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(54) Title of the Invention: **Modular housing and method of manufacturing of modular housing**
Abstract Title: **Stackable housing module**

(57) A housing module comprises: a floor surface comprising a plurality of floor modules; and a plurality of external walls substantially perpendicular to said floor surface, said external walls being formed from wall modules each having a composite structure comprising at least one structural layer and at least one insulating layer; a plurality of internal structural walls configured to transfer structural loads to said external walls; a ring beam extending around a perimeter of the wall modules and connected thereto; and a plurality of metallic structural beams extending substantially vertically between a lower edge of said walls and an upper edge of said walls, each structural beam being connected to at least one wall module and comprising a base plate connected to the ring beam. The vertical beams may have lifting connections at their upper ends. The module may have engaging formations for engaging a like module stacked with the module. The formations may be conical or frusto-conical projections and recesses. The modules may be provided with service connections for connection to services on site.

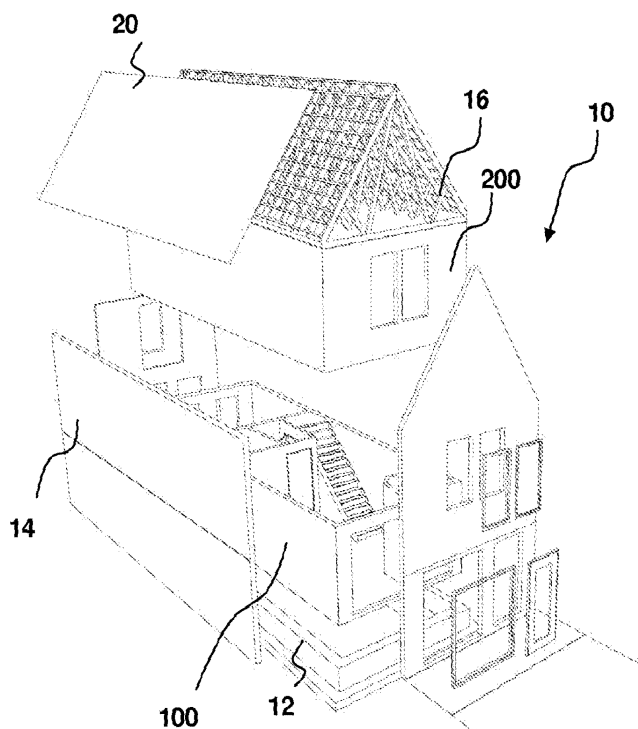


Fig. 1

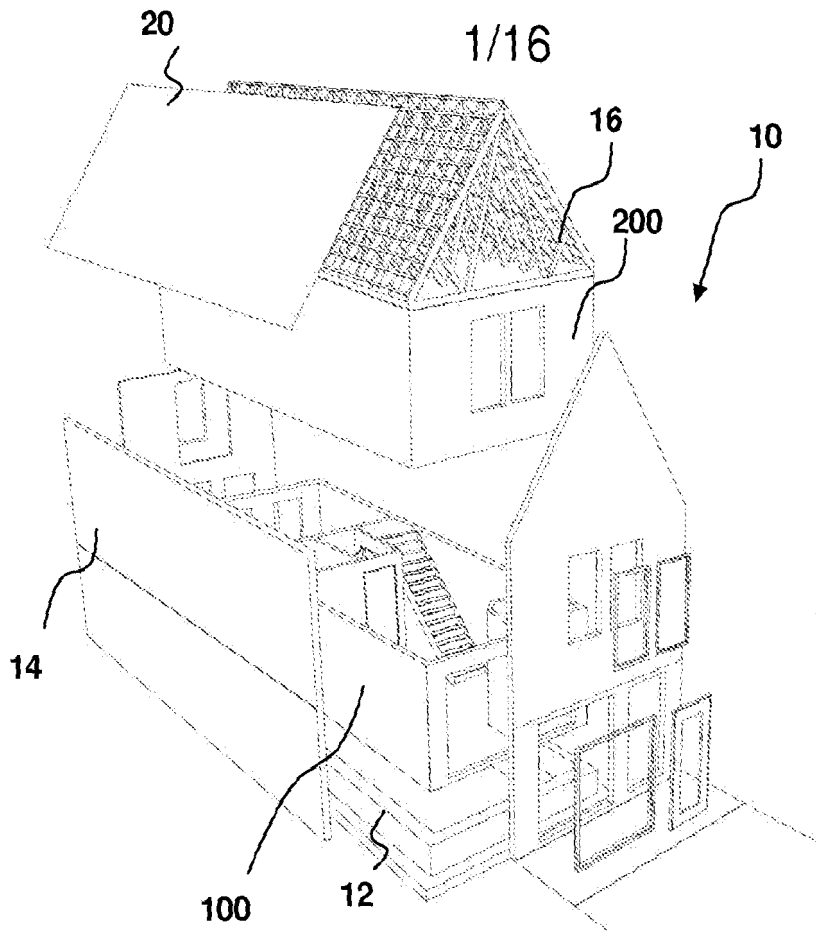


Fig. 1

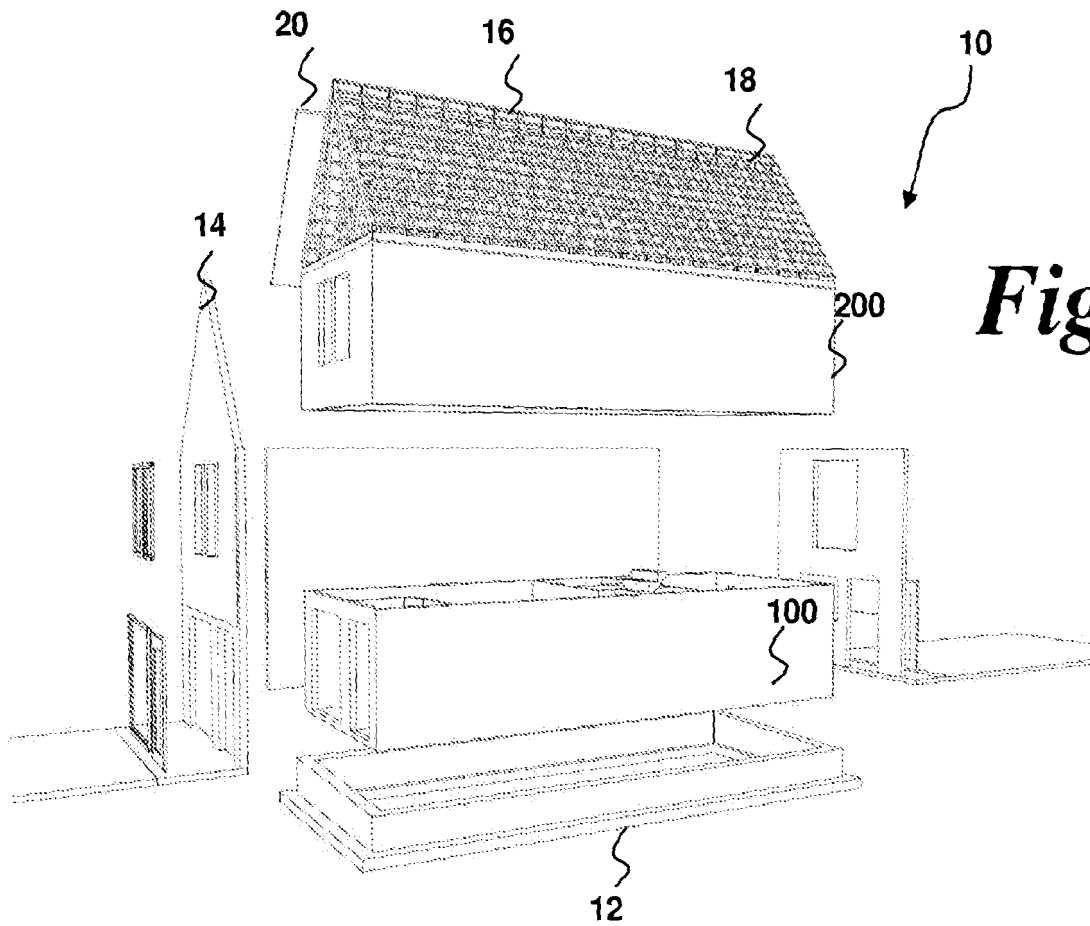


Fig. 2

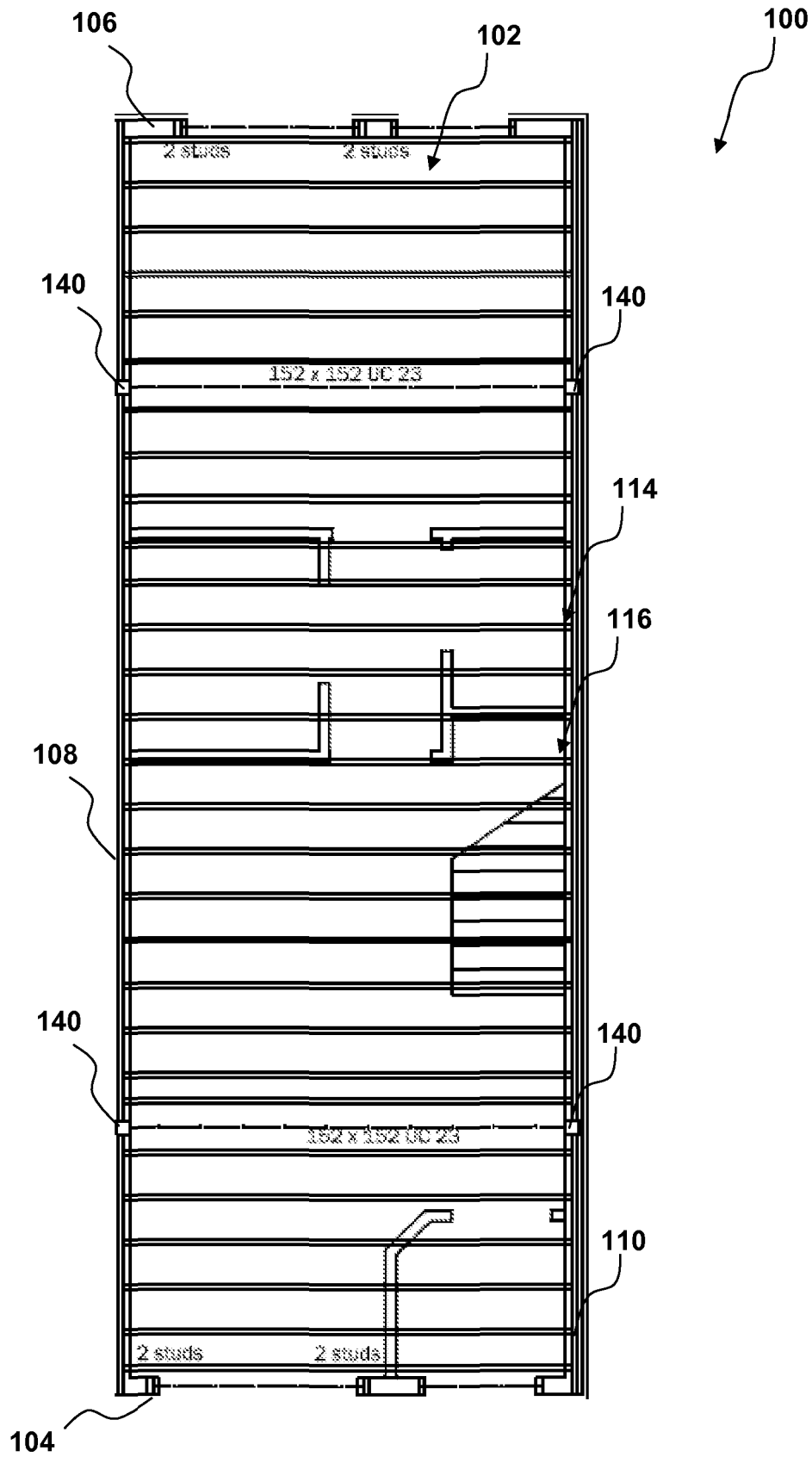


Fig. 3

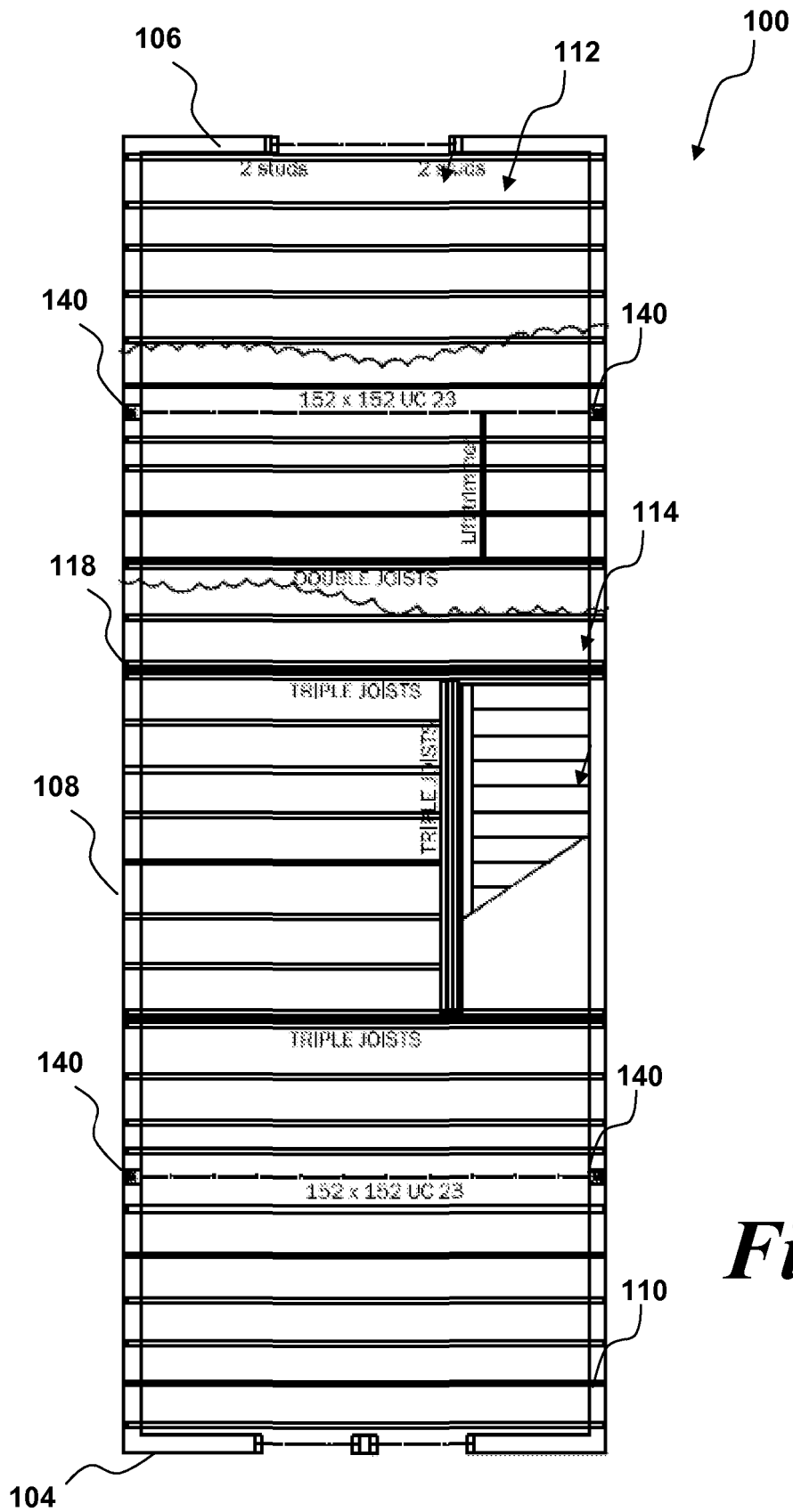


Fig. 4

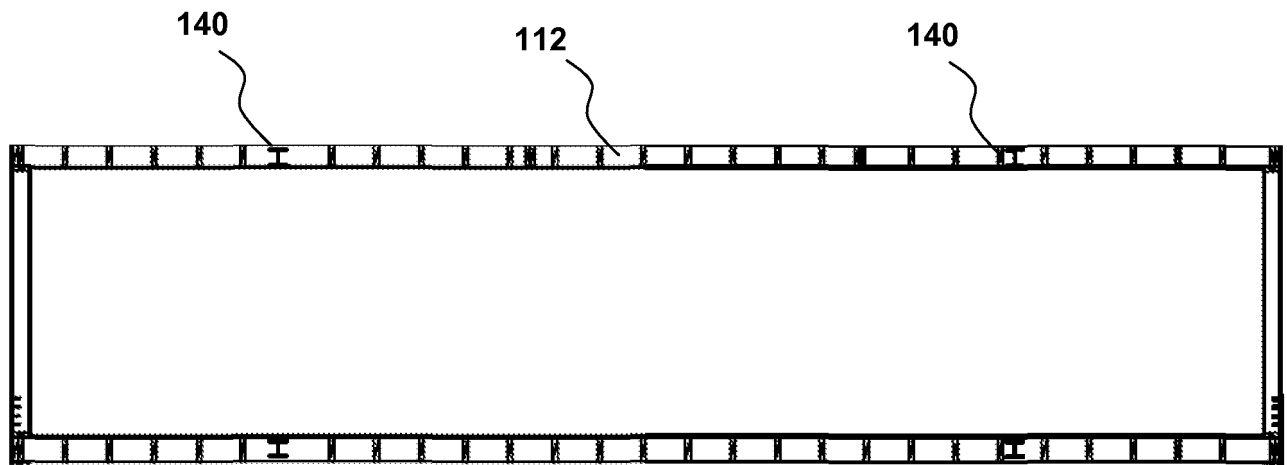


Fig. 5

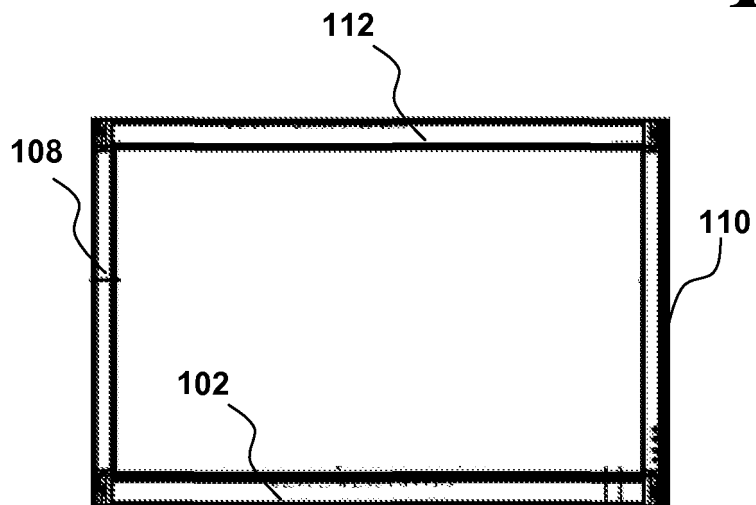


Fig. 6

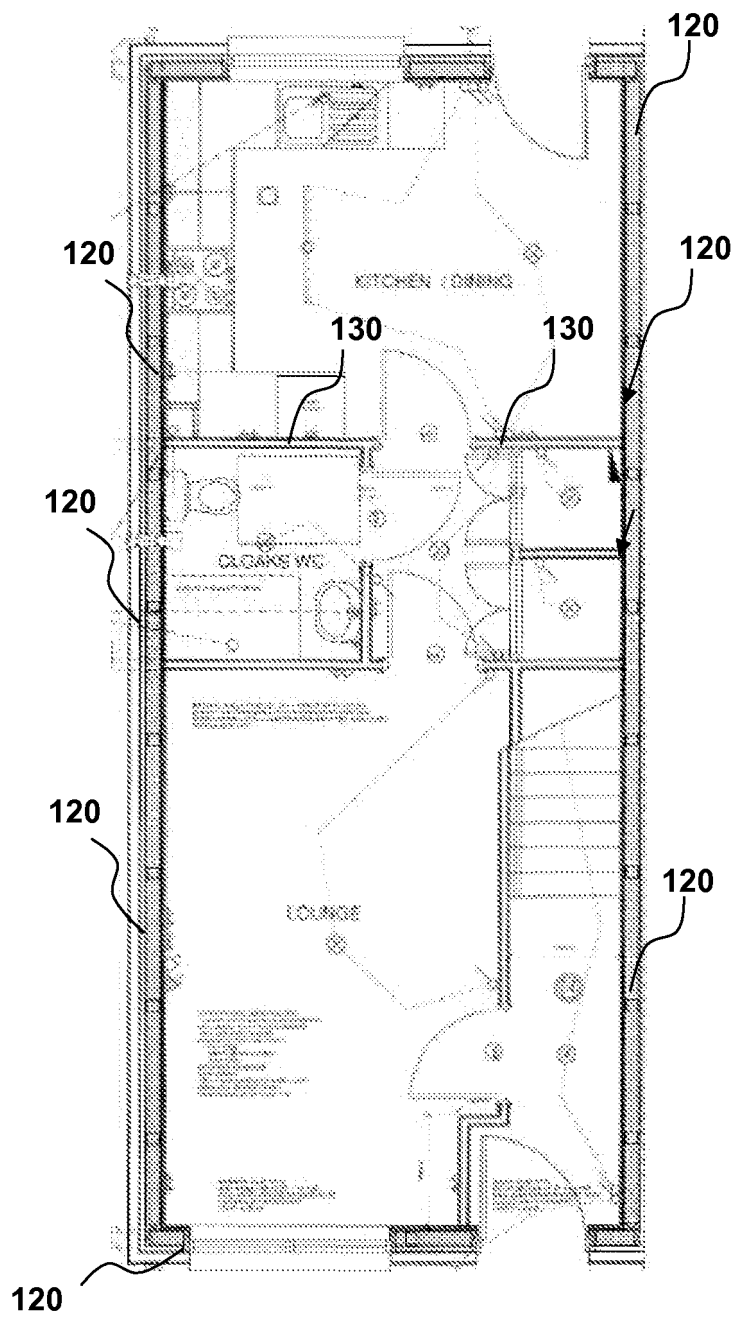
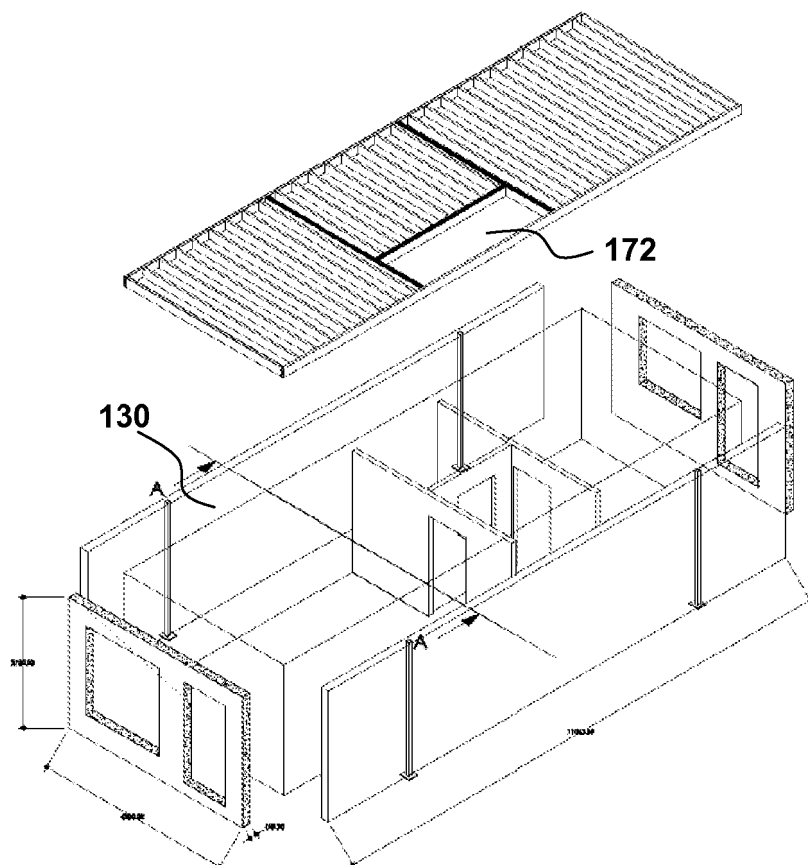
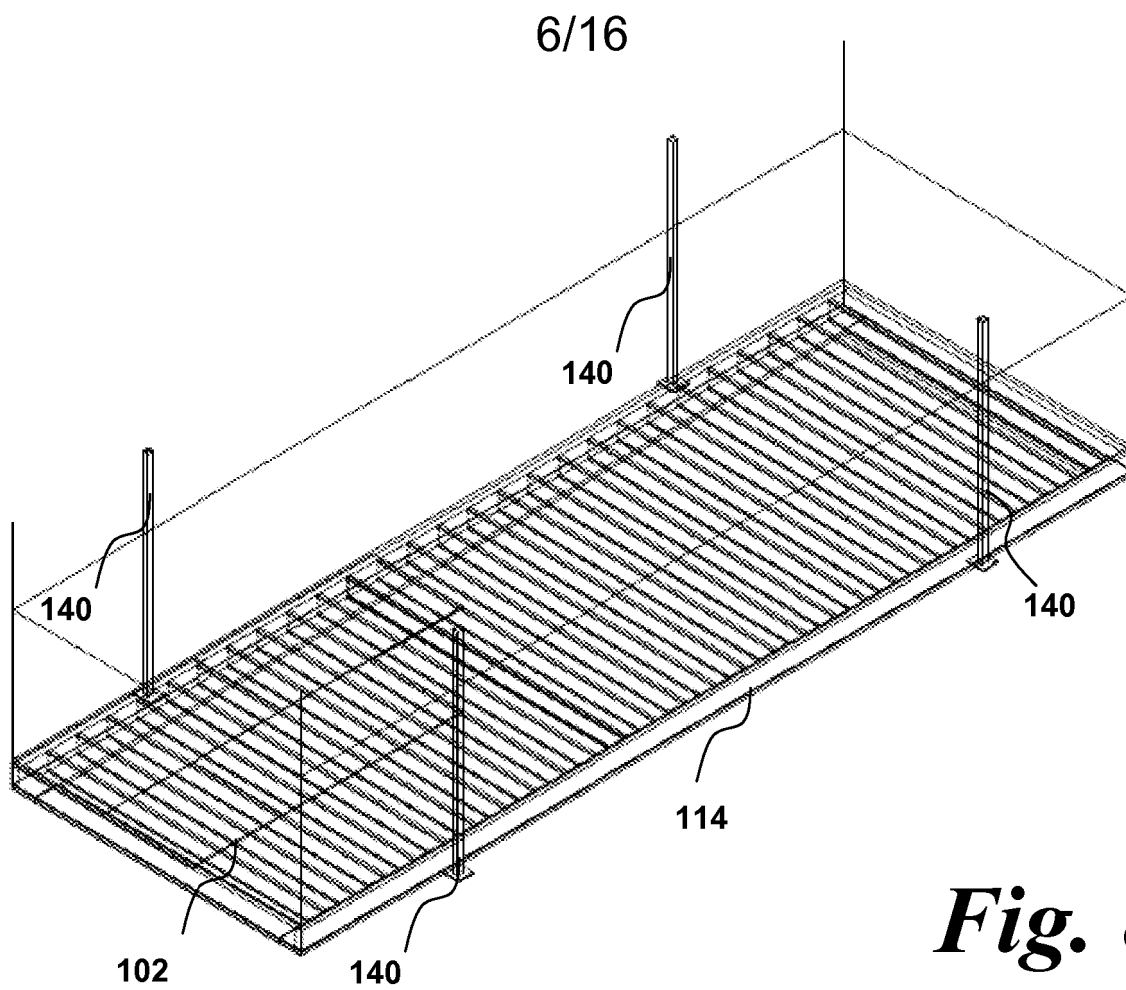


