending web of the projecting portion 3904, but could be formed in another way (e.g. by punching a tab from the web). This structure 3906 is used to retain and support one or more reinforcing bars which extend in a direction substantially parallel to the projecting portion 3904. As in previous embodiments, the projecting portions 3904 will include apertures or voids through which concrete may flow in use. The upper flange of the projecting portions 3904 includes holes 3108 that allow air to escape from under the flange during concrete pour.

It will be appreciated, that the reinforcing rods held by the retaining structure 3906 are located in a lower stratum of the concrete formed by the formwork module such that in use the lower portion of the panel structure, and importantly, the reinforcing bars retained by it are under tension when the slab is formed. It should be understood that the lower stratum of concrete discussed is a portion of the concrete forming the building portion which lies below a neutral line in the concrete which notionally defines those portions of the structure which are under tension or under compression when loaded.

Figure 40 illustrates a variant on the panel Figure 39. The panel 4100 is similar in profile to the Figure 39 with the exception that it includes a stepped boundary portion 4102. The boundary portion 4102 includes a large upward indentation 4104 which serves to reduce the amount of concrete used to form a slab when using panels of this type. Figure 41 illustrates a segment of a formwork module made using panels of the type illustrated in Figure 40. As can be seen, the formwork module 4300 includes a plurality of panels 4302, 4304, 4306. Each panel includes a respective boundary portion e.g. 4302A, and a projecting portion e.g. 4302B. Each projecting portion supports a set of reinforcing bars 4308, which extend across multiple panels. Transversally extending reinforcing bars e.g. 4310 are also provided and supported in retaining structures of the web of the projecting structures. The reinforcing bars can be tack welded to the projecting portions 4302 or to an adjacent contacting reinforcing bar. The bars 4308 and 4310 can be formed into a mesh prior to placement in the module. Next, a plurality of tie bars e.g. 4312, also arranged in a mesh can also be mounted on top of the reinforcing bars 4308 and 4310. Where adjacent reinforcing bar and tie bar sections meet e.g. at point 4314, a section of tie mesh or similar reinforcing material 4320 can be positioned and tied to the reinforcing. Additionally, a lower stratum of the slab, which is located beneath the neutral line in the slab, once formed, can be reinforced by placement of transversally extending reinforcing bars as illustrated at 4322. In use, when the concrete is poured the concrete slab will extend up to the point indicated at 4324. As in the previous embodiment the top flange of the projecting portions 4302A include one or more hole 4106 to allow air escape during concrete pour. An example section of a building portion formed using a permanent formwork module including panels of the type illustrated in Figure 40 is shown in Figure 41.

Figure 43 illustrates a section of formwork for a building which can be formed using formwork modules according to various aspects and embodiments of the present invention. The segment illustrated shows a junction between a slab 4402 and walls 4404 and 4406 of two stories of a building. Accordingly, Figure 43 illustrates a junction between three formwork modules. The formwork module forming wall 4404 is substantially the same as that described in connection with Figures 30 through 32, whereas the slab 4402 is formed using a formwork module substantially the same as that described in connection with Figure 42. The lower wall portion 4406 is formed using a formwork module similar to that of Figures 30 to 31. However, at its top end, an additional reinforcing structure 4408 is provided to support the weight of the slab 4402. In order to accommodate the reinforcing structure 4408 the upper portion of the inside skin 4410 of the lower formwork module 4406 includes an outwardly projecting support element 4408. Continuous reinforcing between the slab 4402 and the lower wall 4406 is provided using a

transversely extending reinforcing rods 4416. These are inserted through slots provided in the walls of respective formwork modules. As can be seen, the upper formwork module 4404 is lowered onto the lower formwork module 4406 and located in place using locating elements 4418 and 4420 in a manner analogous to the process described in connection with Figures 34A to 34D. Concrete is poured into the assembled formwork modules by pouring the slab and lower wall section first. The upper wall portion is poured in isolation later, or at the time of pouring a slab section above it in an analogous manner.

Figure 44 to 46 illustrate the fabrication of an alternative embodiment of a formwork module, whereby formwork for making a beam, or other structure can be formed from panels of the type described herein. Figure 44 and 45 illustrate a panel 4500 having the same general shape as the panel of the 8A, The panels in this embodiment are shaped so as to allow the boundary to be folded transverse to the projecting portion of the panel. In a preferred for the projecting structures have notches therein. The panels (either before or after joining to a neighbouring panel) can be folded through the notches to create a recess within the panel, for example a channel shaped recess.

The panel 4500 is formed (e.g. by roll-forming, pressing or other means) to include a planar boundary portion 4518 and a projecting structure 4516. The projecting structure 4516 runs along one of the long edge portions of the panel 4500. Each projecting structure 4516 includes a vertical (e.g. perpendicular to the boundary portion 4518) web 4516A extending from the boundary portion 4518 to a horizontal flange portion 4516B projecting away from the boundary portion 4518. The horizontal flange 4516B terminates in a short downward return 4516C. The boundary portion 4518 can also includes stiffening ribs (not shown) running along the length of the panel. The panel 4500 also includes an engagement region 4522 that extends along the length of the panel 4500 and is located immediately adjacent to the projecting structure 4516. The engagement region 4522 is recessed by about 2mm and is about 50mm wide, and is adapted to receive a tail portion 4524 of a like adjacent panel when the formwork structure is complete.

The panel 4500 additionally includes a pair of notches 4510 and 4512 that are cut into the projecting structure 4516. The notches 4510 and 4512 are generally triangular in shape and cut at around 90 degrees.

These notches allow the panel 4500 to be folded through the apex of the notches 4510 and 4512 to form a channel shaped formwork module in the manner show in figure 46. The edges of

the notches 4510 and 4512 that are brought together by the folding operation can be welded to each other to strengthen the channel shaped formwork module.

The final formwork module 4600, illustrated in figure 46, is thus a straight-walled channel shape with internally projecting strengthening structures. The module can be arranged to carry reinforcing steel 4602 carried on the projecting structures 4616 in the manner described above, or using more conventional cage structures.

As can be seen this embodiment allows single panels of the type described herein to be formed into channel shaped formwork modules, suitable for floors, beams, band beams, but preferably without the need to attach separate vertical side walls. The structure formed can also be stood upright, and closed off on its open side to define a formwork module for a wall or portion of a wall.

As will be appreciated, the plurality of panels 4500 may be joined together, then have their side walls folded once a panel assembly is formed, or each panel 4500 can be formed into a channel before joining it to the next like panel 4500.

Any number of notches can be cut into the projecting portion 4516 the panel 4500 such that shapes other than a rectangular channel can be formed. Moreover the notches can be cut at any shape or angle to allow different wall angles to be formed.

In an alternative form, the side walls of a formwork module similar to that of figure 46 can be made separately to the floor. The walls and floor of the module can be welded together along their abutting longitudinal edges. The joins along the edge may be strengthened, if needed, by angle sections or brackets as in other embodiments. As will be appreciated, in this case, rather than notching the projecting portions of the panels, the outer ends of the projecting portions can be shaped to form an appropriate angle so that they abut its neighbouring panel at the correct angle.

It will be appreciated that the various aspects of the invention allow for the pre-fabrication of various components in an industrial manufacturing environment which may present significant advantages. For example safety can be improved since less on-site work needs to be performed. In particular much of the working at height or overhead is eliminated. Cost could also be lowered since automation techniques can be employed during manufacture, delays due to wet weather on site are reduced and speed of installation on site is increased. The placement

of installed elements is simplified since placement of reinforcing, ducting and services can either be performed by machine, or if performed by hand these can be performed by a worker at ground level, at a comfortable working height and safe manner.

Moreover tolerances for formwork can be improved over that for most conventional formwork (particularly timber formwork) since the tolerances in a manufacturing environment can be controlled better than the manual formwork creation process. Ultimately this may transfer to improved building quality.

The pre-fabricated modules can be quickly and relatively easily transported and placed on site. It is anticipated that a floor of a building could be formed and poured within 2-3 days and with appropriate back propping, additional floors added at a similar rate.

For simplicity the term concrete has been used herein throughout to refer to a building material that is delivered in a flowable form, but which subsequently sets to form a portion of a building. It will be appreciated that aspects of the invention are able to be used with materials other than conventional concrete and thus 'concrete' should be interpreted in a broad sense to encompass a wide range of such flowable, settable building materials.

It will be understood that the invention disclosed and defined in this specification extends to all alternative combinations of two or more of the individual features mentioned or evident from the text or drawings. All of these different combinations constitute various alternative aspects of the invention.

The claims defining the invention are as follows:

1. A pre-fabricated formwork module for a building portion; the module including:

two or more panels each including a boundary portion and one or more projecting structures, the panels being arranged such that their boundary portions together define a first substantially continuous boundary for forming concrete, the projecting structures projecting from the boundary to project into the concrete; and

one or more reinforcing bars fixed in position relative to the boundary for transport and to reinforce the concrete.

2. The module of claim 1 wherein each panel is at least predominantly integrally formed of sheet material.

3. The module of any one of claims 1 or 2 wherein the projecting structures include one or more receiving voids opening outwardly from the first boundary to receive one or more reinforcing bars.

4. The module of claim 3 wherein portions of the projecting structures defining the receiving voids are shaped to carry a reinforcing bar at a predetermined spacing from the boundary.

5. The module of claim 3 wherein the portions of the projecting structures defining the receiving voids are shaped to carry at least two reinforcing bars at at least two different predetermined spacings from the first boundary.

6. The module of claim 3, 4 or 5 wherein the module further includes a retaining structure to capture the reinforcing bars in the receiving voids.

7. The module of claim 6 wherein, the retaining structure includes a plurality of apertures which in use contact the projecting structures of respective panels and through which the retaining structure is welded to the projecting structures.

8. The module of claim 6 or 7 wherein the retaining structure defines a second substantially continuous boundary, for forming concrete, spaced from the first boundary.

9. The module of any one of claims 1 to 7 including further structure defining a second substantially continuous boundary, for forming concrete, spaced from the first boundary.

10. The module of any one of claims 3 to 9 wherein the receiving voids are shaped such that the panels may be formed from blanks cut from a common sheet of material, said blanks being arranged on the sheet such that at least one projecting structure portion of one blank is interleaved with a similar projecting structure of a neighbouring blank and located within the receiving voids of the other blank.

11. The module of any one of claim 1 to 10 wherein the reinforcing bars are fixed to the projecting structures.

12. The module of any one of claims 1 to 11 further including two or more spaced beam members supporting the panels.

13. The module of claim 12 wherein the beam members have a profiled cross section including a face which is arranged to form the concrete.

14. The module of claim 12 or 13 wherein at least a portion of each projecting structure spans the space between the beam members.

15. The module of any one of claims 1 to 14 wherein each projecting structure terminates in a hook formation for keying into the concrete.

16. The module of any one of claims 1 to 15 wherein each projecting structure defines a supporting structure carrying a reinforcing bar.

17. The module of claim 16 wherein the supporting structure includes a channel.

18. A pre-fabricated formwork module for a building portion; the module including:

a form defining a substantially continuous boundary for forming concrete; and

one or more projecting structures;

the projecting structures projecting from the boundary to project into the concrete and defining a supporting structure carrying a reinforcing bar.

19. The module of claim 18 wherein the supporting structure includes a channel.

20. The module of claim 18 or 19 wherein the supporting structure and the reinforcing bar carried thereby are positioned to reinforce a lower stratum of the concrete.

21. A pre-fabricated formwork module for a building portion, the module including

one or more forms defining a void for forming concrete; and

locating structure by which the module may be located relative to a vertically adjacent like or similar module.

22. The module of claim 21 wherein the locating structure includes a locating element including

an engagement portion by which it is fixed relative to the forms; and

a lead-in portion to locate the vertically adjacent like or similar module.

23. The module of claim 21 or 22 wherein the forms are complementary to the forms of the like module when mounted atop the like module.

24. The module of any one of claims 21 to 23 including an inner form and an outer form, the outer form at least partly encircling the inner form to define the void about the inner form.

25. The module of claim 24 wherein each of the forms is tubular whereby said defined void is tubular.

26. The module of any one of claims 21 to 25 wherein a portion of one the forms projects upwardly beyond another portion of the forms to form an inner edge of a concrete structure above the other form portion.

27. The module of any one of claims 21 to 26 including one or more reinforcing bars fixed in position relative to the forms for transport and to reinforce the concrete.

28. The module of any one of claims 21 to 27 wherein at least one of the forms includes two or more panels; and each panel:

includes a boundary portion and one or more of the projecting structures; and

is at least predominantly integrally formed of sheet material;

the panels within the, or each, form being arranged such that their boundary portions together define a substantially continuous boundary for forming the concrete.

29. A building portion including the module of any one of claims 1 to 28 and concrete.

30. A locating element including

an engagement portion configured to engage with a formwork module in use; and

a lead-in portion to locate a vertically adjacent like or similar module in use.

31. A locating element as claimed in claim 30 wherein the engagement portion includes:

a flange insertable to engage a formwork module; and

a stop portion to limit the insertion of the flange.

32. The locating element of claim 31 wherein the lead-in portion and the stop portion are respective sides of a triangular portion.

33. The locating element of claim 32 wherein the triangular portion is tubular.

34. A panel for a building portion; the panel including:

a boundary portion for forming concrete, and

one or more projecting structures projecting from the boundary portion to project into the concrete and defining one or more receiving voids opening outwardly from the boundary to receive one or more reinforcing bars.

35. The panel of claim 34 being at least predominantly integrally formed of sheet material.

36. The panel of claim 34 or 35 wherein an edge portion of the sheet material is deflected relative to the boundary portion to form the projecting structure.

37. The panel of claim 36 including

an edge portion opposite the deflected edge portion;

a presentation surface outward from the concrete;

a region adjacent the deflected edge portion recessed relative to the presentation surface to receive the opposite edge portion of a like adjacent panel whereby the presentation surfaces of the adjacent panels substantially align.

38. The panel of any one of claims 34 to 37 wherein the receiving voids are shaped for the panels to be formed from interleaved blanks.

39. The panel of claims 34 to 38 wherein portions of the projecting structures defining the receiving voids are shaped to carry a reinforcing bar at a predetermined spacing from the boundary.

40. The panel of claims 34 to 39 wherein the portions of the projecting structures defining the receiving voids are shaped to carry at least two reinforcing bars at at least two different predetermined spacings from the boundary.

41. The panel of claims 34 to 40 wherein each projecting structure defines a supporting structure carrying a reinforcing bar.

42. The panel of claim 41 wherein the supporting structure includes a channel.

43. A method of building a building portion including

installing one or more modules of any one of claims 1 to 28 at a building site to create at least part of a concrete formwork structure;

filling the concrete formwork structure with wet concrete;

allowing the concrete to cure.

44. A method of building a building portion including

installing the module of any one of claims 21 to 28 at a building site to provide a formwork structure for at least part of a building;

filling the concrete formwork structure with wet concrete;

installing a like module atop the module.

45. The method of claim 44 wherein the concrete is allowed to at least partially cure to strengthen the building portion before installing the like module.

46. The method of claim 43, 44 or 45 including leaving the module in place to protect the cured concrete during the life of the building.

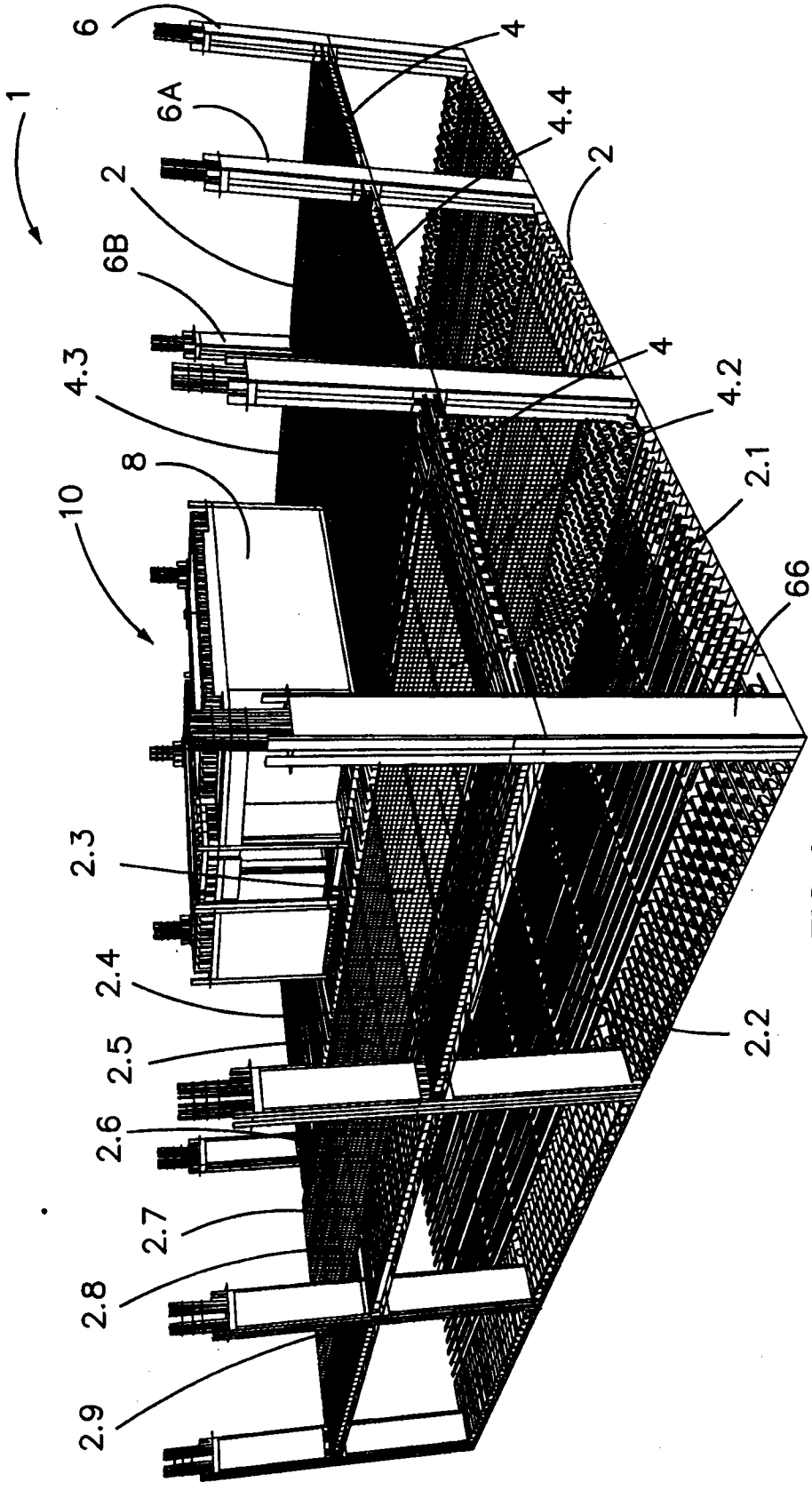


FIG. 1

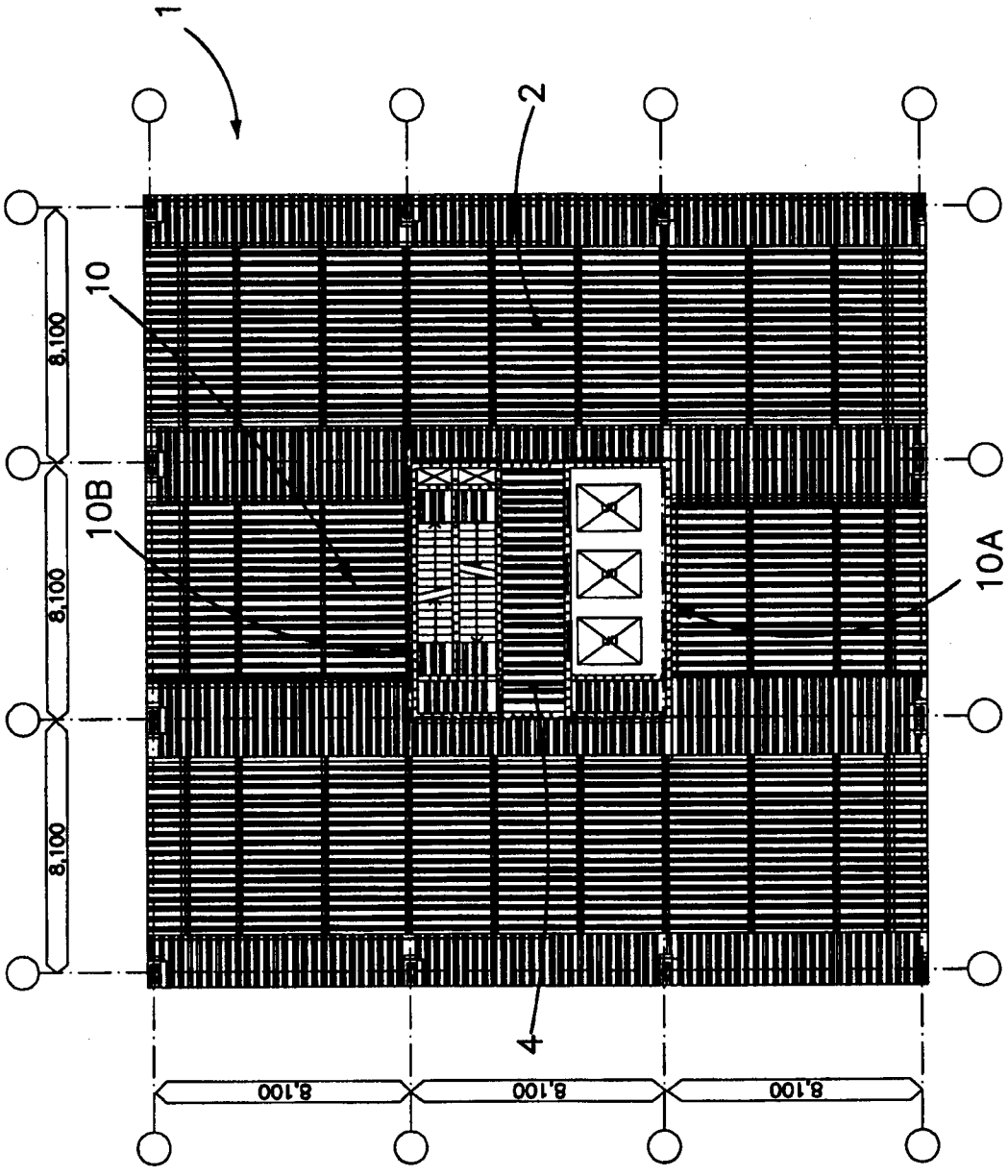


FIG. 2

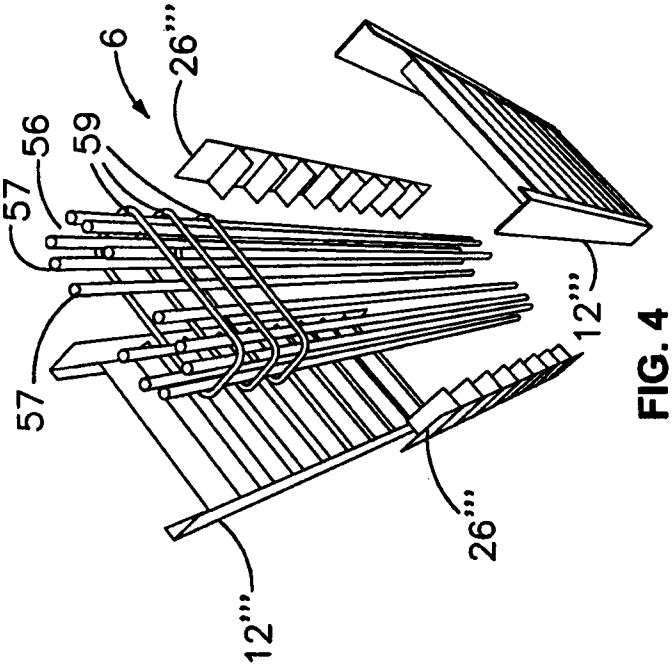


FIG. 4

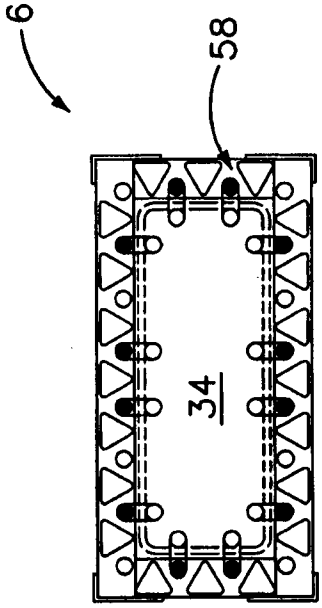


FIG. 5

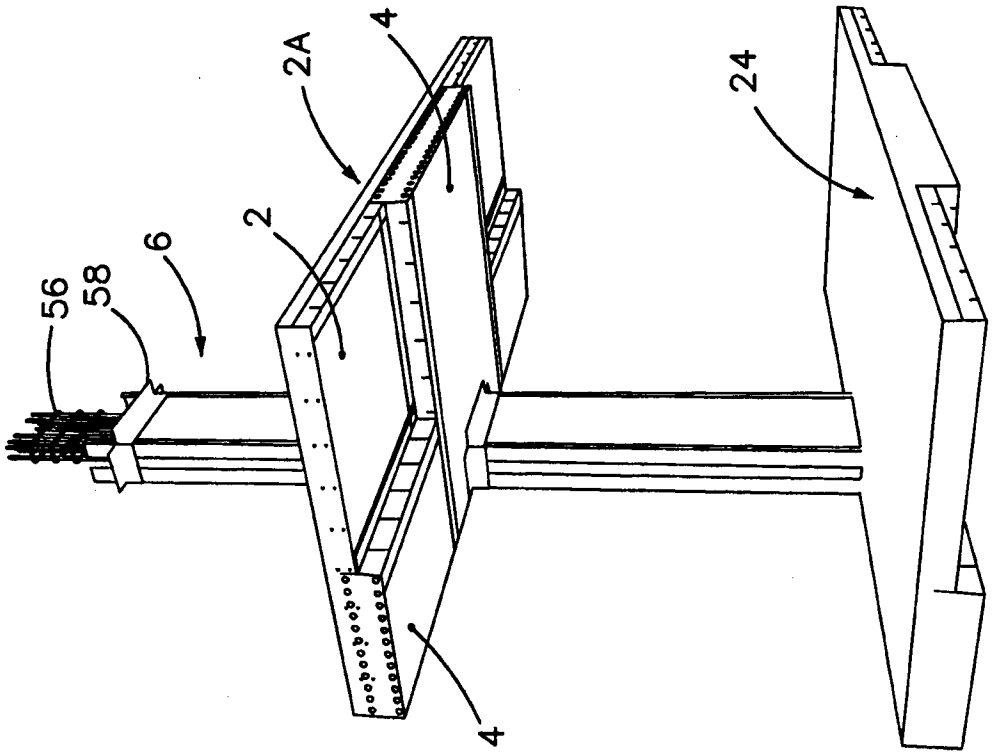


FIG. 3

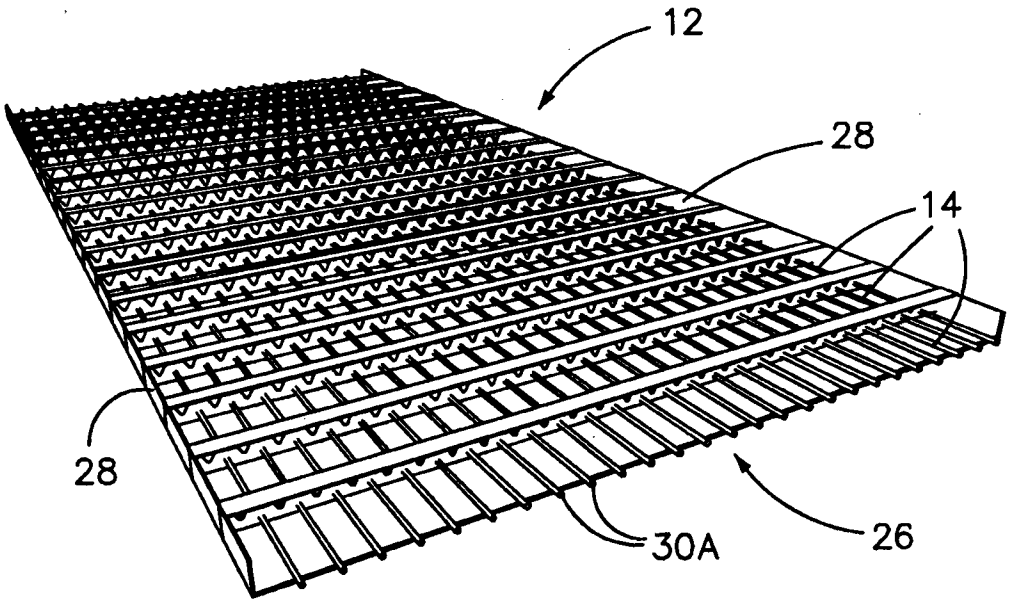


FIG. 6

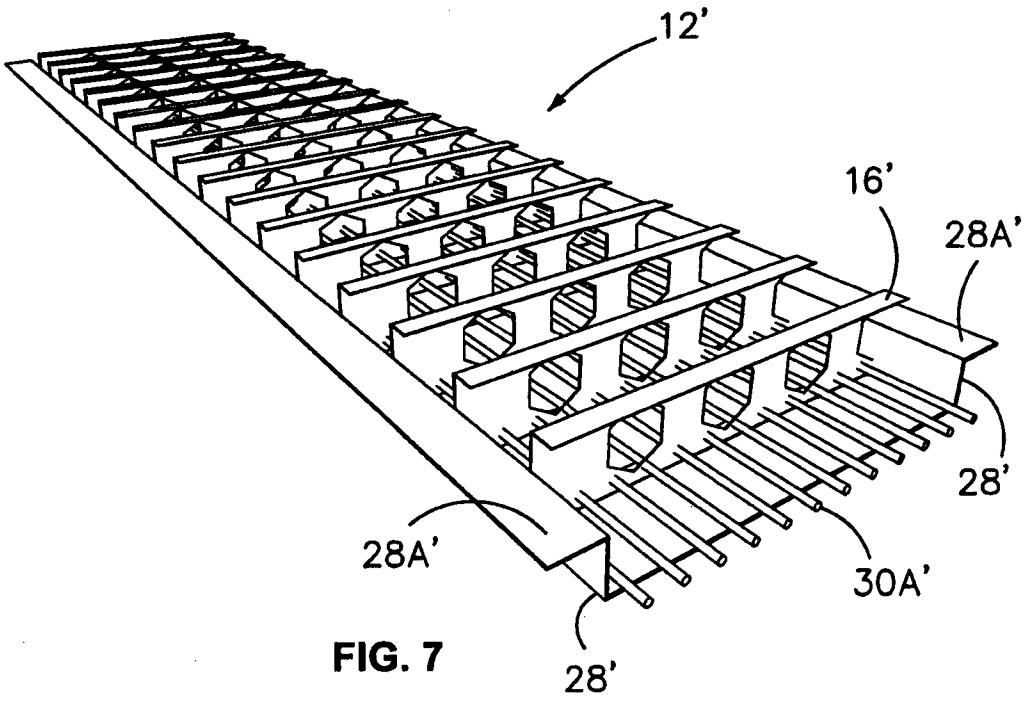


FIG. 7

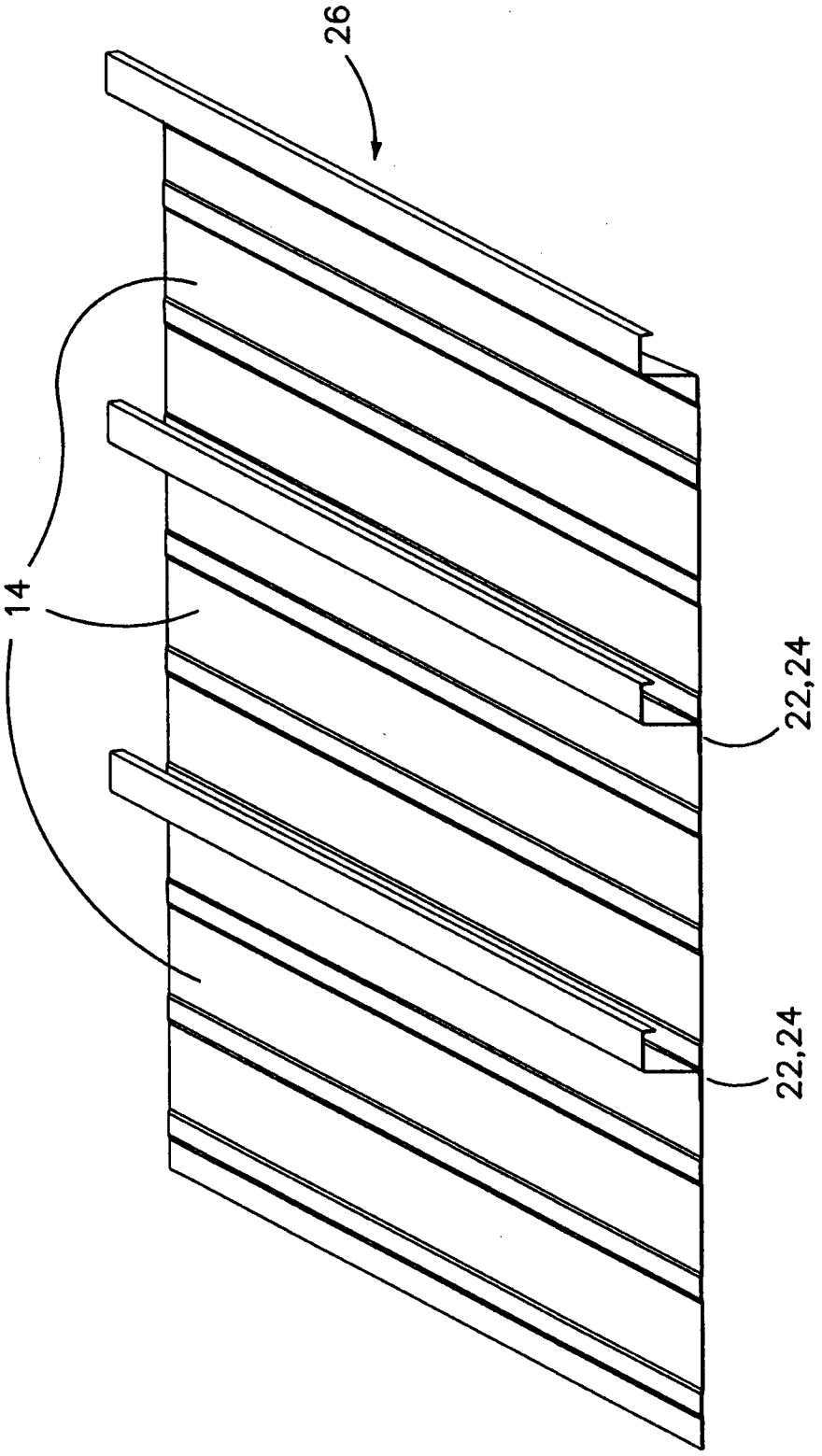


FIG. 8B

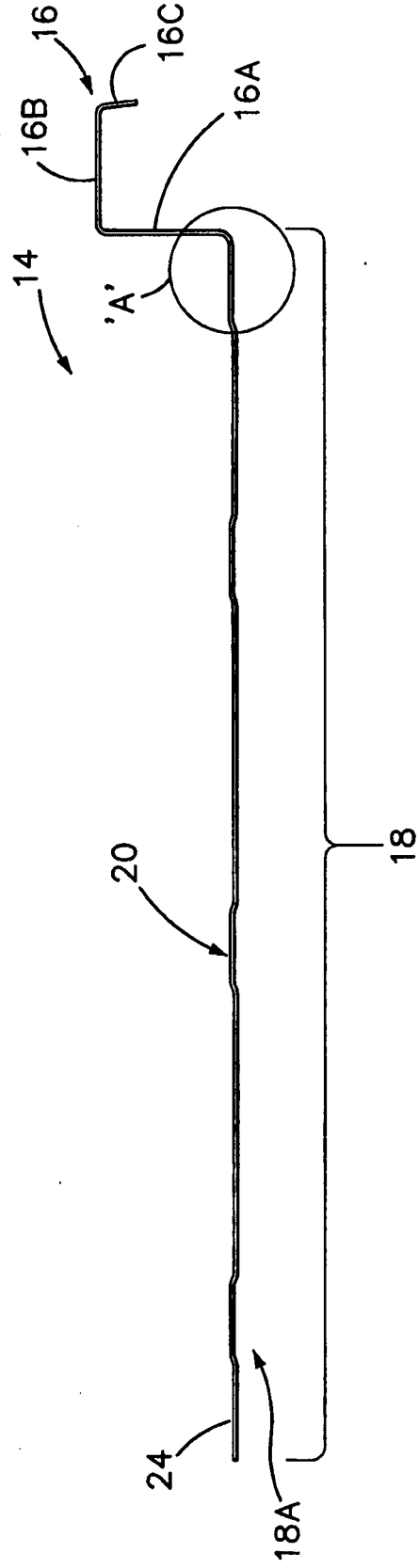


FIG. 8A

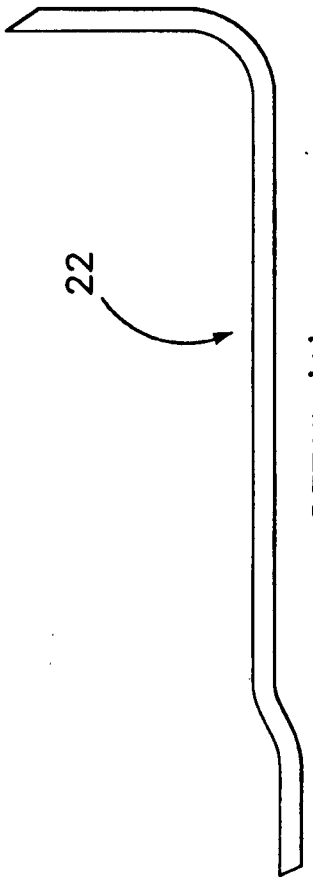


FIG. 9

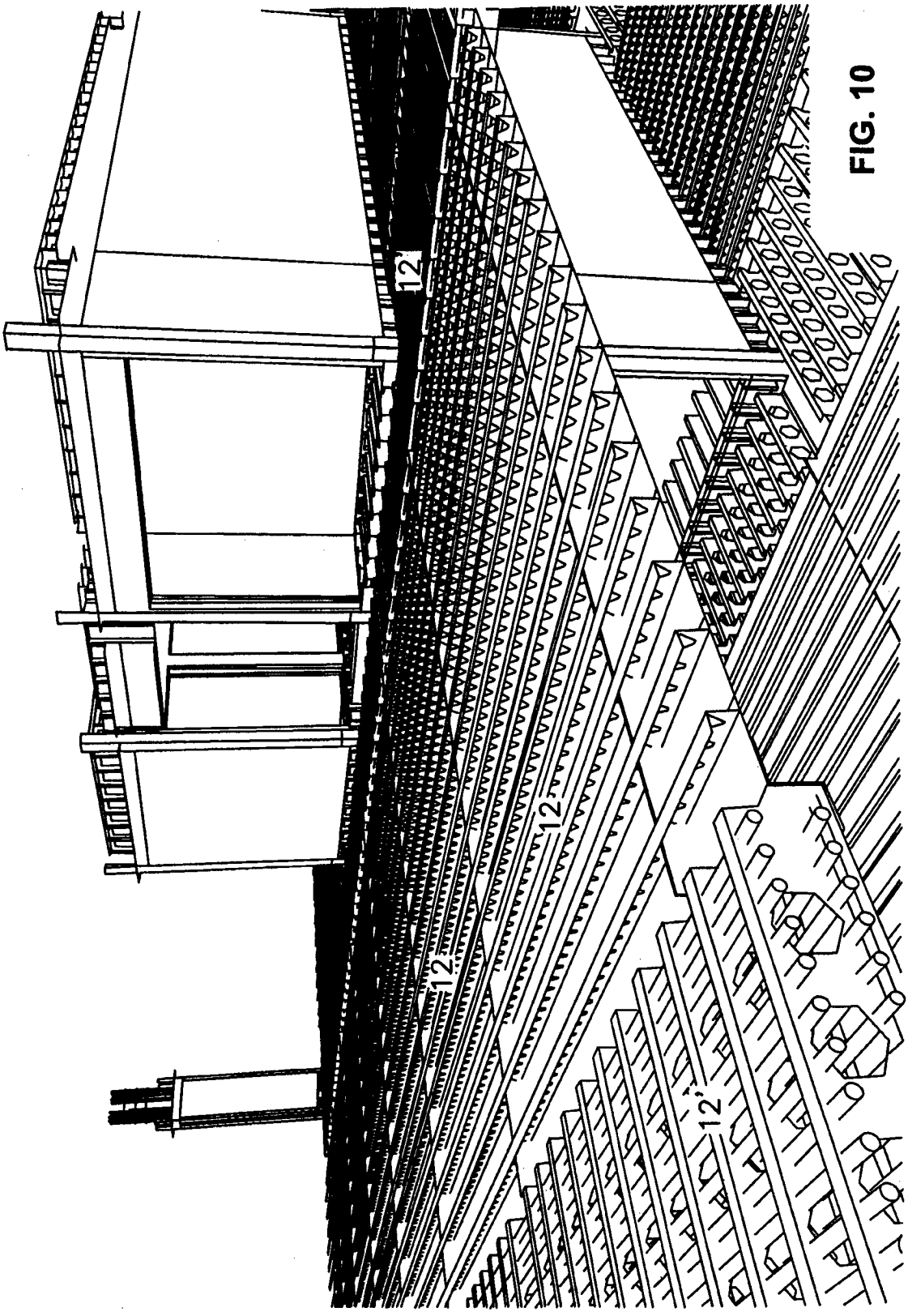


FIG. 10

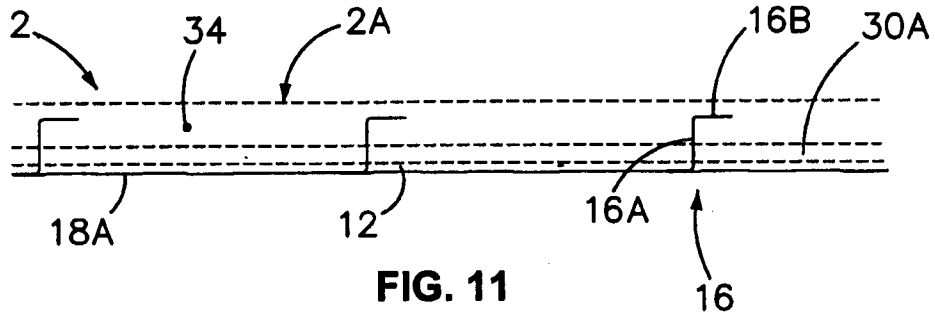


FIG. 11

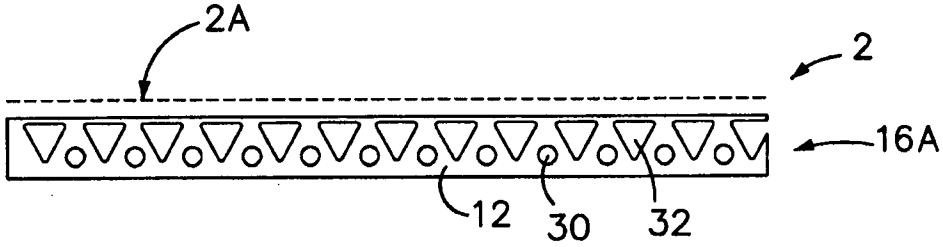


FIG. 12

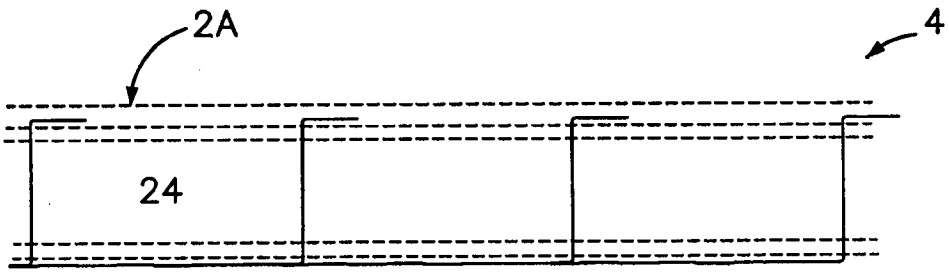


FIG. 13

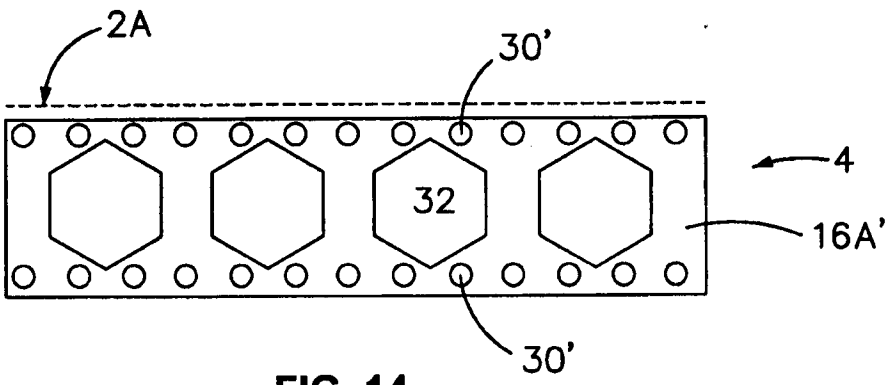


FIG. 14

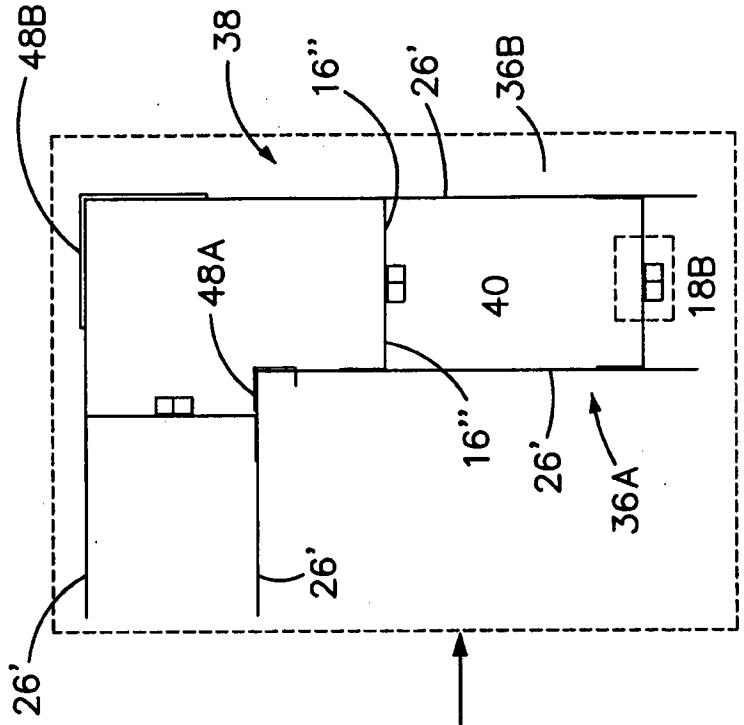


FIG. 18

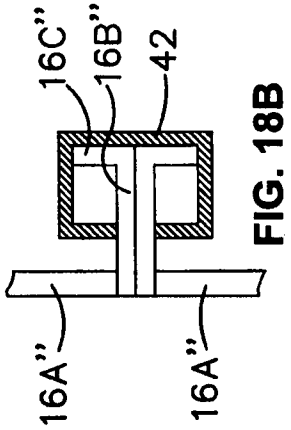


FIG. 18B

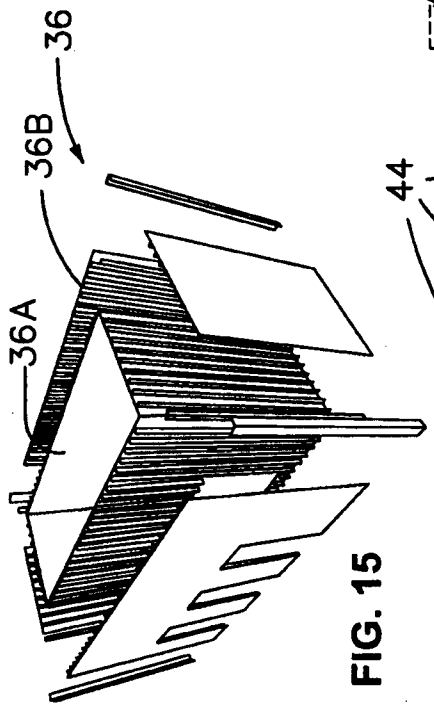


FIG. 15

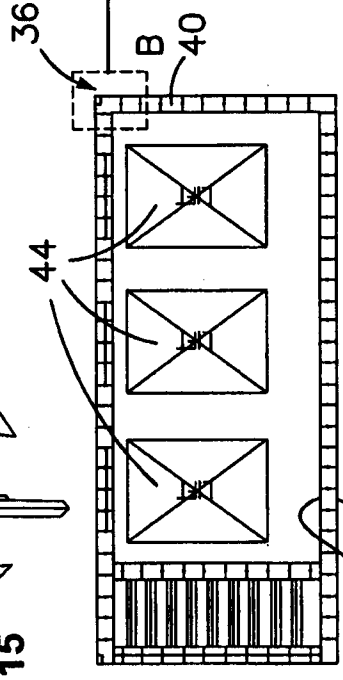


FIG. 16

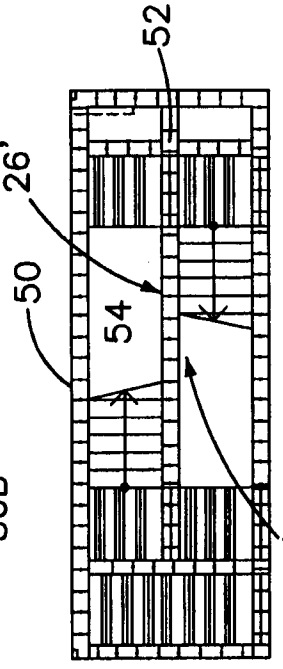


FIG. 17

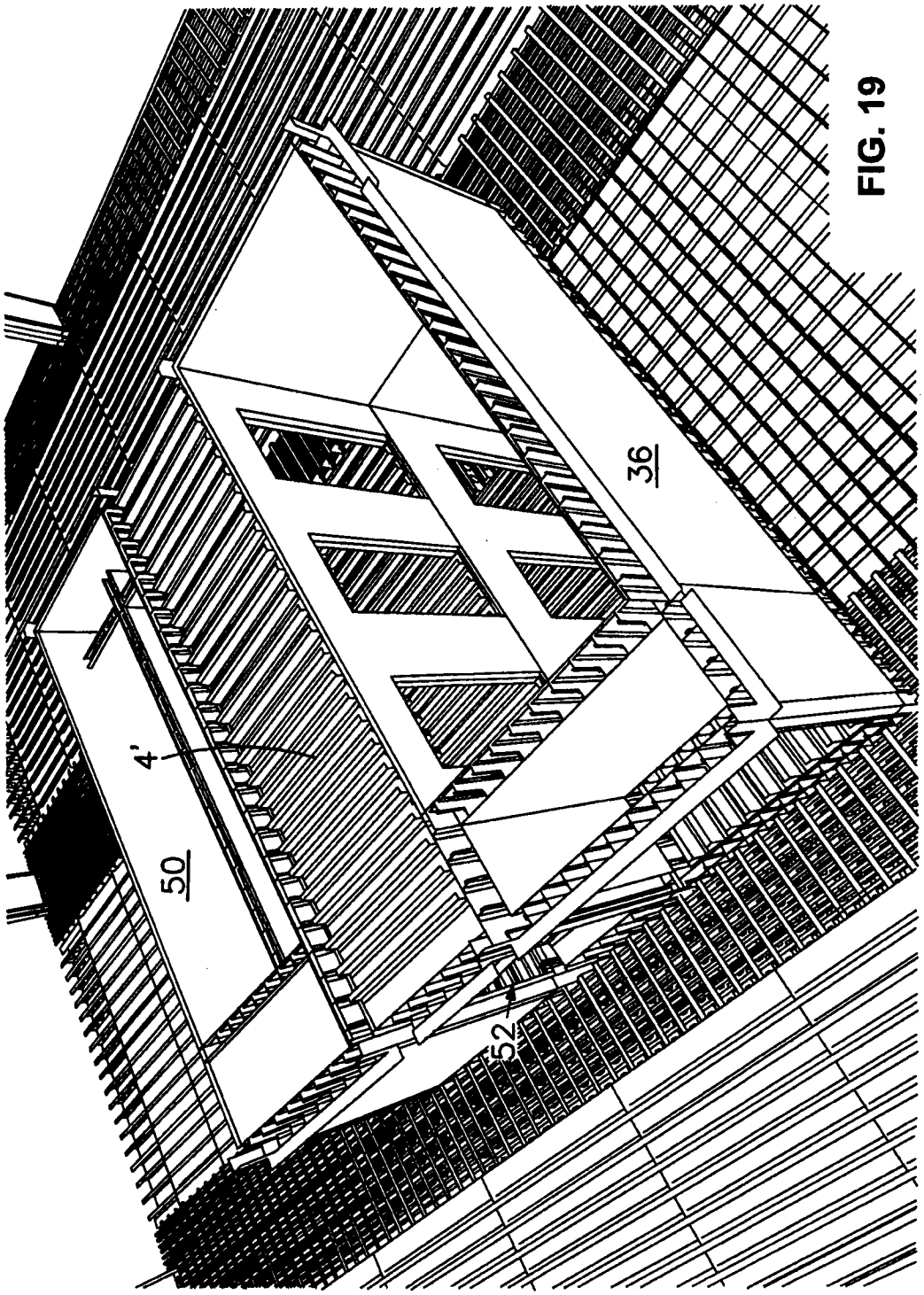


FIG. 19

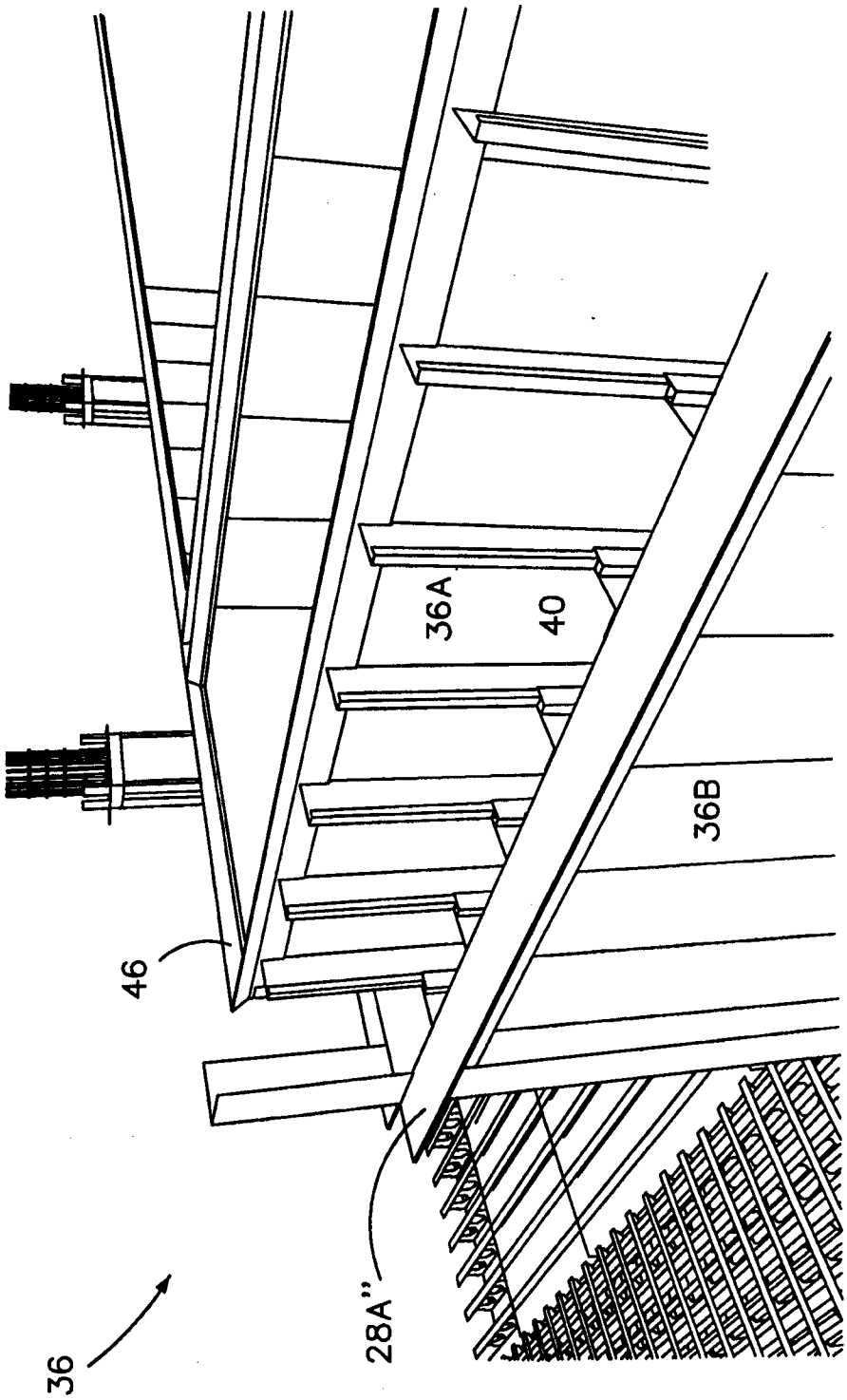


FIG. 20