Fig. 7



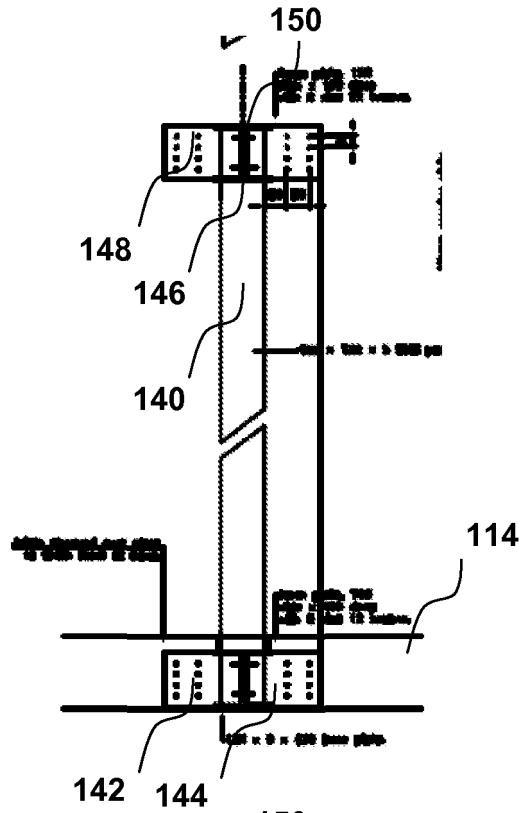


Fig. 10

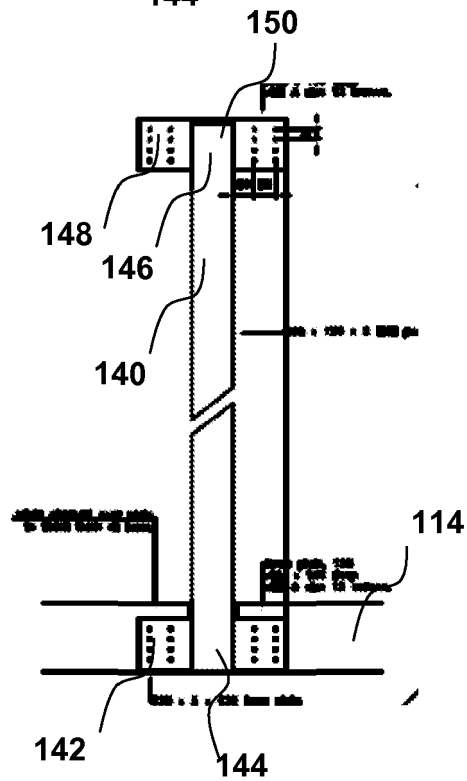


Fig. 11

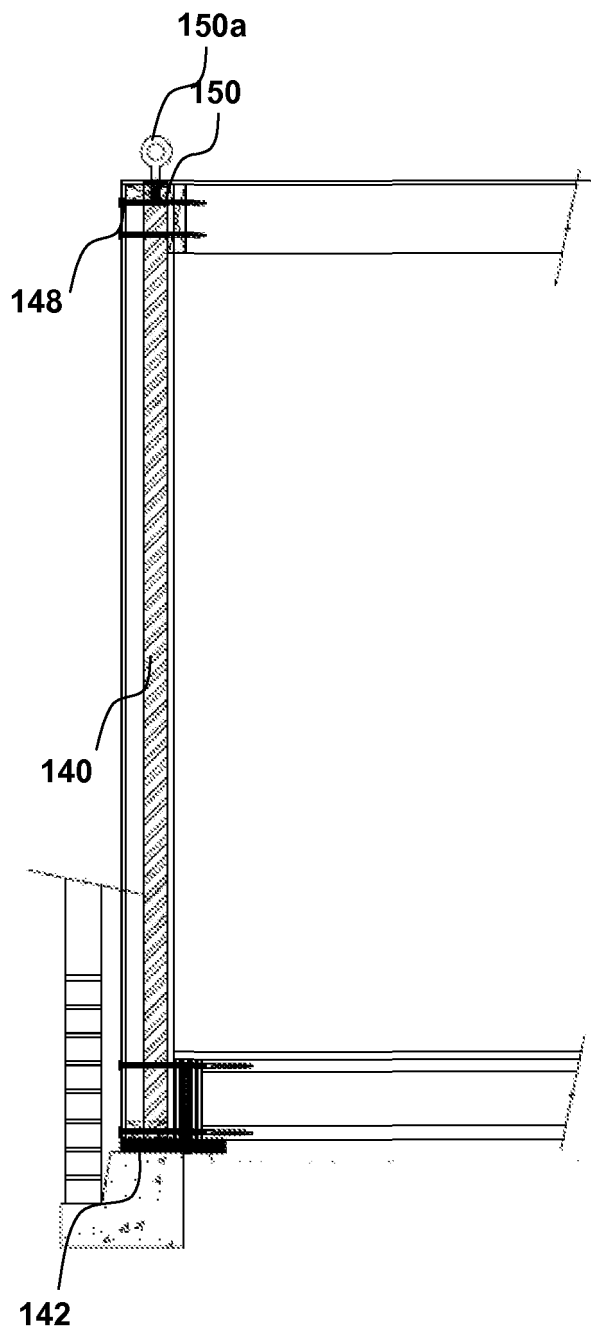


Fig. 12

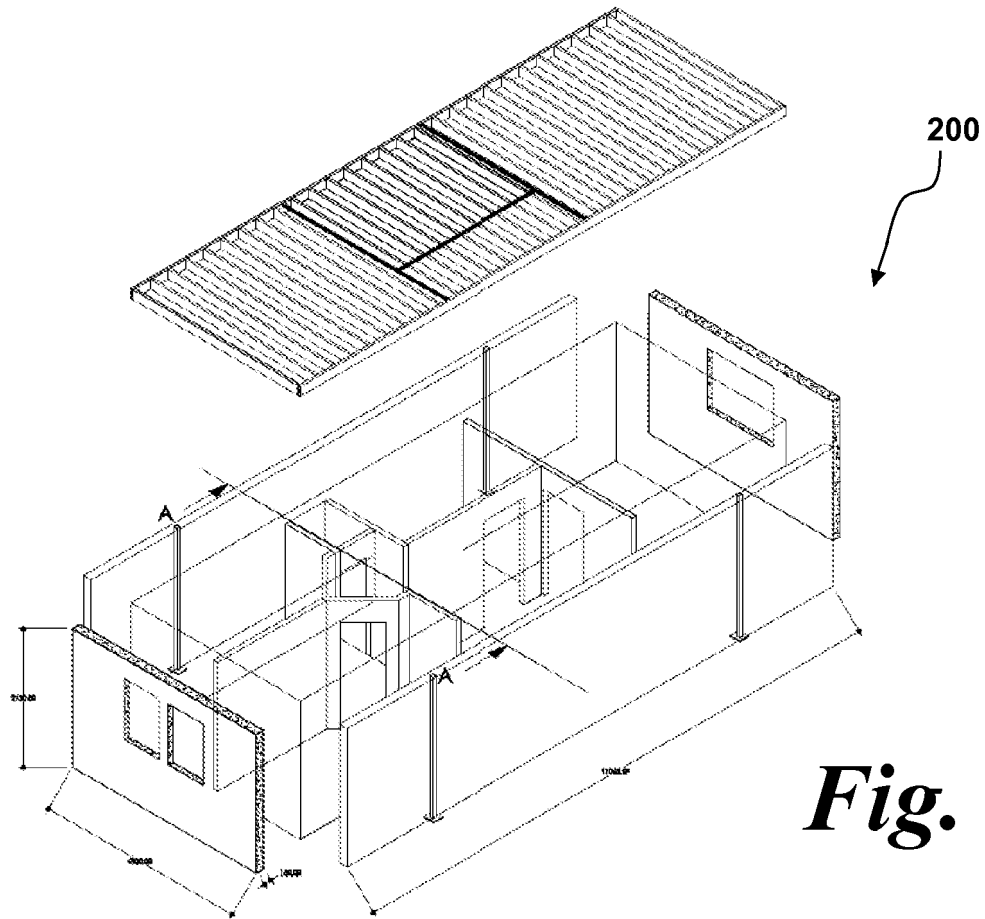


Fig. 13

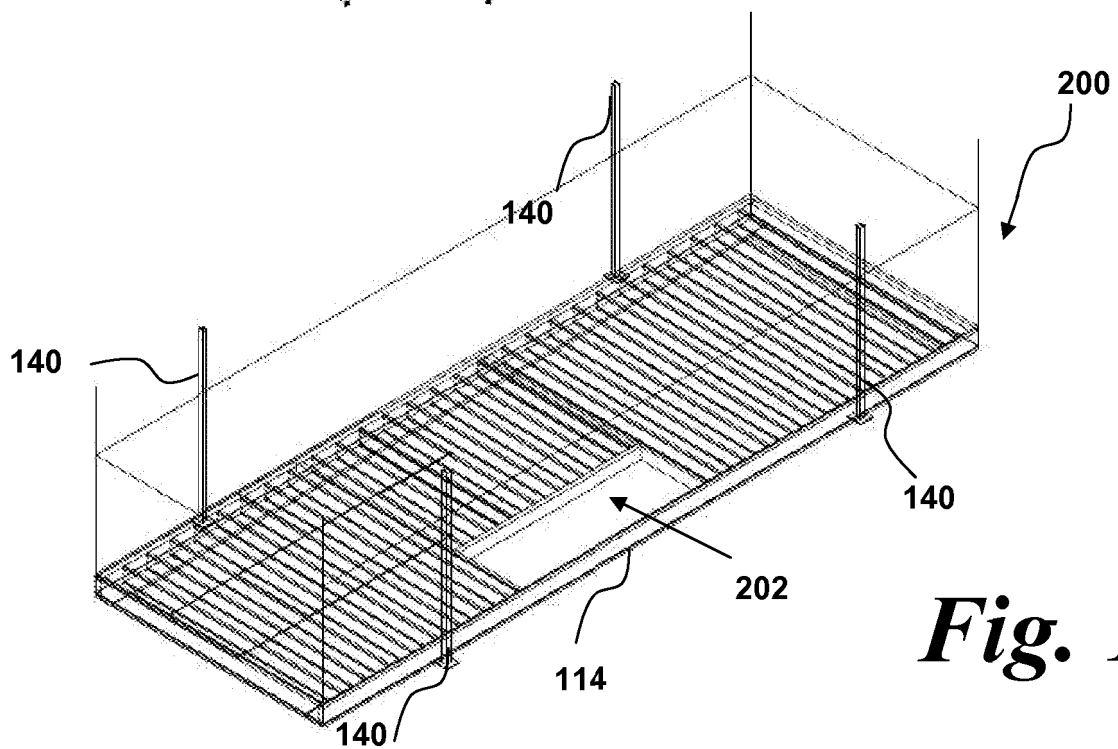


Fig. 14

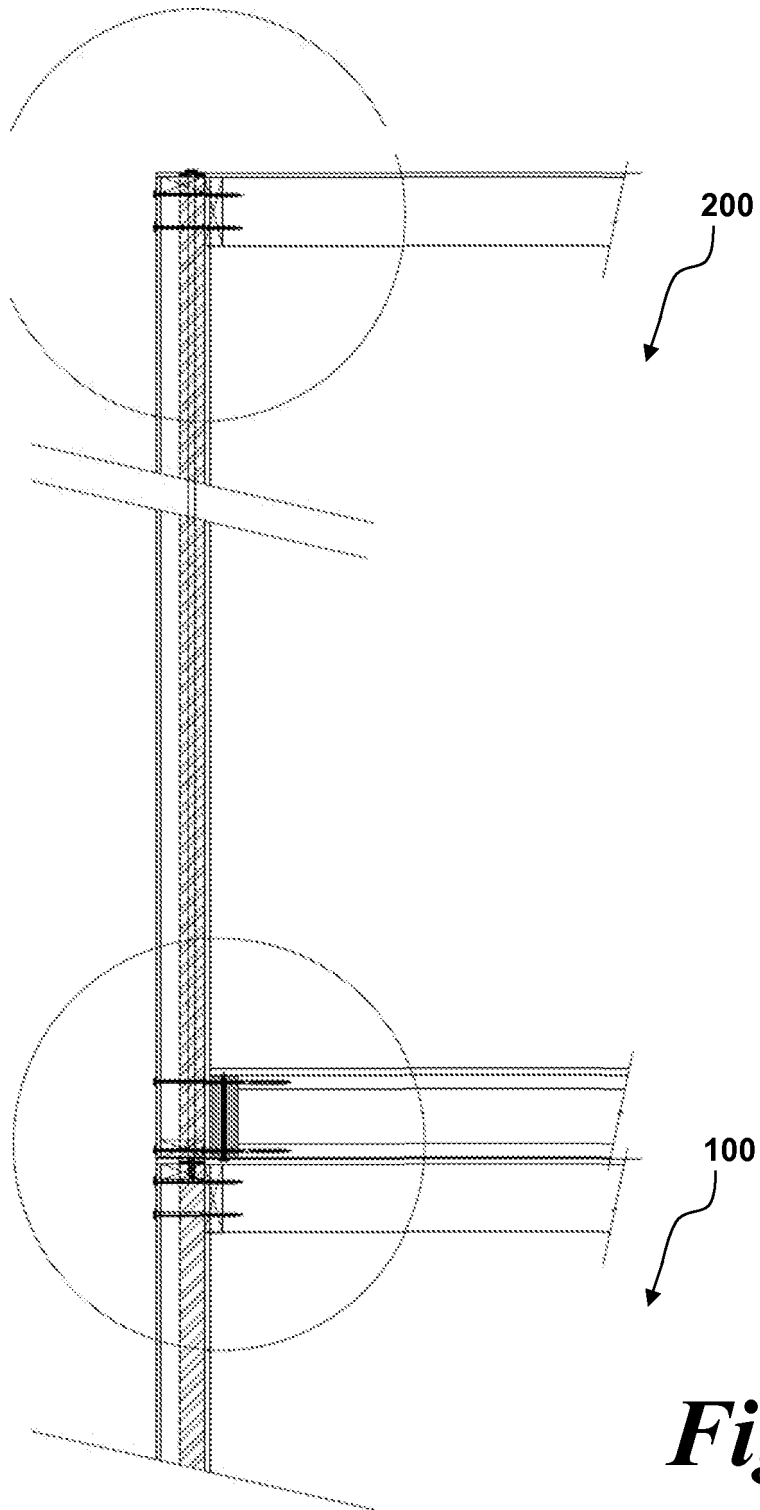


Fig. 15

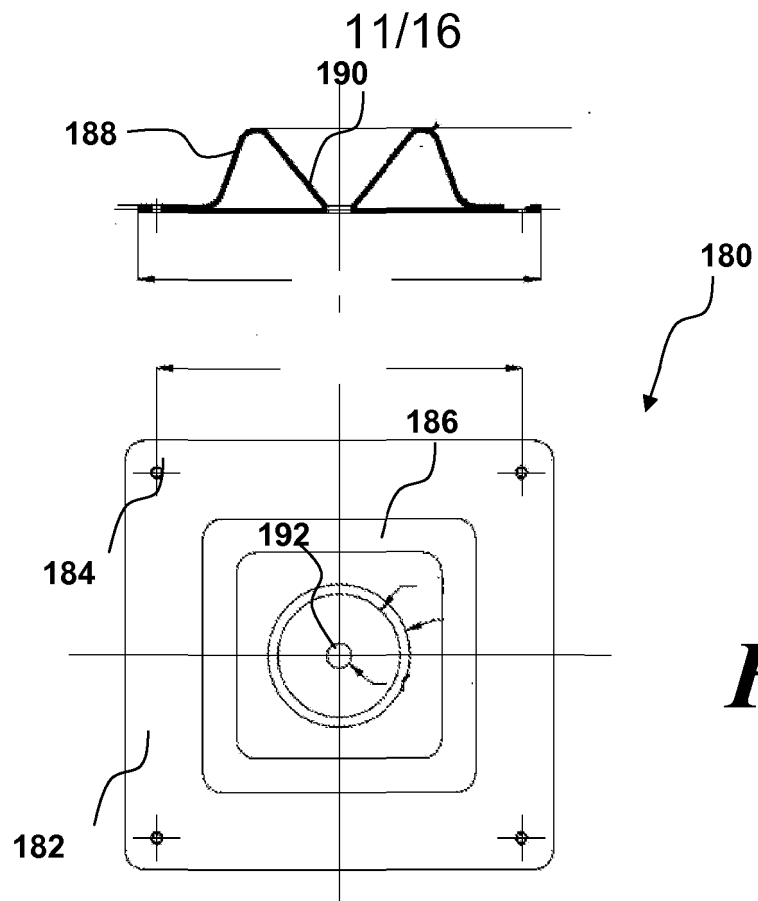


Fig. 16

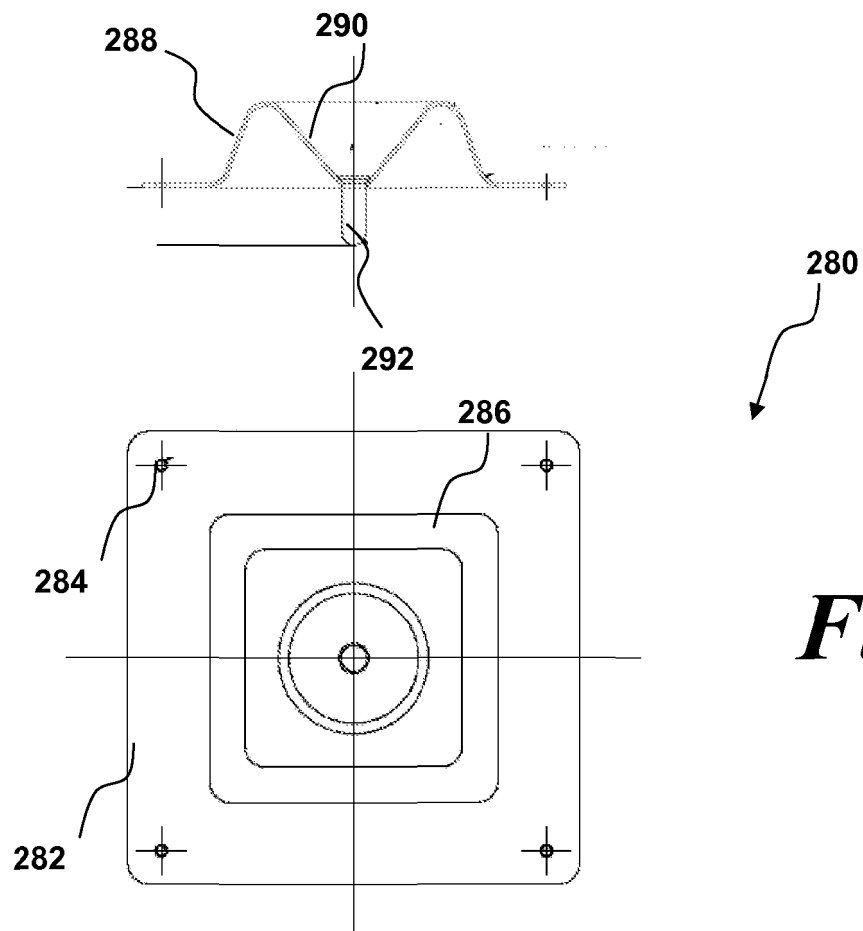


Fig. 17

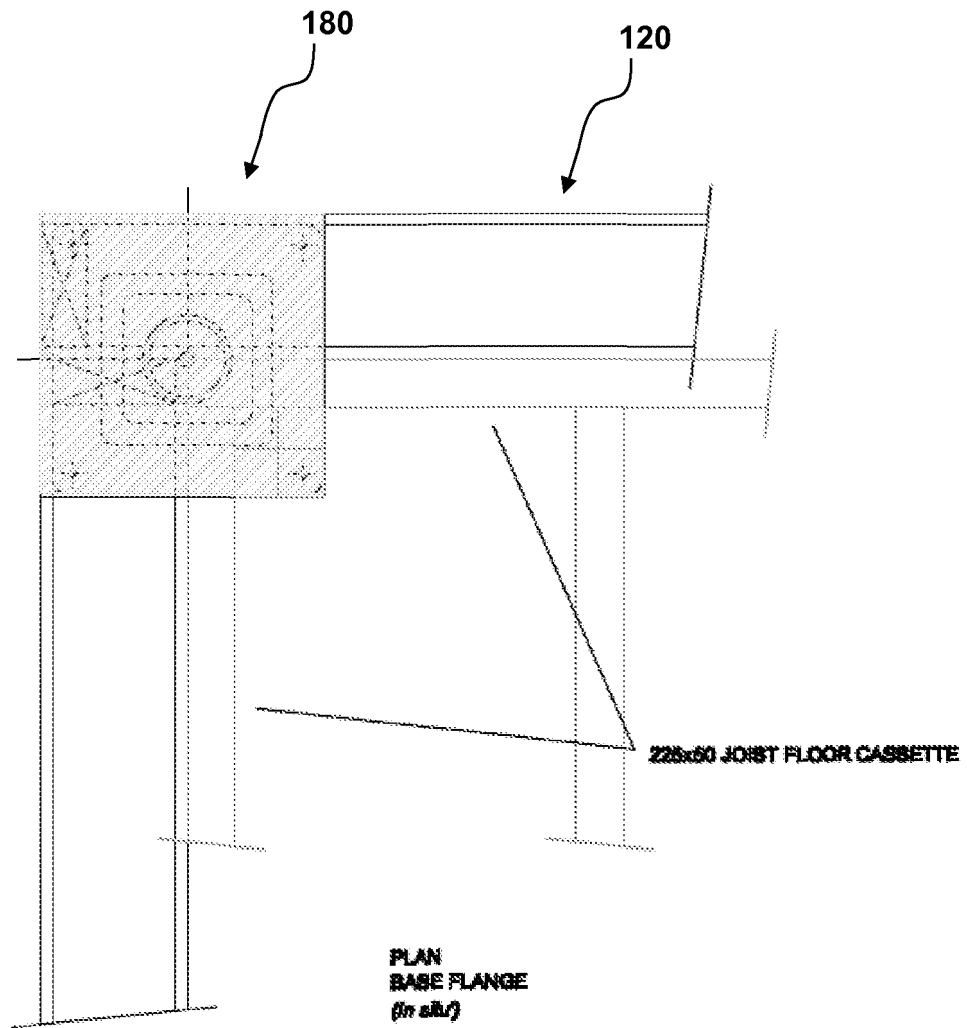


Fig. 18

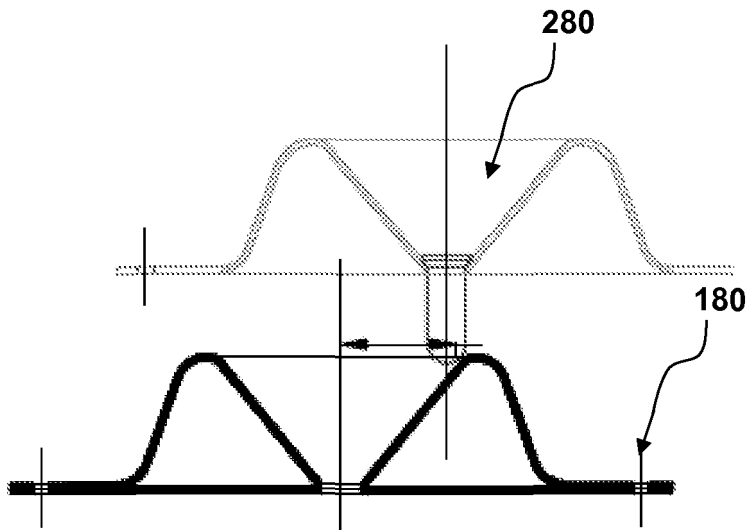


Fig. 19a

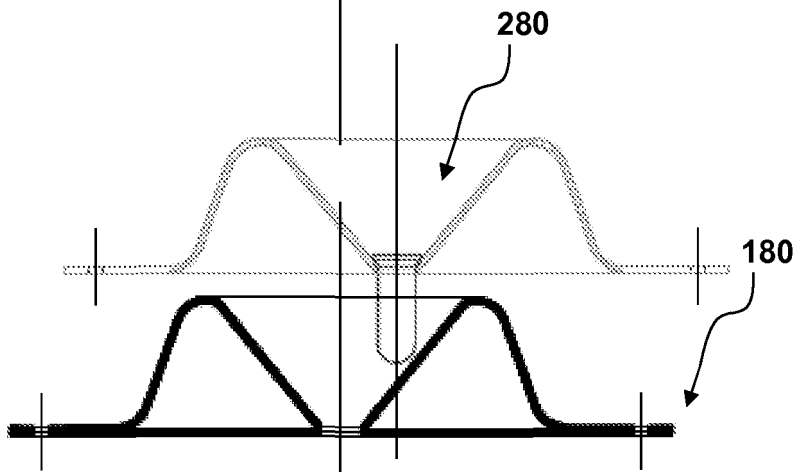


Fig. 19b

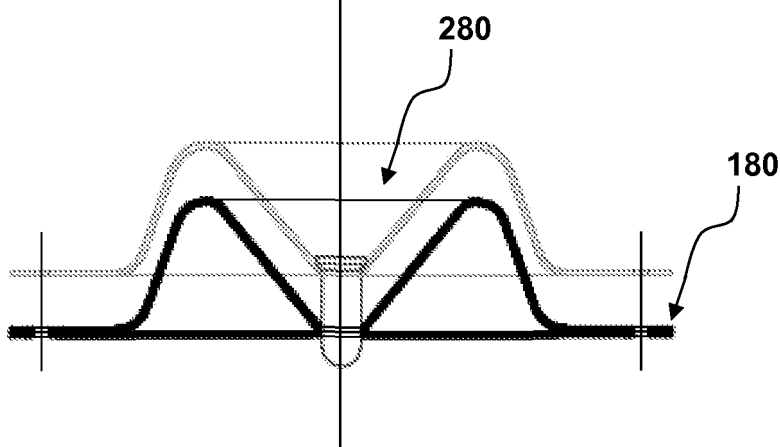


Fig. 19c

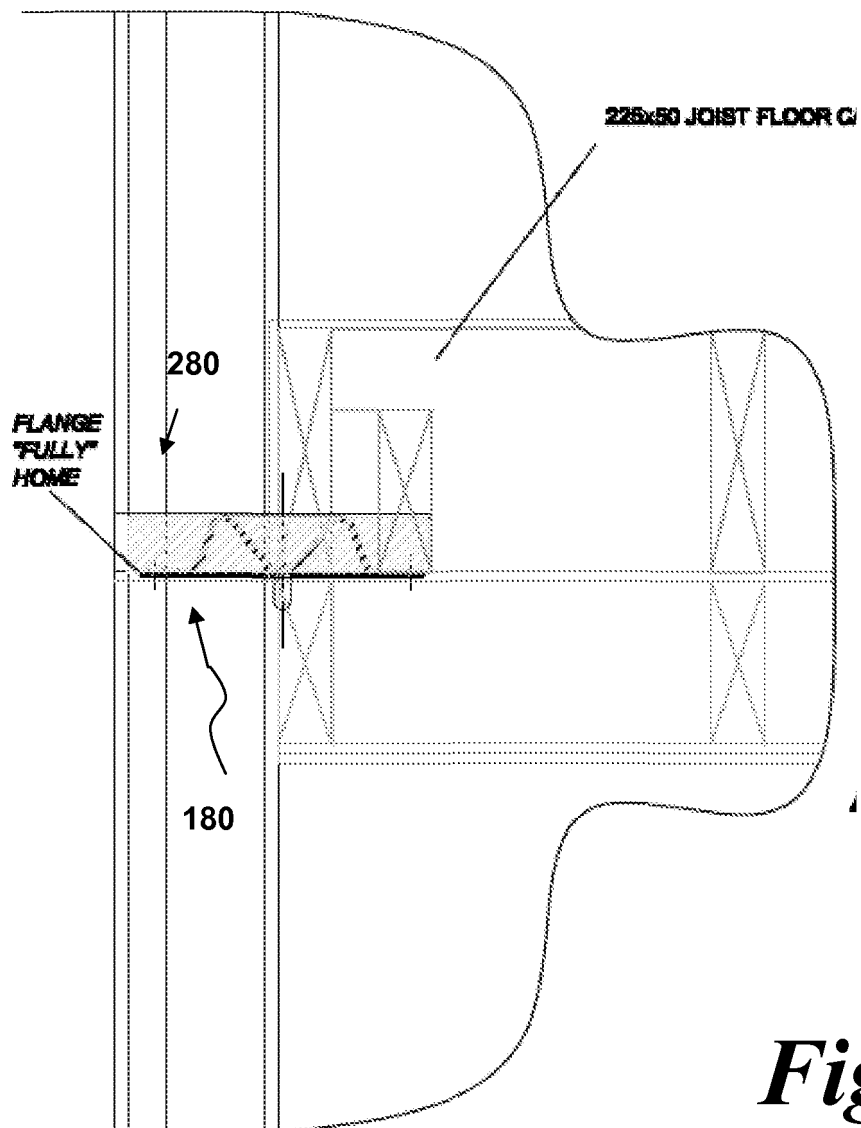


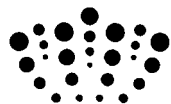
Fig. 20

15/16





Fig. 23



The following terms are registered trademarks and should be read as such wherever they occur in this document:

PARALLAM

Modular Housing and Method of Manufacturing of Modular Housing

The present invention relates to modular housing. More preferably, the present invention relates to a housing module for forming part of a dwelling.

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Often, houses, buildings and other dwellings are built directly onto a plot of land where the dwelling is desired to be located. In general, very little of the structure of modern homes is prefabricated and complete construction of the dwelling from scratch is required. This, inevitably, increases transportation and labour costs due to the need to source independently materials and labour. Further, the unpredictable effects of, for example, weather conditions can increase the lead time and cost to complete a dwelling. Additionally, the need essentially to produce a dwelling from basic components may lead to a lack of consistency of structural fitting from building to building.

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A more recent approach to structure building is the use of Structural Insulated panels (SIPs). SIPs are a composite building material and generally comprise an inner foam layer sandwiched between two structural outer layers. The outer layers may comprise any suitable structural material such as sheet metal, plywood or oriented strand board (OSB).

20

SIPs are available in relatively large sheets which can be used individually, or combined, to form the walls of a building. SIPs have the advantages of providing both structural and insulating properties whilst facilitating more straightforward construction of buildings when compared to conventional brick or concrete block construction.

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However, in most cases, a significant amount of labour is still required to assemble a building on-site from basic SIP units.