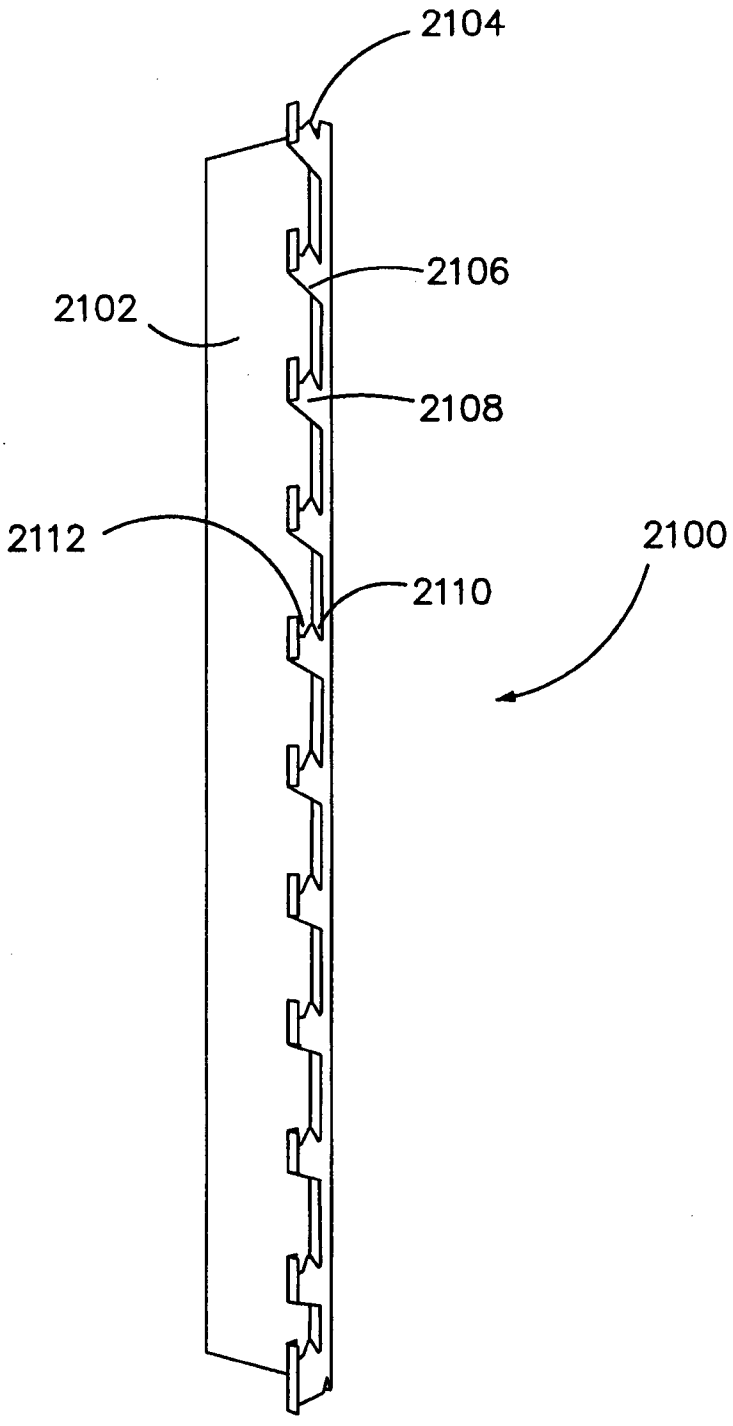


FIG. 21

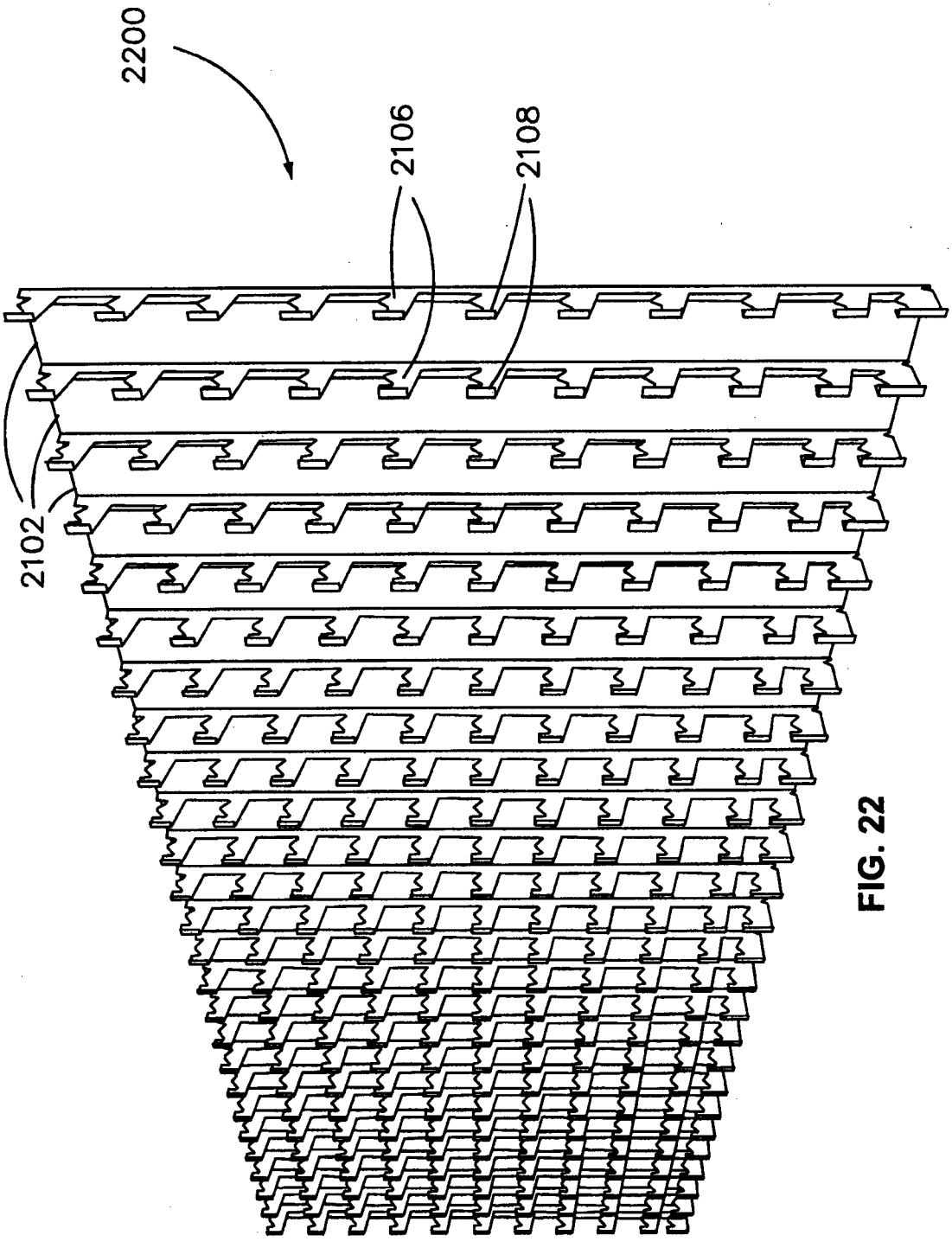


FIG. 22

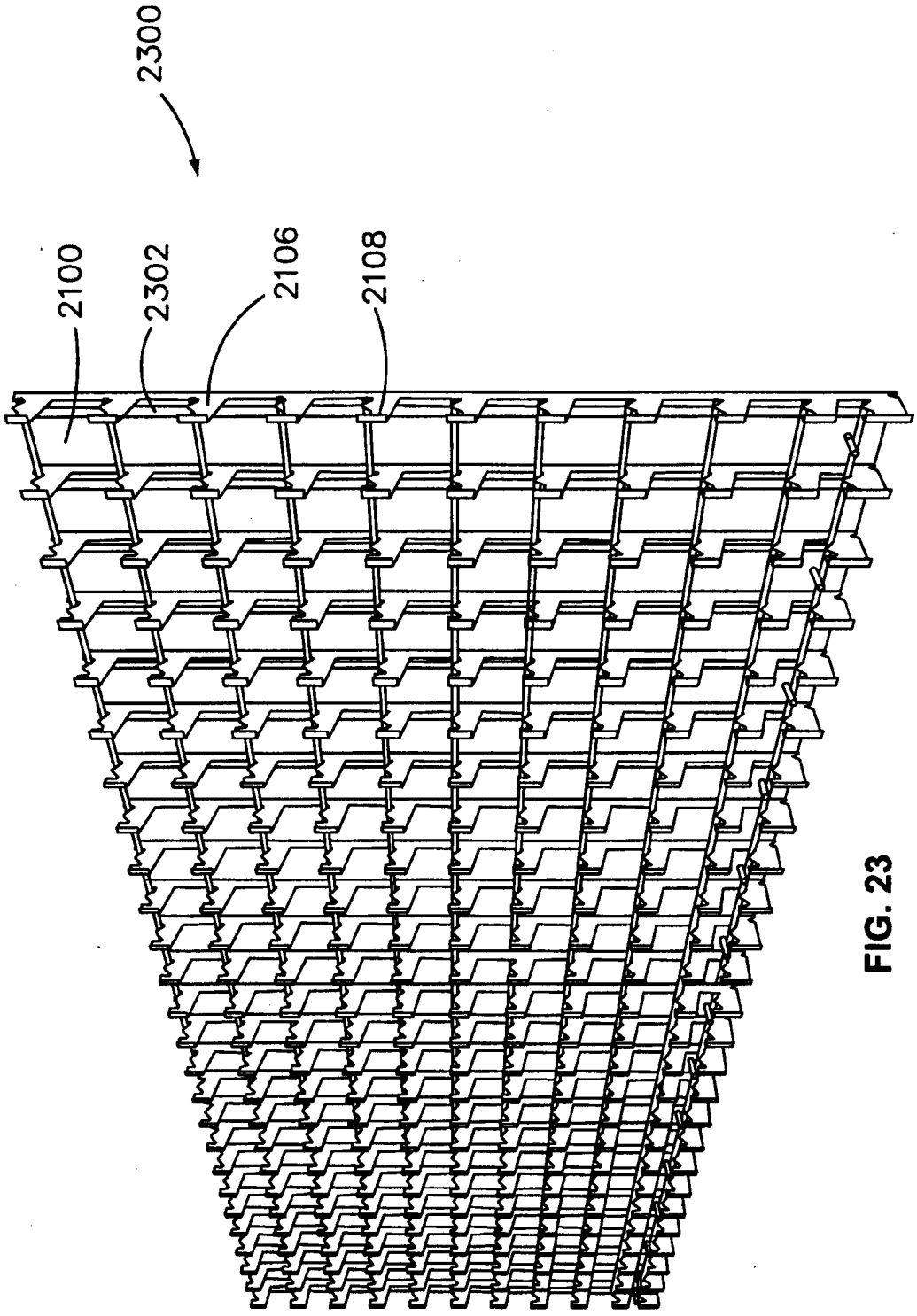


FIG. 23

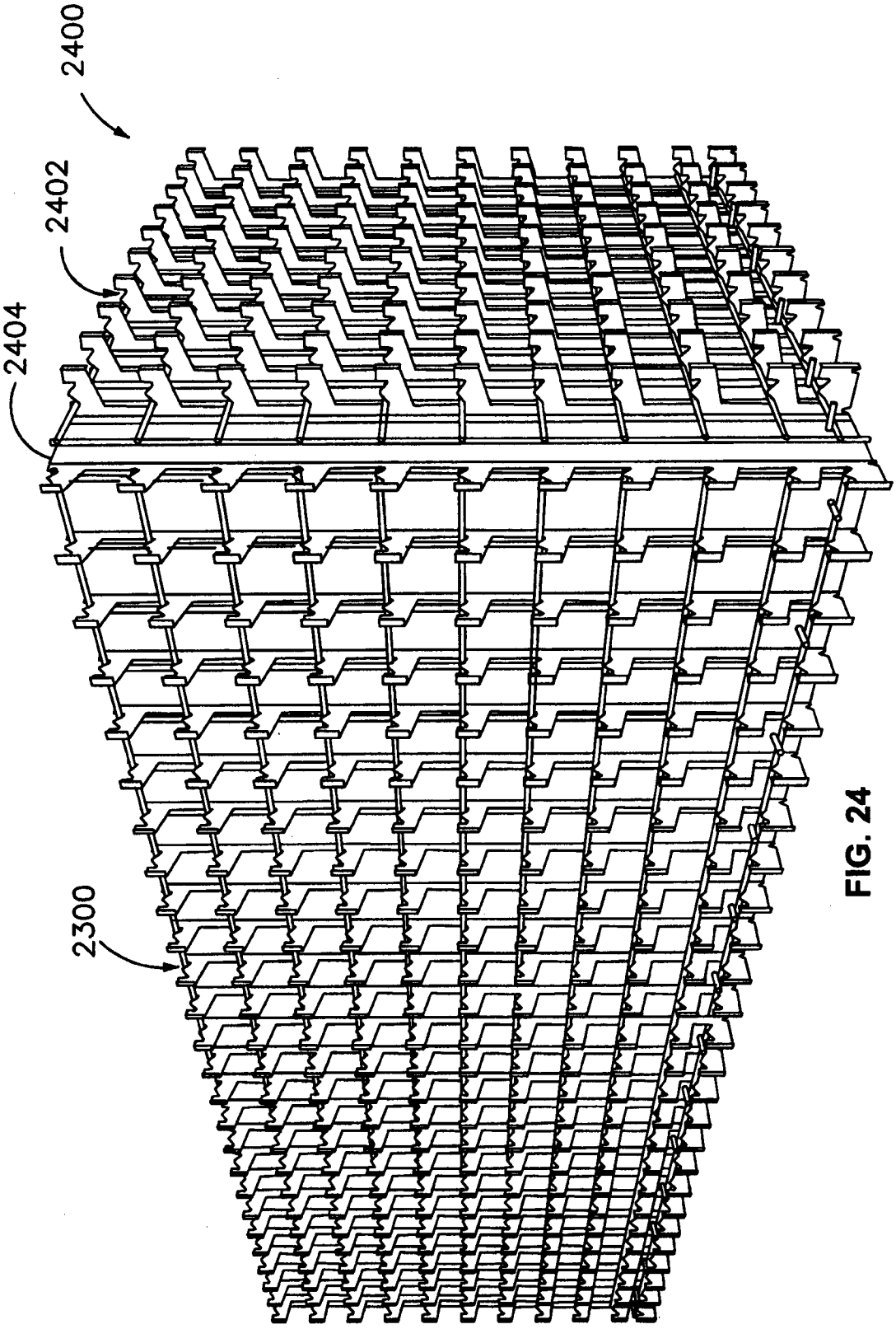


FIG. 24

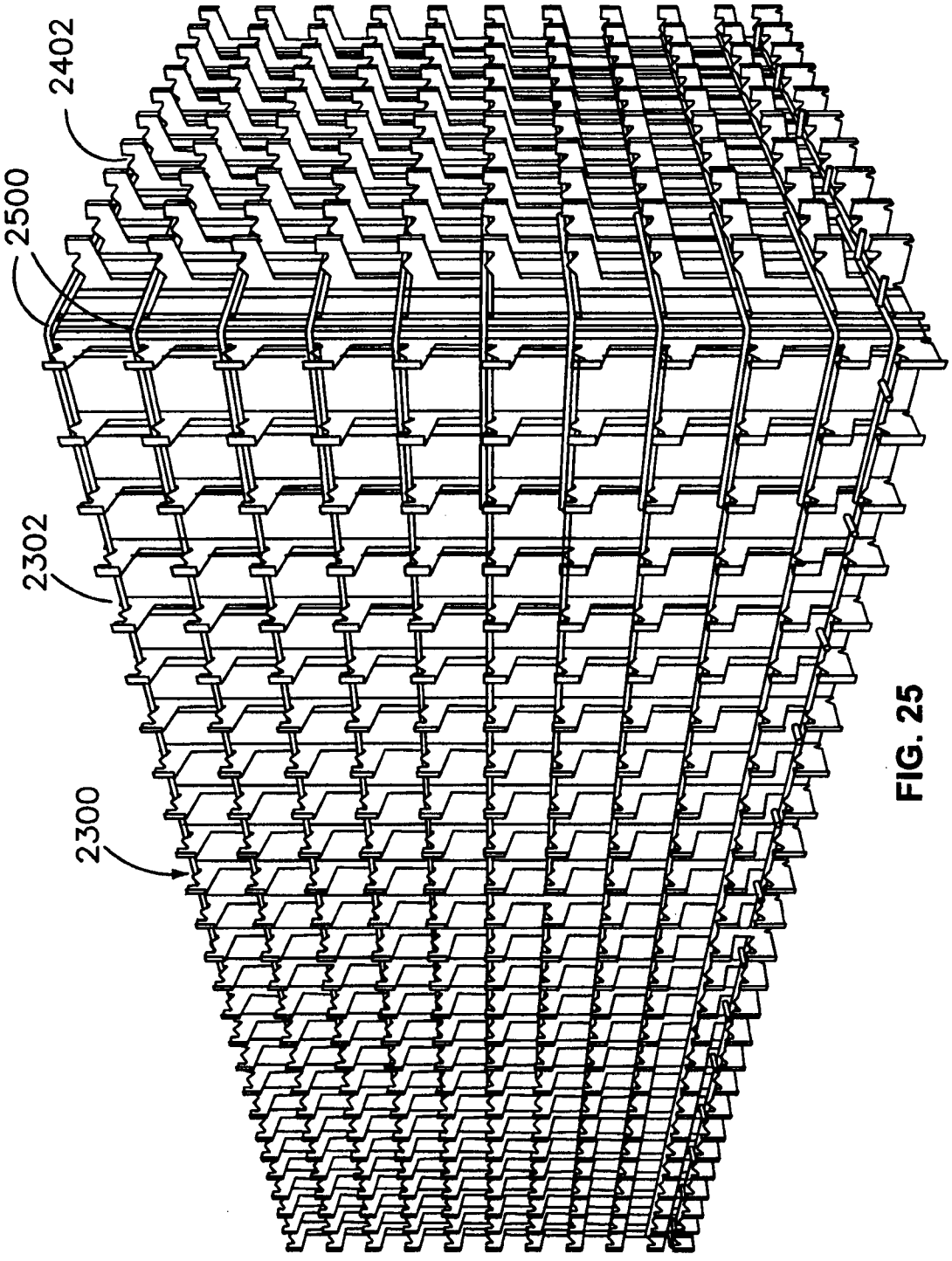


FIG. 25

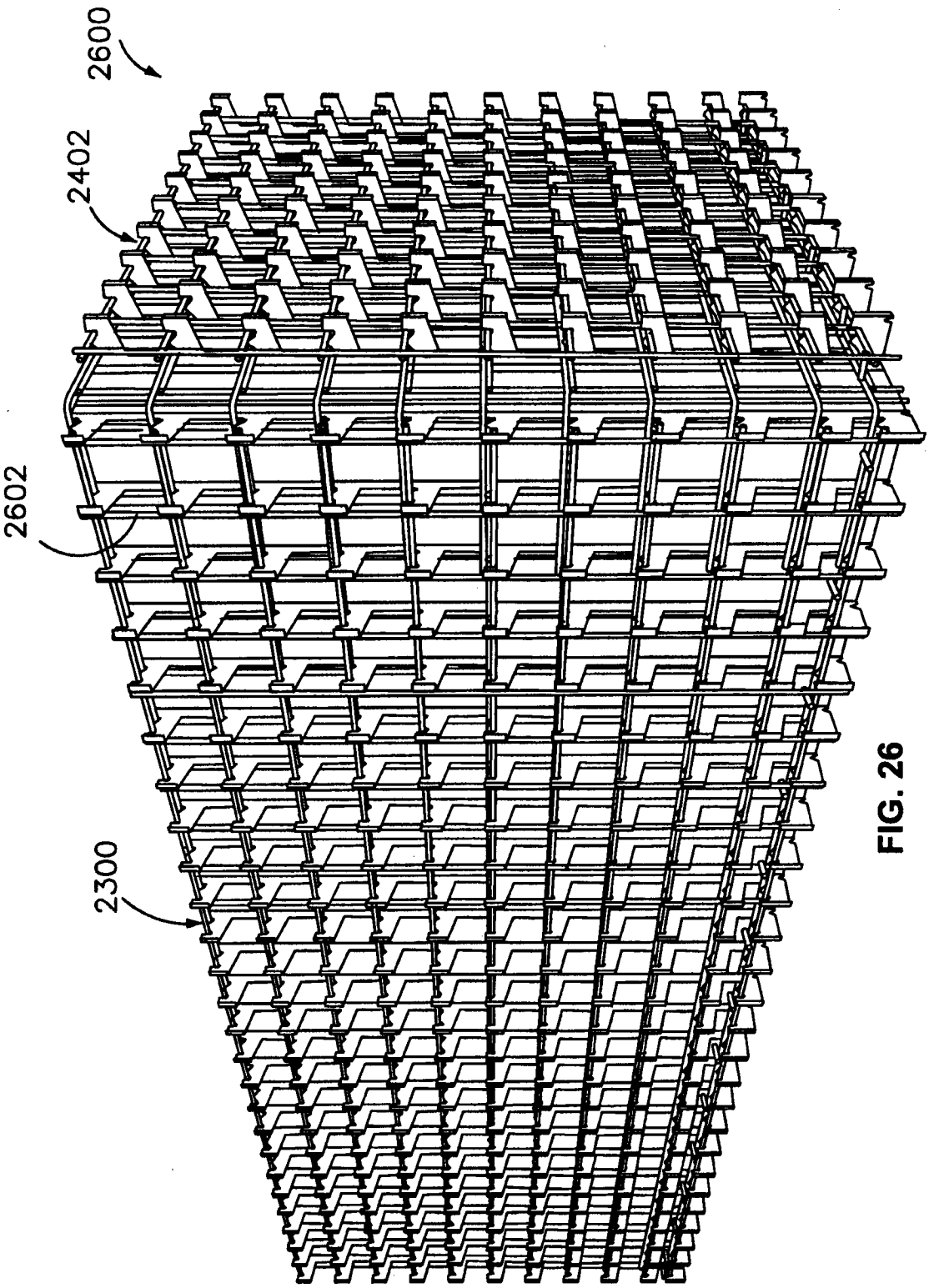


FIG. 26

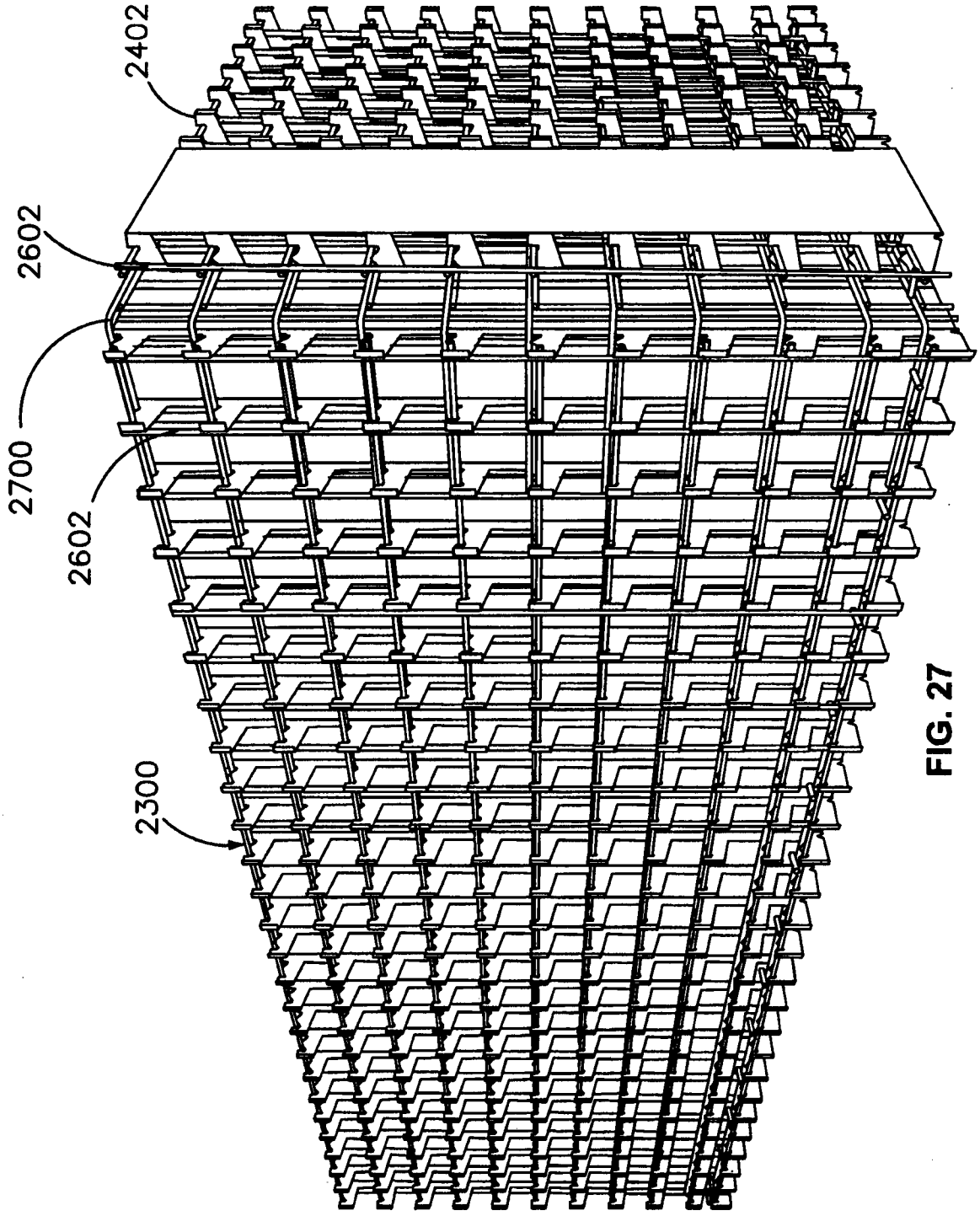


FIG. 27

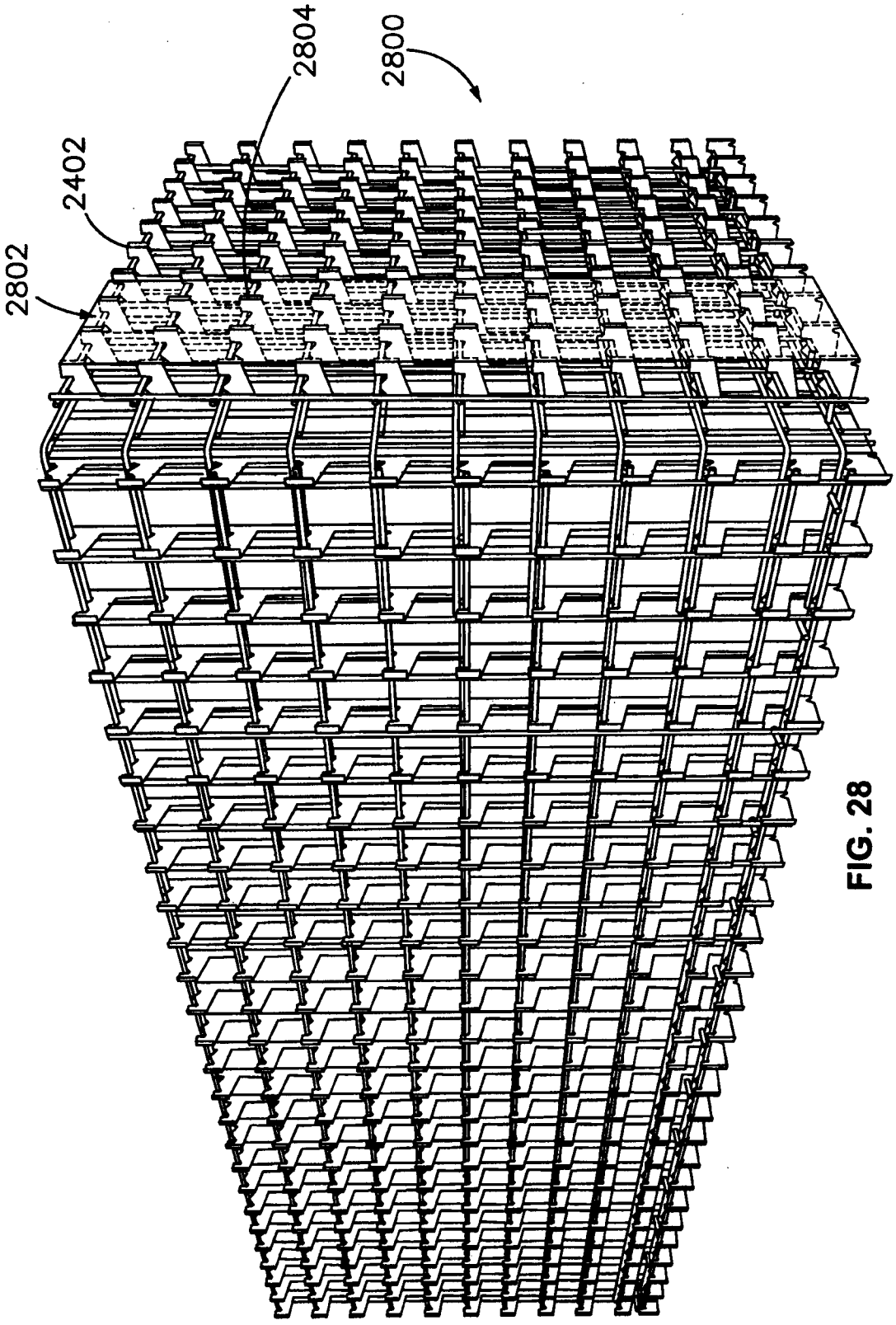


FIG. 28

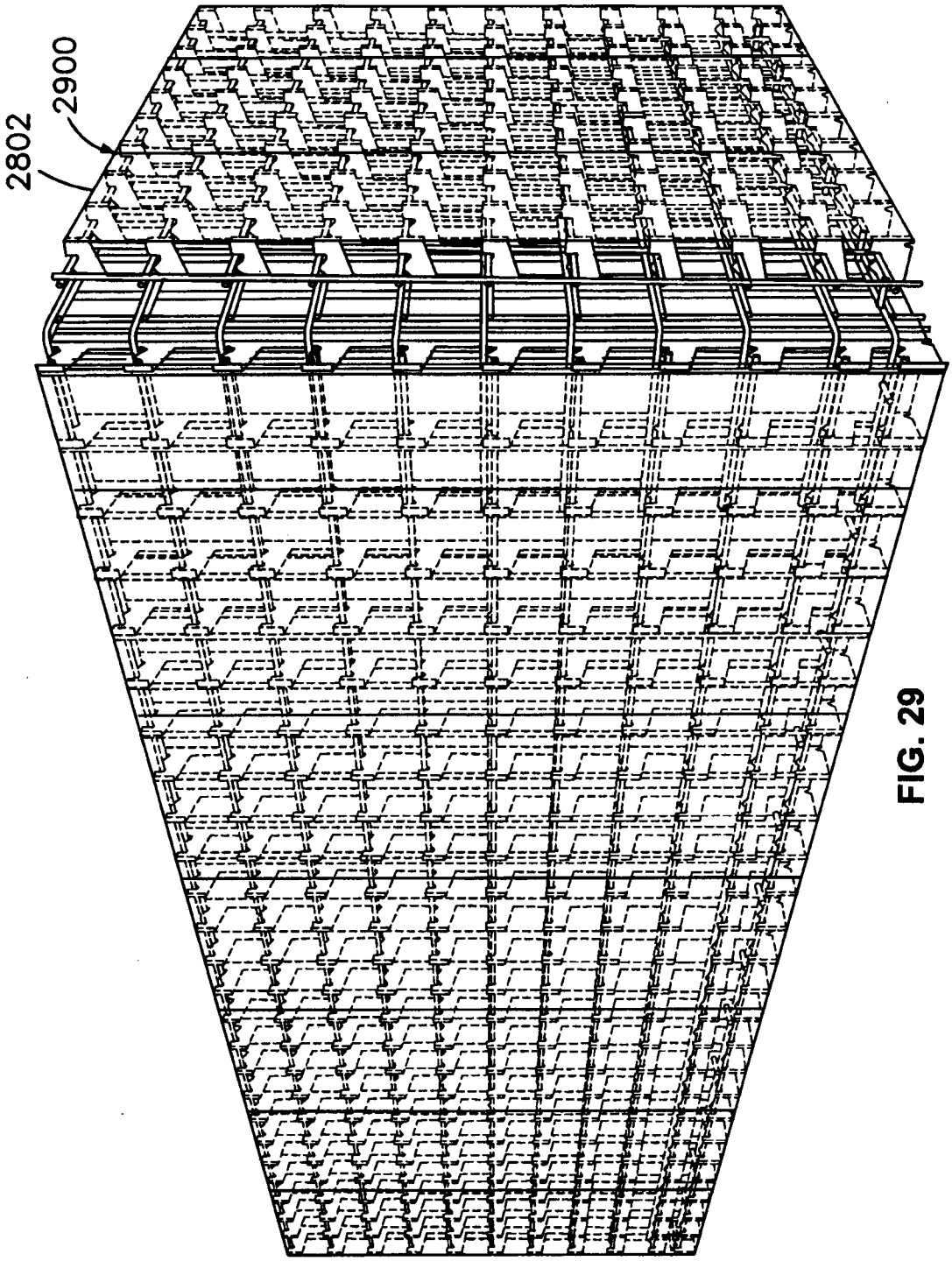


FIG. 29

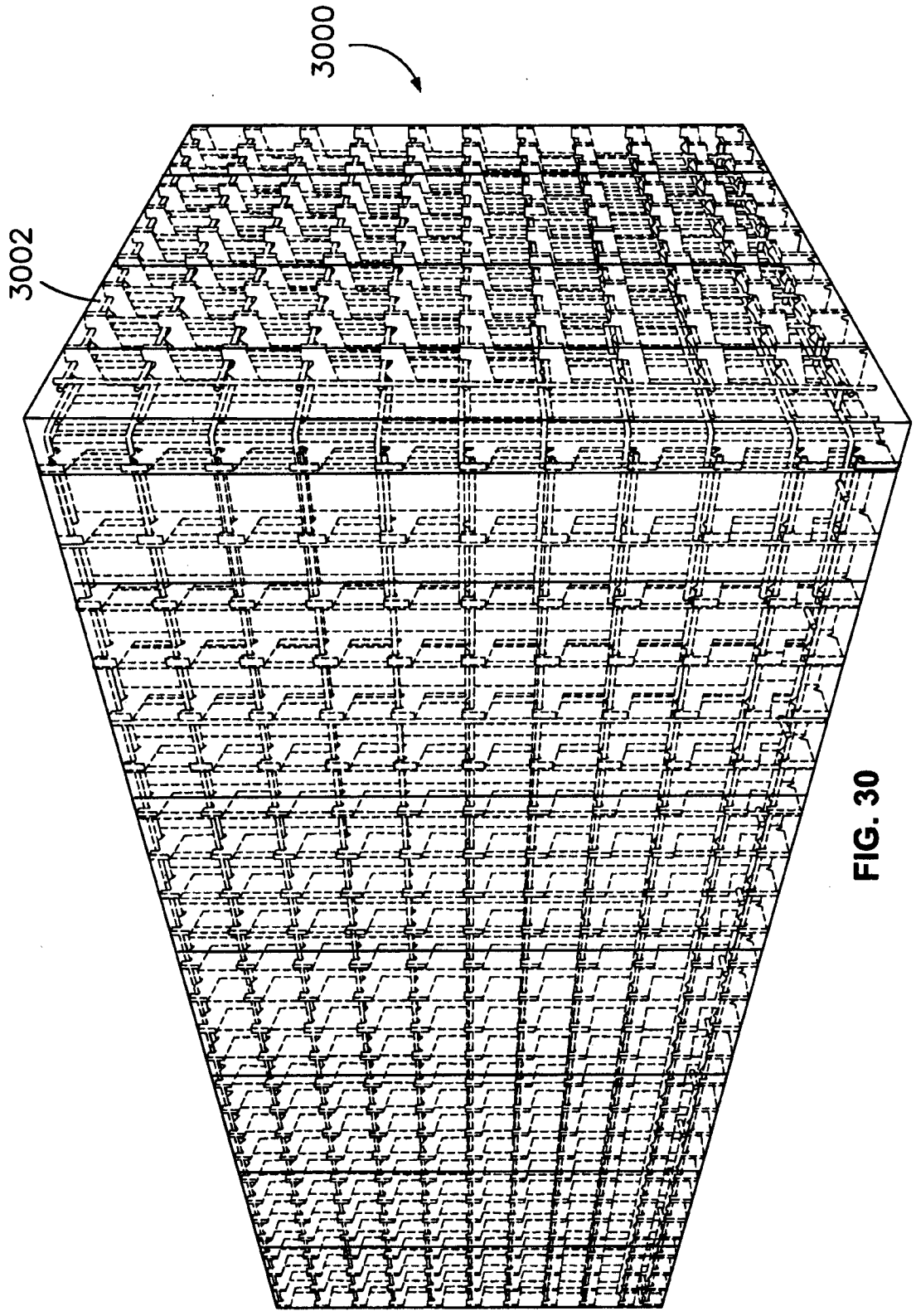


FIG. 30

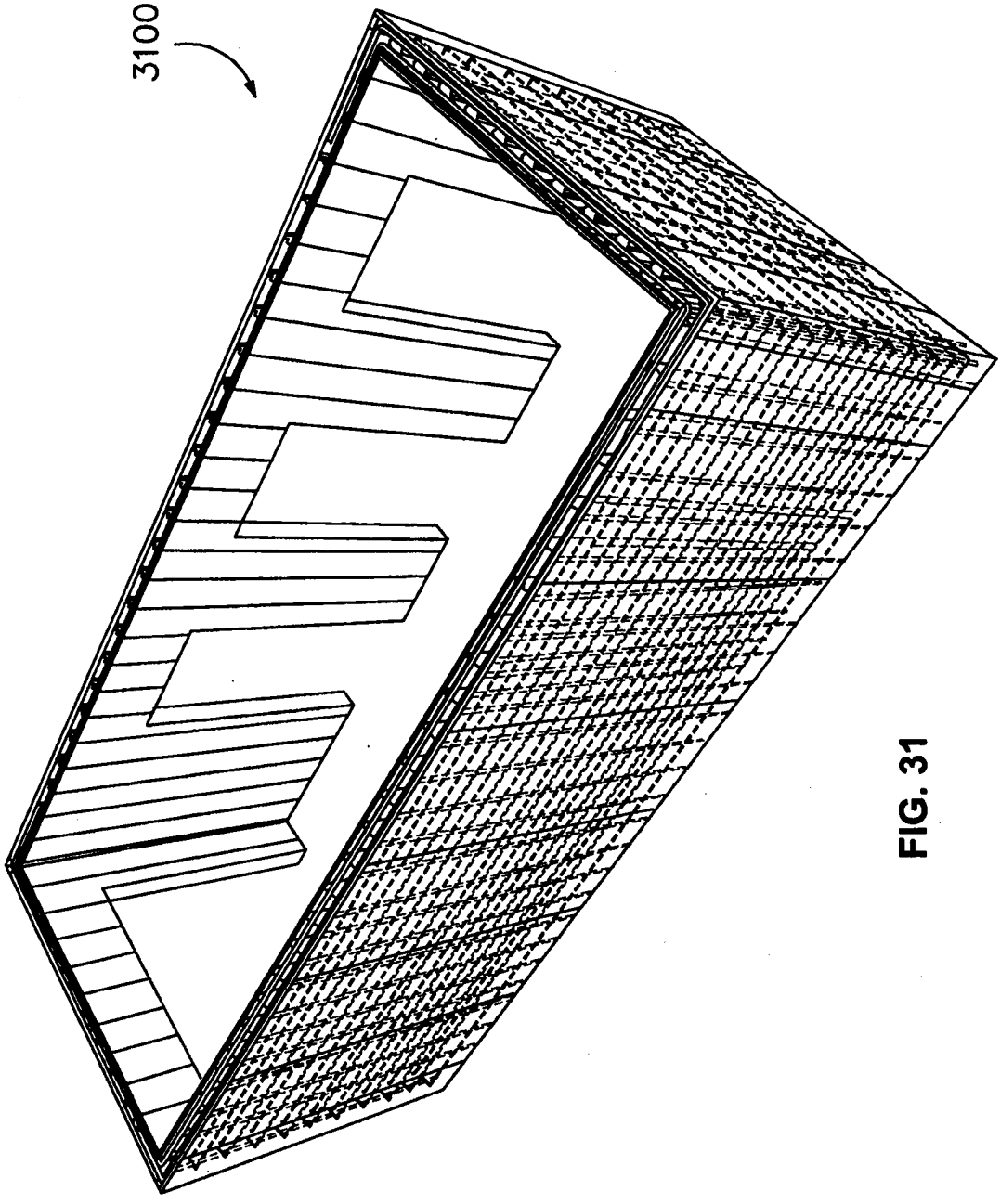


FIG. 31

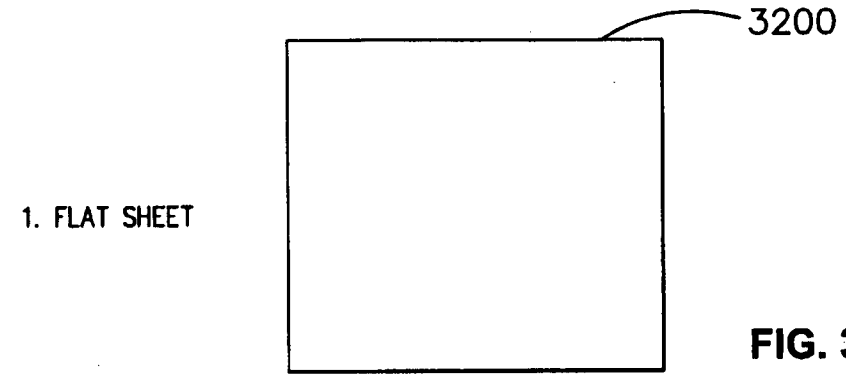


FIG. 32A

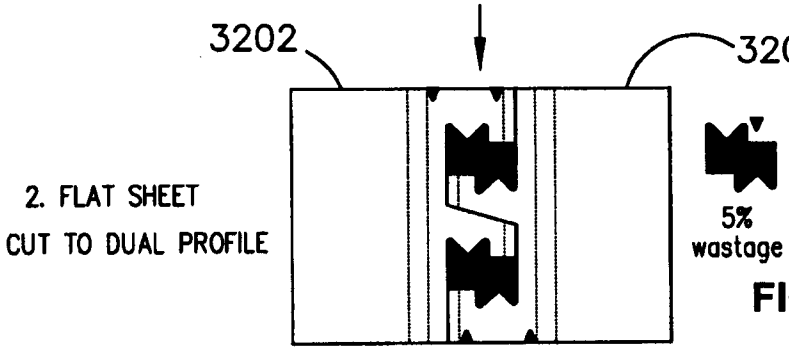


FIG. 32B

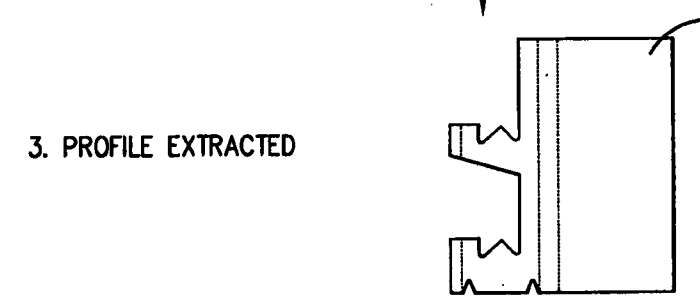


FIG. 32C

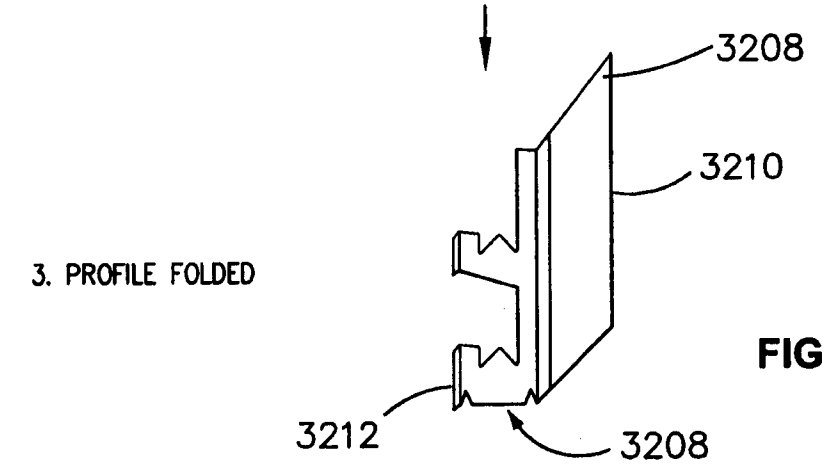


FIG. 32D

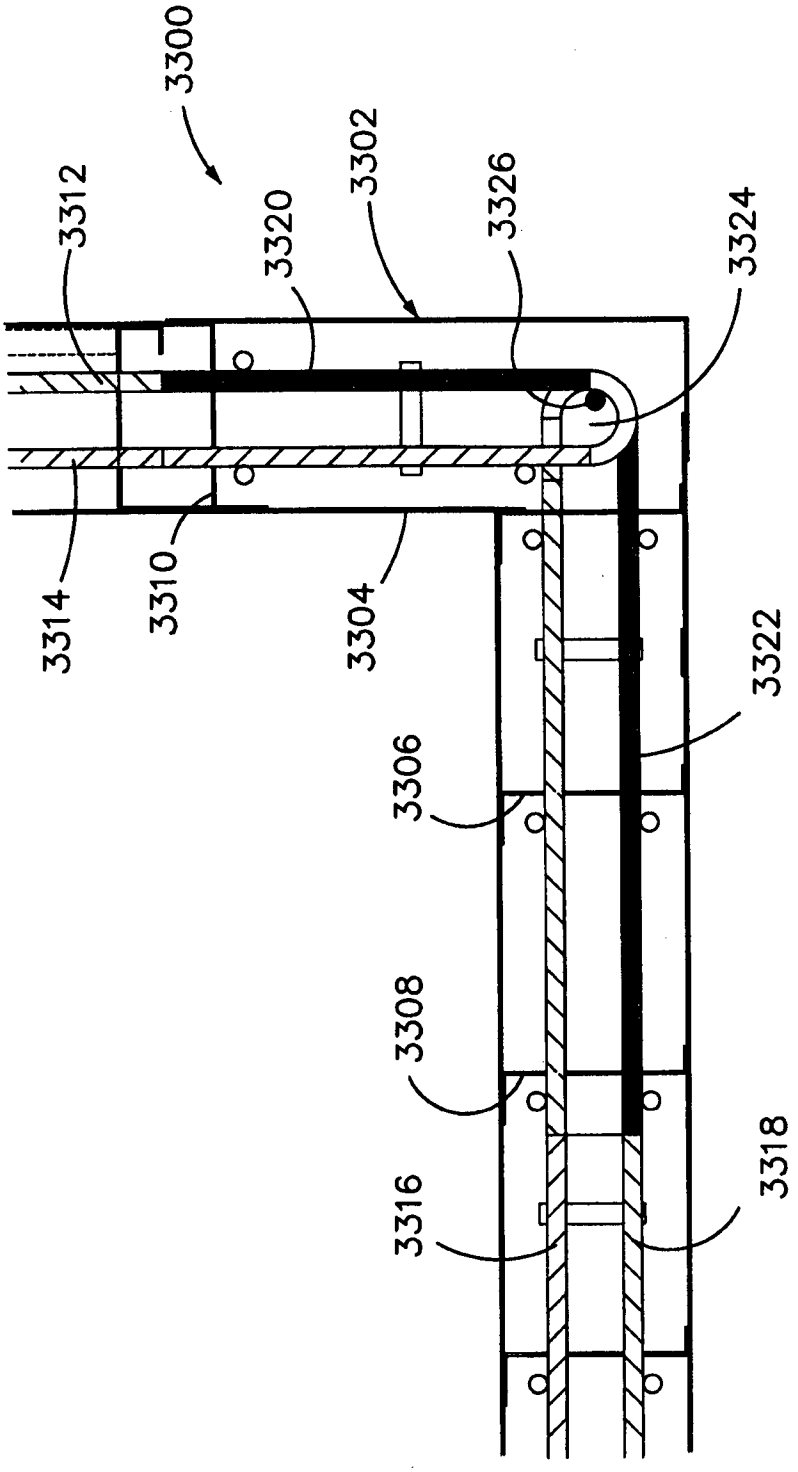

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FIG. 33

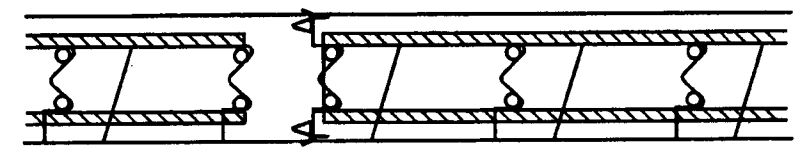


FIG. 34D

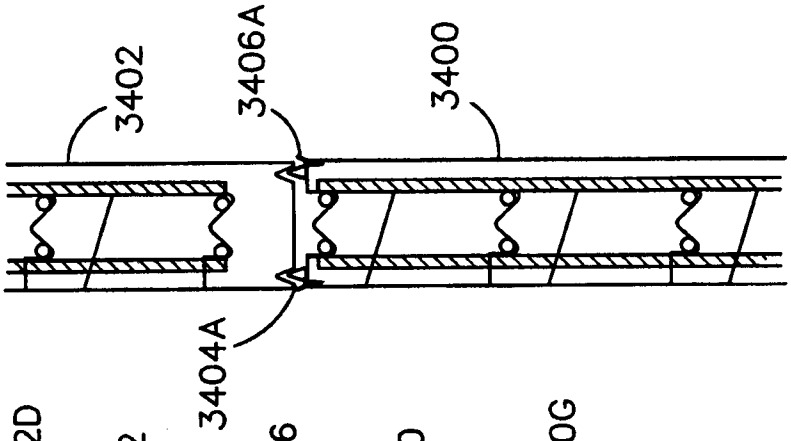


FIG. 34C

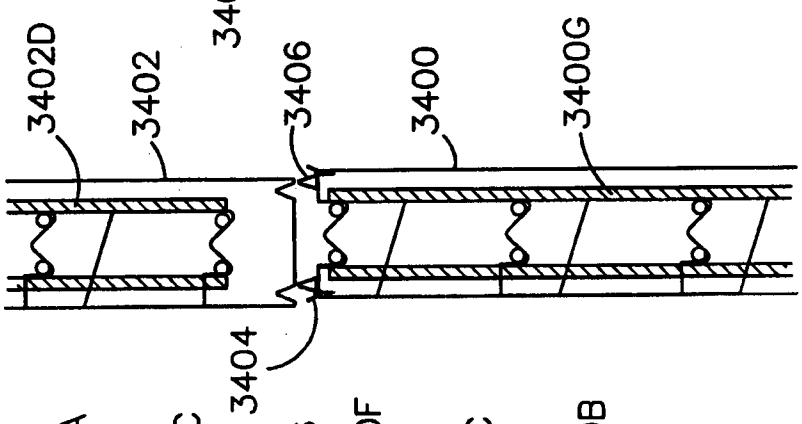


FIG. 34B

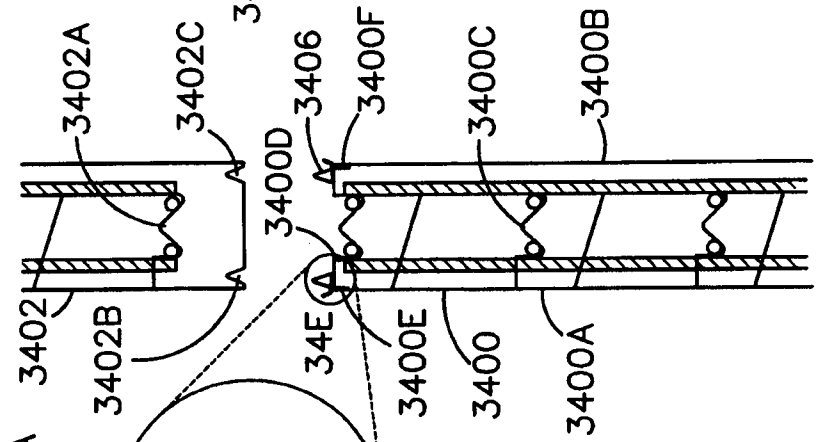


FIG. 34A

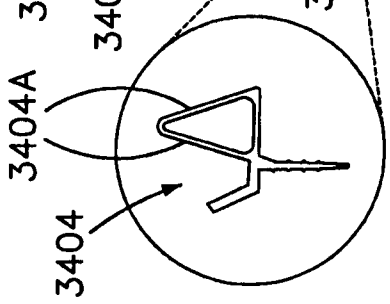