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An alternative approach to building manufacture for production of a building (or part thereof), is to produce the building structure in a factory and then transport the semi-completed unit to a building site where final construction and finishing of the building structure and internal decoration is completed.

The advantages of construction off-site are numerous. Manufacturing costs are lower due to reduced labour and transportation. Further, more accurate construction is possible due to the controlled environment in which the components are assembled. This
5 enables a dwelling formed from prefabricated components to meet more readily demanding energy consumption requirements for modern homes.

However, to date, such arrangements are difficult to transport in an entirely complete fashion. This is because the units are subject to shock, vibration and damage in
10 transportation. This makes it difficult to provide delicate internal finishings (such as, for example, cabinets, painted walls and fitted skirting boards) prior to transportation because flexure or vibration of the arrangement during transportation may lead to cracks and damage to the internal fittings.

15 Therefore, there is a need in the art to provide a prefabricated structure which can be almost entirely assembled and decorated to a high standard in a controlled single location but which can then be transported to a dwelling site by road or rail with no, or minimal, damage to the structure and/or internal fittings.

20 According to a first aspect of the present invention, there is provided a housing module for forming a part of a dwelling, the module comprising: a floor surface comprising a plurality of floor modules; a plurality of external walls substantially perpendicular to said floor surface, said external walls being formed from wall modules each having a composite structure comprising at least one structural layer and at least one
25 insulating layer; a ring beam extending around a perimeter of the wall modules and connected thereto; a plurality of internal structural walls configured to transfer structural loads to said external walls; and a plurality of metallic structural beams extending substantially vertically between a lower edge of said walls and an upper edge of said walls, each structural beam being connected to at least one wall module and comprising a
30 base plate connected to the ring beam.

In one embodiment, each structural beam further comprises a connection at an upper end to enable the module to be lifted.

5 In one embodiment, said connection is further operable to enable a further housing module to be connected and secured thereto.

In one embodiment, said housing module has a front wall, a rear wall and two side walls, said structural beams forming part of said side walls.