FIG. 34E

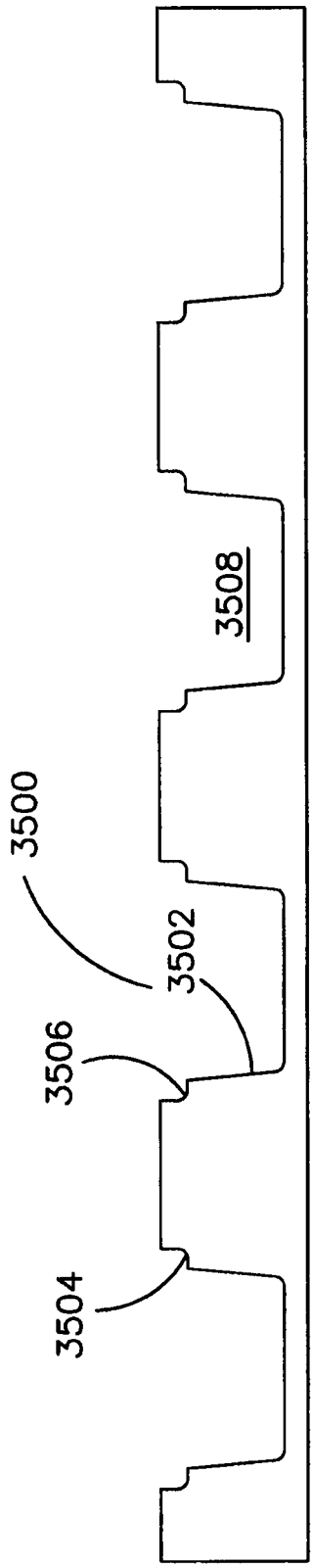


FIG. 35

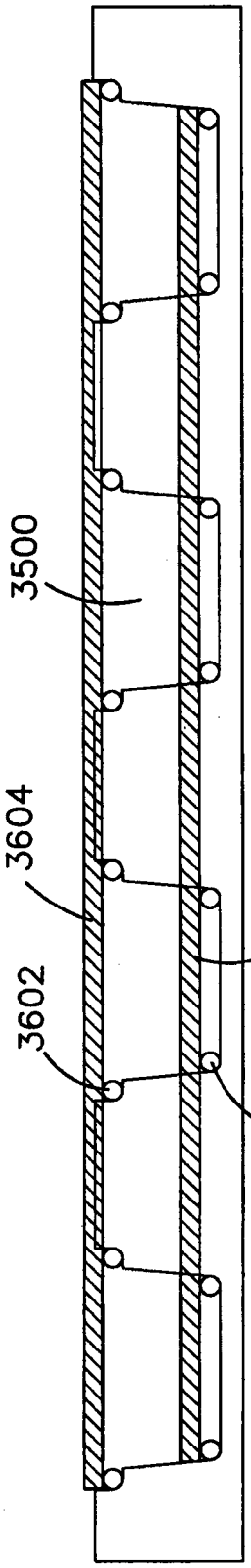


FIG. 36

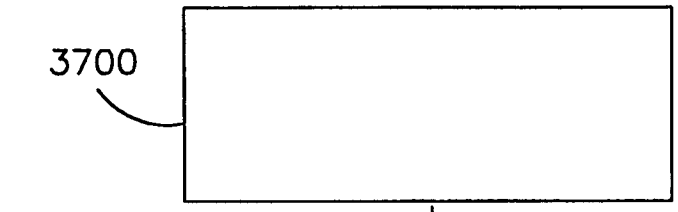


FIG. 37A

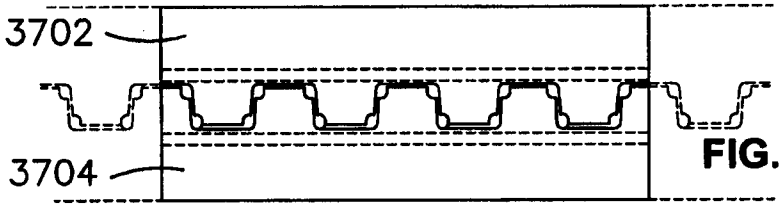


FIG. 37B



FIG. 37C

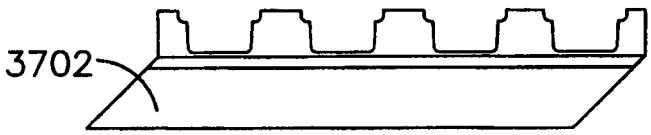


FIG. 37D

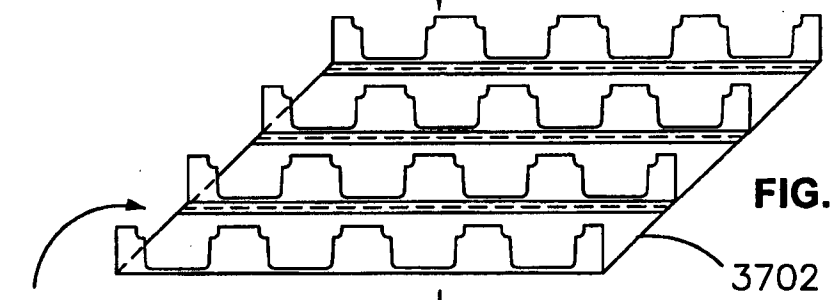


FIG. 37E

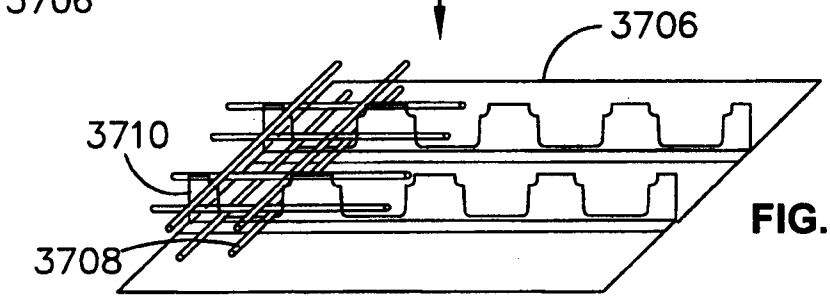


FIG. 37F

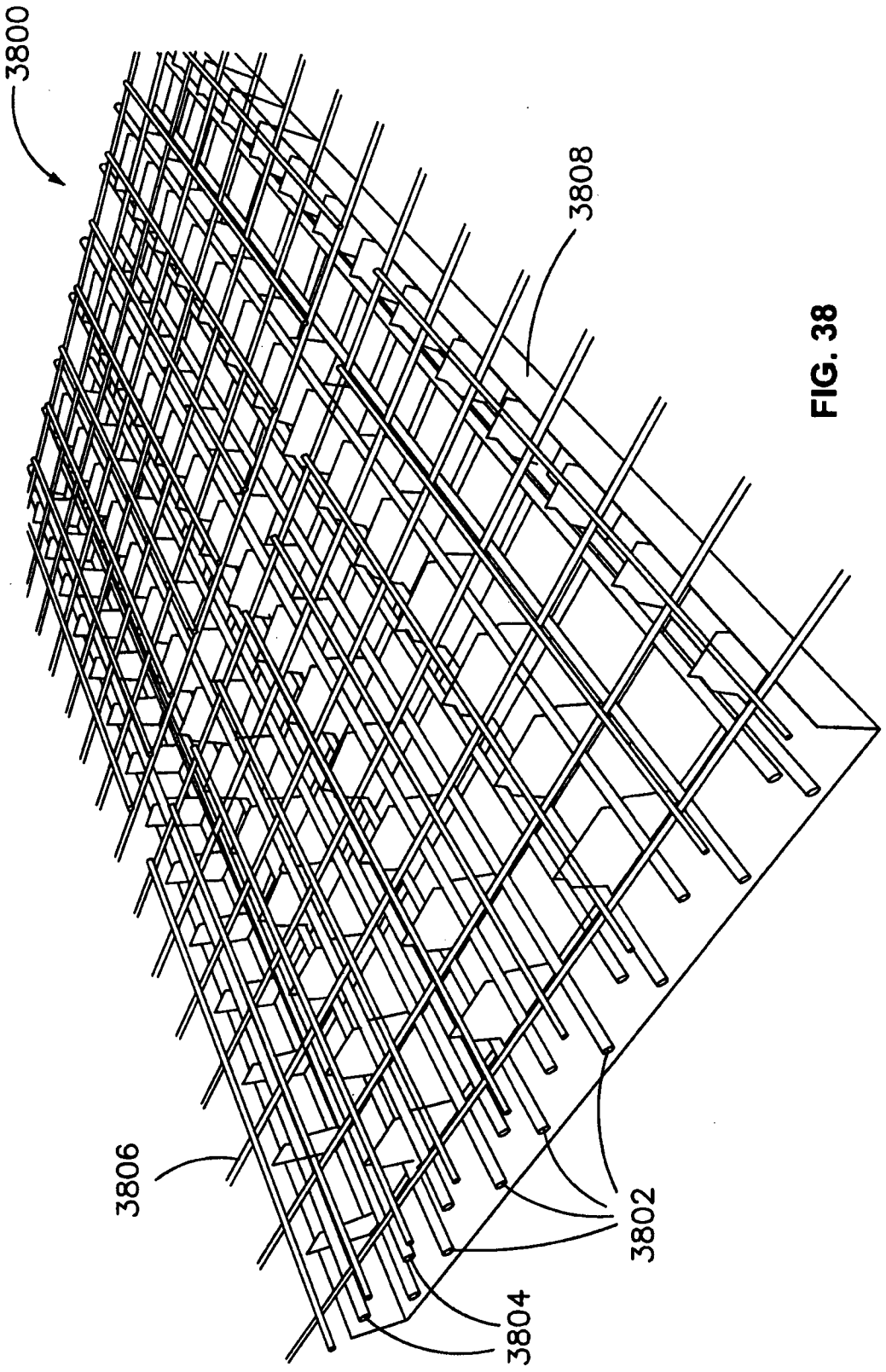


FIG. 38

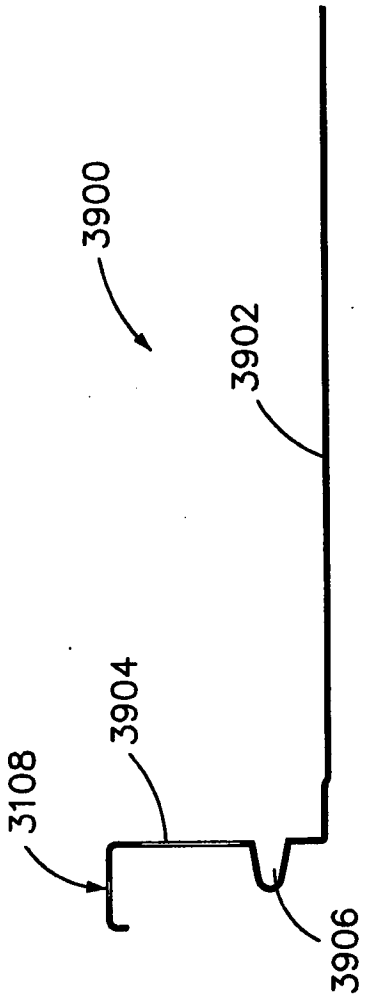


FIG. 39

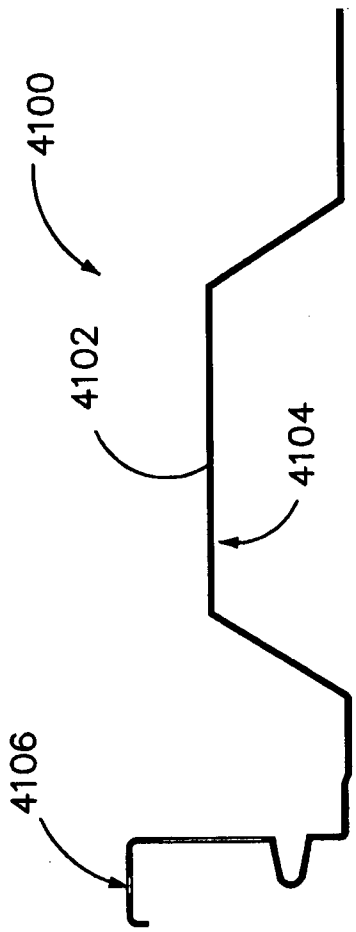


FIG. 40

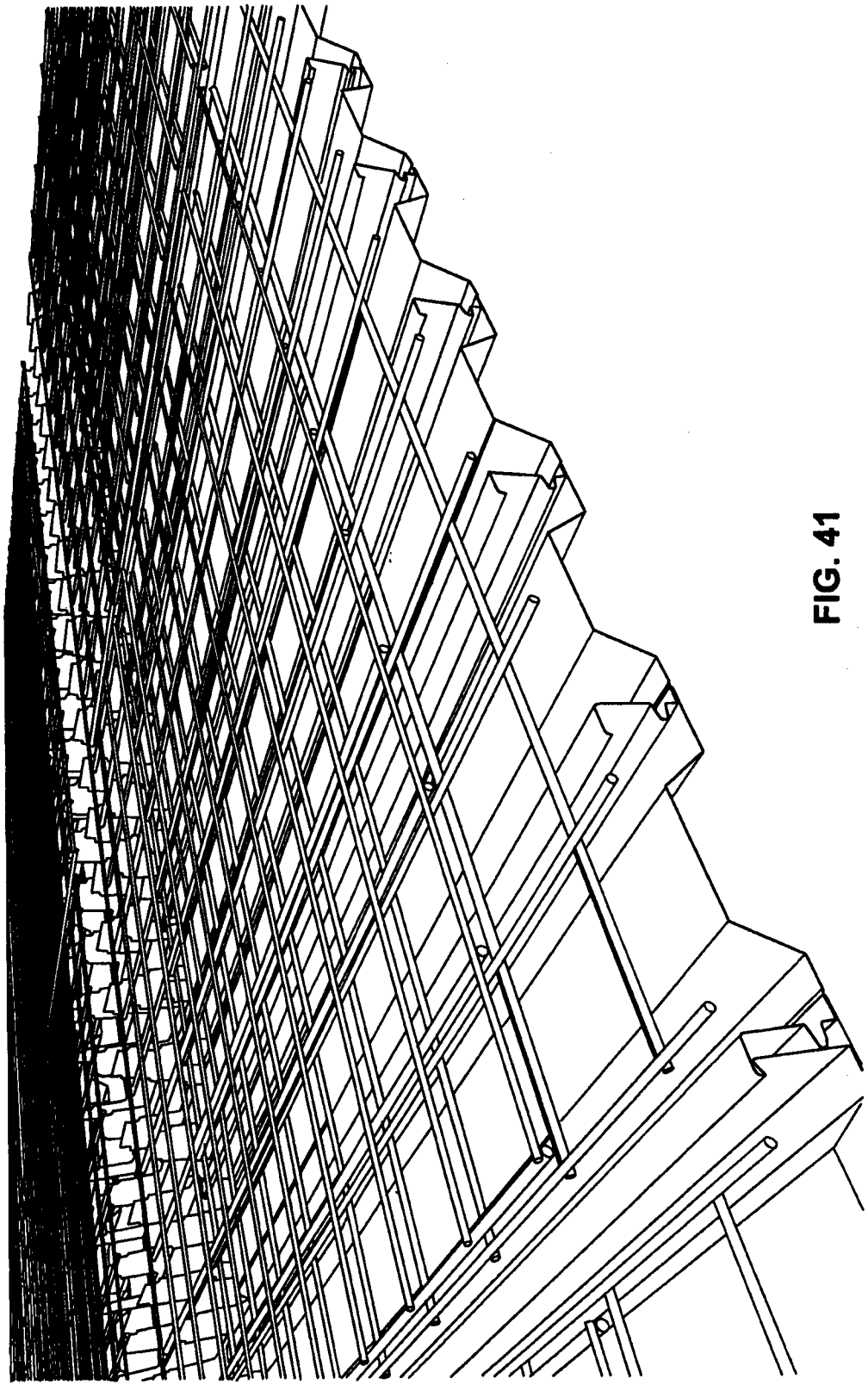


FIG. 41

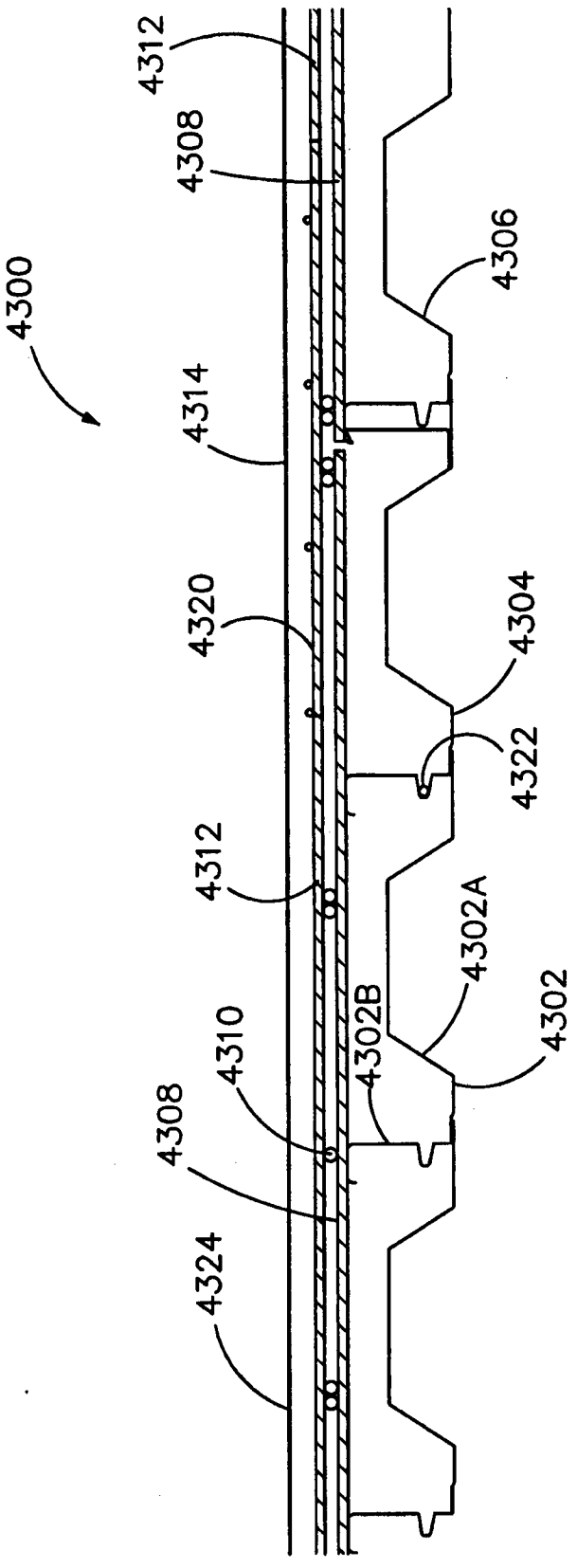

4300
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FIG. 42

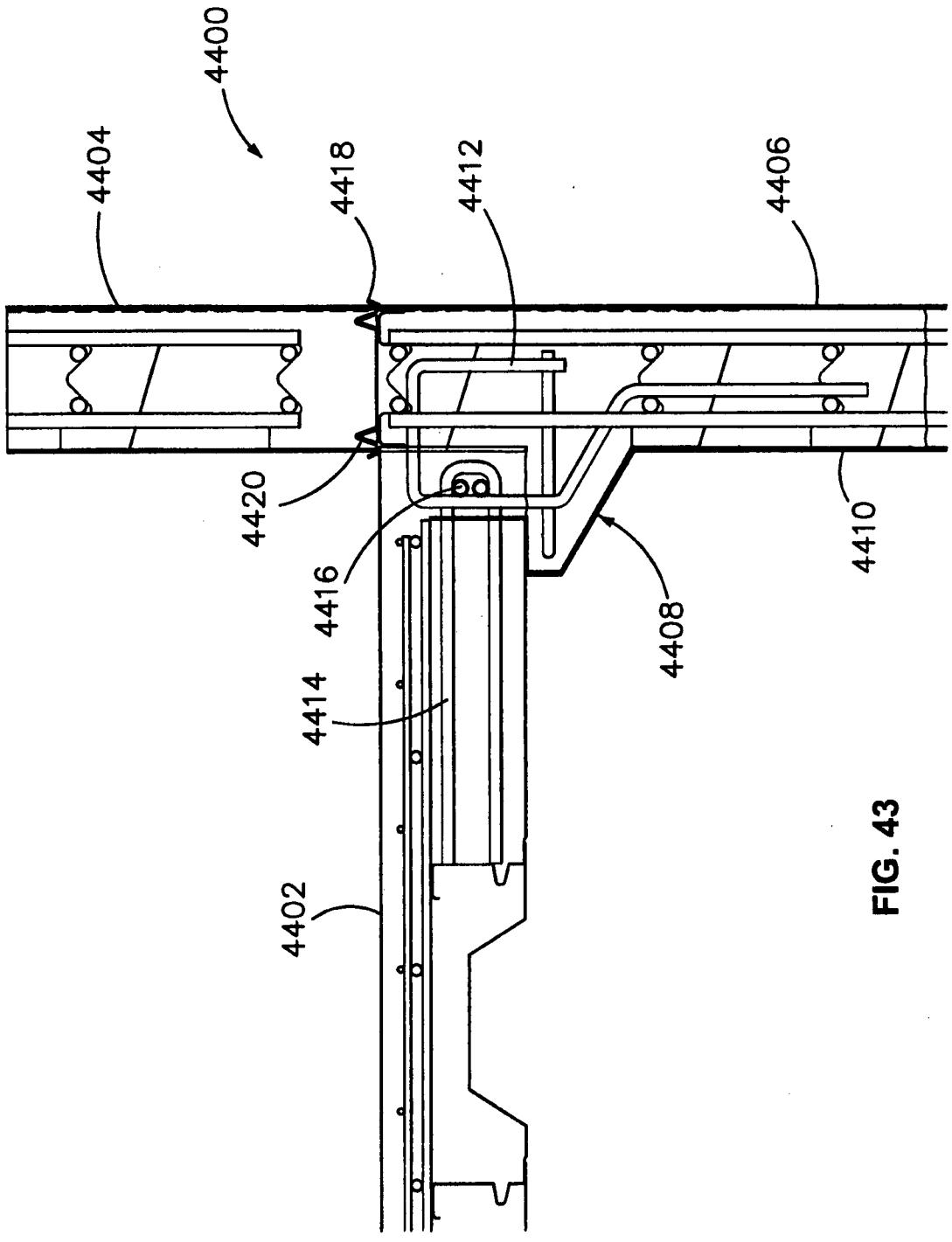


FIG. 43

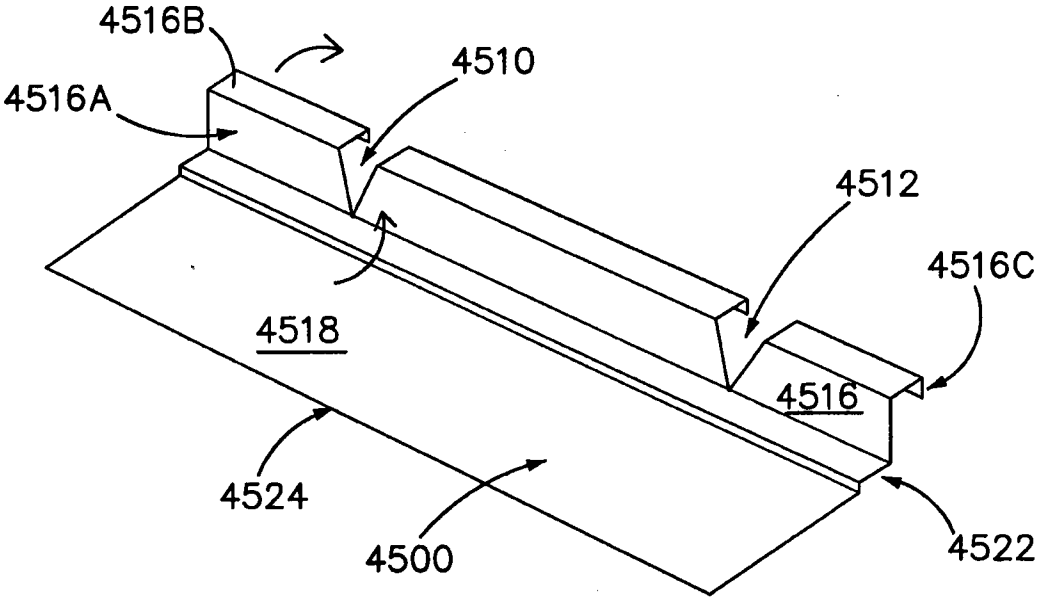


FIG. 44

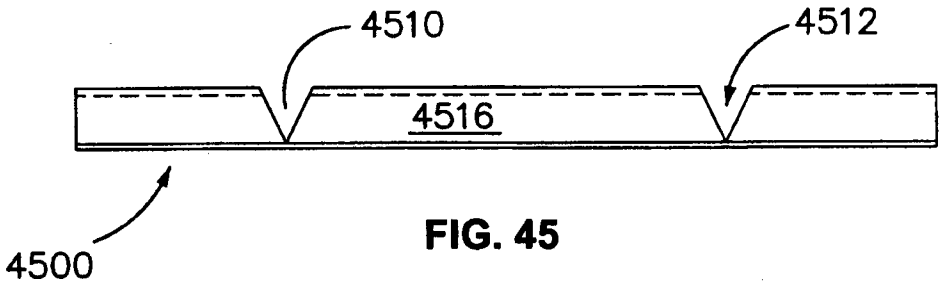


FIG. 45

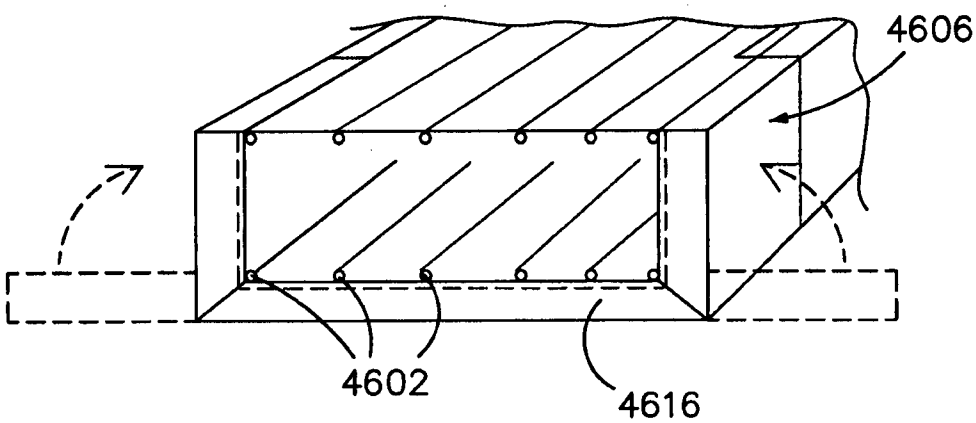


FIG. 46

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2011/000525

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

E04B 1/16 (2006.01) ***E04B 2/86*** (2006.01) ***E04G 11/36*** (2006.01)
E04B 1/348 (2006.01) ***E04G 11/02*** (2006.01)
E04B 2/84 (2006.01) ***E04G 11/06*** (2006.01)

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)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPODOC & WPI: /IC /EC E04B, E04G AND KEYWORDS (FORM, PRE-FABRICATE, REINFORCE, ROD, STAMP, SHEET, INTERLEAVE, PROJECTION AND LIKE TERMS)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2007/061276 A1 (MUROS R DE MEXIO SOC DE RESPON [MX] et al.) 31 May 2007 See English abstract retrieved from EPODOC database and figures 1, 2, 8 and 10	1-20,29,43,46

☐ 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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 August 2011	02.09.2011
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. +61 2 6283 7999	Authorized officer **PARMINDER SINGH** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : +61 2 6225 6135

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

[See Supplemental Box]

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-20, 29 (when appended to any of claims 1-20) , 43 (when appended to any of claims 1-20) and 46 (when appended to claim 43, which is in turn appended to any of claims 1-20)

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Supplemental Box
(To be used when the space in any of Boxes I to IV is not sufficient)

Continuation of Box No: BOX NO. III

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are three different inventions based on the following features that separate the claims into distinct groups:

1. Claims 1-20, 29, 43 and 46 are directed to pre-fabricated formwork module including a form defining a substantially continuous boundary for forming concrete, one or more projecting structures, and the projecting structures projecting from the boundary to project into the concrete and defining a supporting structure carrying a reinforcing bar. The feature added by claim 10 is specific to this group of claims.

2. Claims 21-33 and 43-46 are directed to a formwork module or a locating element by which the module may be located relative to a vertically adjacent like or similar module. The feature of locating structure or element by which the module may be located relative to a vertically adjacent like or similar module is specific to this group of claims.