10 In one embodiment, at least four structural beams are provided.

In one embodiment, said structural beams are equispaced about the centre of mass of the housing module.

15 In one embodiment, said structural beams have a square cross section.

In one embodiment, said structural beams are substantially hollow.

20 In one embodiment, said wall modules comprise structural insulating panels including a central foam layer surrounded by structural layers.

In one embodiment, said structural insulating panels have a width between 100 – 150 mm.

25 In one embodiment, the internal walls are connected to said floor surface and operable to transfer structural loads to said metallic structural beams.

In one embodiment, said internal walls comprise structural insulated panels.

30 In one embodiment, said internal walls have a thickness of 100 mm or less.

In one embodiment, said module is up to 5 m wide.

In one embodiment, said module further comprises at least one location unit locatable at an upper or lower corner thereof.

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In one embodiment, said location unit comprises a tapering section operable to receive a complementary tapering section on another housing module.

In one embodiment, said tapering section is conical or frustoconical.

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In one embodiment, when located on an upper surface, the tapering section is conical and comprises an aperture for receiving a projection located at a distal end of the complementary tapering section.

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In one embodiment, when located on a lower surface, the tapering section further comprises a projection arranged to extend into the tapering section of a location unit located on an upper surface of another module.

According to a second aspect of the present invention, there is provided a set of a first housing module and a second housing module located vertically above said first housing, said first housing module comprising at least one lower location unit comprising a lower tapered locating portion, and said second housing module comprising at least one complementary upper location unit comprising a complementary upper tapered locating portion, said lower tapered locating portion being operable to receive said upper tapered locating portion in close relationship thereto.

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In one embodiment, said tapered portions comprise frustoconical portions.

In one embodiment, said upper tapered locating portion comprises a protrusion operable to mate with a corresponding opening formed in said lower tapered locating portion.

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In one embodiment, four location units are provided on each module.

According to a third aspect of the present invention, there is provided a dwelling
5 comprising a foundation, a first housing module located on said foundation and a second
housing module located vertically above said first housing module, said first and second
housing modules being configured as set out in any one of the preceding claims.

In one embodiment, the dwelling further comprises a further set of a first housing
10 module located on a foundation and a second housing module located vertically above
said first housing module, such that said dwelling comprises a semi-detached house.

In one embodiment, the dwelling further comprises a plurality of further sets of a
first housing module located on a foundation and a second housing module located
15 vertically above said first housing module, such that said dwelling comprises one of a
number of terraced houses.

In one embodiment, the dwelling further comprises outer structural walls
surrounding the modules.

20

In one embodiment, the dwelling further comprises a roof structure.

According to a fourth aspect of the present invention, there is provided a method
of constructing a dwelling, the method comprising: preparing a foundation comprising
25 service connections; locating a first housing module as claimed in any one of claims 1 to
14 on said foundation, said first housing module having complementary service
connections; connecting said two sets of service connections; locating a second housing
module as claimed in any one of claims 1 to 14 in vertical relation to said first module;
securing said second housing module to said first housing module; providing an outer
30 structural layer surrounding said first and second modules; and providing a roof structure
above said second module.

According to a fifth aspect of the present invention, there is provided a method of constructing a dwelling, the method comprising: preparing a foundation; locating a first housing module on said foundation, said first housing module comprising at least one
5 upper location unit comprising an upper tapered locating portion; locating a second housing module above said first housing module, said second housing module comprising at least one complementary lower location unit comprising a complementary lower tapered locating portion, said step of locating a second housing module comprising:
lowering said second housing module so that said lower tapered locating portion is
10 adjacent said upper tapered locating portion on said first housing module such that said upper and lower location units enable automatic location of said first and second housing modules in relation above one another; and securing said second housing module to said first housing module.

15 In an embodiment, the method further comprises: providing an outer structural layer surrounding said first and second modules; and providing a roof structure above said second module.

Embodiments of the present invention will now be described in detail with
20 reference to the accompanying drawings, in which:

Figure 1 is an exploded schematic diagram of a dwelling according to an embodiment of the present invention;

25 Figure 2 is an alternative exploded schematic diagram of the dwelling shown in Figure 1;

Figure 3 is a cross-section of a ground floor module taken along a horizontal plane at floor level;

30 Figure 4 is a cross-section of the ground floor module of Figure 3 taken along a

horizontal plane at ceiling level;

Figure 5 is a cross section taken along a vertical plane showing the side of the ground floor module of Figure 3;

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Figure 6 shows a cross-section taken along a vertical plane perpendicular to the cross-sectional plane of Figure 5;

Figure 7 is an alternative cross-sectional view of the module of Figure 3 showing the construction of wall modules;

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Figure 8 shows a schematic view of the floor surface of the module of Figure 3 comprising floor cassettes and structural beams;

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Figure 9 shows a schematic exploded view of the entire housing module of Figure 3;

Figure 10 is a schematic diagram of an internally-facing side of a structural beam forming part of the module of Figure 3;

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Figure 11 is a schematic diagram of an externally-facing side of a structural beam forming part of the module of Figure 3;

Figure 12 is a section of a ground floor module as shown in Figure 3 showing a structural beam;

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Figure 13 is an exploded view of the module of Figure 3;

Figure 14 is a view showing components of the module of Figure 3;

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Figure 15 is a side section showing the mating of upper and lower modules;

Figure 16 is a side and plan view of a location unit for a lower module;

Figure 17 is a side and plan view of a location unit for an upper module;

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Figure 18 is a plan view showing a location unit in place on a lower module;

Figures 19a to 19c show a process of mating location units;

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Figure 20 shows two modules located using location units;

Figure 21 is cross-sectional elevation view of a dwelling according to another embodiment of the present invention in which a lower module and an upper module are located;

15

Figure 22 is a view similar to Figure 21 albeit taken along an offset plane to show different aspects of the dwelling of Figure 21; and

Figure 23 is a front view of the dwelling of Figures 21 and 22 showing a different aspect thereof.

20

Figures 1 and 2 show exploded views of a dwelling 10 formed according to the present invention. The dwelling 10 comprises a lower module 100 and an upper module 200 located on a foundation 12 surrounded by a plurality of outer structural layers 14 and a roof structure 16.

25

The dwelling 10, in Figures 1 and 2, takes the form of a detached house having two floors. However, other embodiments are contemplated. For example, later embodiments illustrate a pair of semi-detached dwellings formed from a central core of four modules 100, 200.

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The foundation 12 comprises, in this embodiment, a shallow concrete foundation operable to transfer building loads to the ground. The foundation 12 is sized to receive the lower module 100. The foundation 12 may also comprise electrical and plumbing connections. These connections are operable to connect to complementary connections
5 located on the lower module 100. These will be described later.

The electrical connections are operable to supply the lower module 100 (and the dwelling 10 as a whole) with an electricity supply. The plumbing connections supply the lower module 100 (and the dwelling 10 as a whole) with waste disposal necessities, a
10 water supply. A gas connection may also optionally be provided to enable a gas cooking appliance to be installed in the dwelling 10.

The outer structural layers 14 are provided to enable structural integrity, weather-proofing and a pleasing aesthetic appearance for the dwelling 10. The outer structural
15 layers 14 may comprise, for example, brickwork or other forms of structural cladding. It is envisaged that a completed dwelling 10 may resemble a conventional house or building constructed using conventional methods. The outer structural layers 14 assist in the provision of this. The outer structural layers 14 further provide additional racking (shear force resistance) benefits and weather- and wind-resistance.

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The roof 16 is comprised of a rafter structure 18 covered with roof tiles 20. The rafter structure 18 provides additional structural integrity and the provision of an additional loft space. The roof tiles 20 may be any suitable roof covering for a dwelling and, in general will be conventional as is known in the art. The roof tiles 20 provide
25 weather-proofing and are angled to enable, for example, rain water to drain away from the roof area of the dwelling 10. The roof tiles and rafter structure are not material to the present invention and so will not be discussed any further here.

The modules 100, 200 will now be described in more detail. The lower module
30 100 is designed to provide an essentially complete downstairs floor of the dwelling 10.

Concomitantly, upper module 200 is designed to couple to the lower module 100 in vertical relation to provide an upstairs floor of the dwelling 10.

5 The dwelling 10 is designed specifically to provide affordable housing. The use of the modular structure (with two modules 100, 200 for each dwelling 10) enables the modules 100, 200 to be entirely manufactured and built on a single site (such as a factory). This enables the modules 100, 200 to be manufactured in advance, quickly, efficiently and with a high standard of quality control.

10 The modules 100, 200 are sized to enable handling and legal transportation by road (including in countries such as the UK) and are arranged to possess sufficient inherent robustness to prevent any form of damage in transit.

15 In addition, the reproducible and efficient building methodology of the modules 100, 200 enables the dwelling 10 to meet stringent requirements for sustainably and running costs with non-reliance on gas and oil for space and water heating.

Energy-efficiency of a building can be defined in terms of a building regulation Code. The Code is intended to reflect future Building Regulations in relation to Carbon emissions from a home and the energy use of that home, with the intention of providing greater regulatory certainty for the homebuilding industry.

20 The Code uses a star rating system (from 1 to 6) to define the overall sustainability performance of a new home. Minimum standards for energy and water consumption are set for each Code level. The structure of the modules 100, 200 enable the modules 100, 200 to be produced to a Code level 4 standard without the need for any other additional energy-saving elements.

25 There is no reliance on gas or oil to run space or water heating. This will mean that the end user will have very little running costs in the "whole life" of the building. Additionally, the structure of each module 100, 200 has been designed such that at least 92% of the components used in construction are available to be

recycled at the end of the useful life span of the dwelling 10.

Figures 3 to 6 show schematic diagrams of a ground floor module 100 in more detail. Figure 3 shows a cross-section of the ground floor module 100 taken along a horizontal plane at floor level. Figure 4 shows a cross-section of the ground floor module 100 taken along a horizontal plane at ceiling level. Figure 5 shows a cross section taken along a vertical plane showing the side of the module 100. Figure 6 shows a cross-section taken along a vertical plane perpendicular to the cross-sectional plane of Figure 6.

The module 100 comprises a floor surface 102, a front wall 104, a rear wall 106, side walls 108, 110 and a ceiling structure 112. The module 100, in this embodiment, has front and rear walls of width 5 m. In other words, the maximum width of the module 100 is 5 m. This is the maximum permitted width to enable legal road transportation of the complete module 100.

In this embodiment, the module 100 has a length of 11.6 m and a height of 2.5 m. This enables provision of a full-size dwelling 10 having sufficient internal volume to provide essential (and possibly lifetime) services as required.

The module 100 is connected by a ring beam 114 which extends around the perimeter of the module 100. In this embodiment, the ring beam 114 is formed from ParallamTM. ParallamTM is a wood material formed from veneer strands arranged in parallel alignment and bonded together with an adhesive. It is generally formed in a continuous beam.

However, other suitable materials for forming the ring beam 114 may be used; for example, other types of timber or metals may be used. The skilled person would be readily aware of types of material which would be suitable for use as a ring beam in the present invention.

The ring beam 114 has a generally rectangular cross section and sections of the

ring beam are connected together using a “gangnail” arrangement whereby metal plates comprising a plurality of nails-like protrusions are used to secure different, substantially perpendicular, sections of the ring beam 114 together. This enables the ring beam 114 to be structurally designed such that long lengths thereof can be fabricated in one continuous section without additional machining or complex interlocking shapes being required to secure the different sections of the ring beam 114 to one another.

The floor surface 102 comprises a plurality of floor cassettes 116. Each floor cassette 116 comprises an engineering joist and a layer of insulating material sandwiched between two layers of structural material. In this embodiment, the insulating material comprises foam or mineral fibre material and the structural material comprises plyboard.

Metal joists 118 are located between the side walls 108, 110 to ensure the structure has sufficient rigidity. The joists comprise I-section steel rods lying in the plane of the floor surface.

The perimeter walls 104, 106, 108, 110 comprise wall modules 120. Each wall module 120 comprises a structural insulated panel. In this embodiment, a structural integrated panel width of 125 – 150 mm is required to provide the required strength and resistance to axial loads, both during transportation and general requirements for a standing structure (e.g. weather and wind resistance) when the dwelling 10 has been completed and assembled on-site. Any suitable number of wall modules 120 may be used to provide a wall 104, 106, 108, 110 of the module 100.

A plan view of the module 100 is shown in Figure 7. In Figure 7, the structure of the wall modules 120 is shown. In this embodiment, at least some of the wall modules 120 comprise primary and secondary structural layers. The primary, outward-facing structural layer is formed from OSB. In the present case, the OSB layer may range from 9 mm to 11 mm in thickness.

The secondary structural layer faces internally and is formed from plasterboard

which is, in this embodiment, 12.5 mm thick. The internal plasterboard layer can be decorated to suit