3. Claims 34-42 are directed to a panel including a boundary for forming concrete, one or more projecting structures, and the projecting structures projecting from the boundary to project into the concrete and defining one or more receiving voids to receive one or more reinforcing bars. The feature added by claim 37 is specific to this group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art. When there is no special technical feature in common between the claims there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claims and therefore cannot provide the required technical relationship. The only feature common to all of the claims and which provides a technical relationship among them is a formwork module. Furthermore, the only feature common to the first and third claim groups which provides a technical relationship among them is a formwork module including a panel including a boundary portion and one or more projecting structures, the panel arranged such that the boundary portion defines a first substantially continuous boundary for forming concrete and one or more reinforcing bars fixed in position relative to the boundary for transport and/or to reinforce the concrete. However the common features do not make a contribution over the prior art because they are disclosed in D1 (refer English abstract retrieved from EPODOC database and figures 1, 2 and 7-14):

D1: WO 2007/061276 A1 (MUROS R DE MEXIO SOC DE RESPON [MX] et al.) 31 May 2007

Therefore in light of this document the common features cannot be special technical features. Therefore there is no single special technical feature present in the claims or between any two claim groups and the requirements for unity of invention are consequently not satisfied *a posteriori*.

Given the *a posteriori* lack of unity between the first and third claim groups, the dependent claims have been scanned to identify any inventions. Claims 10 and 37 stand out as potentially contributing special technical features. Consequently, the International Searching Authority has found that claims 10 and 37 define different inventions.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2011/000525**

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Member
WO 2007061276	NONE

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX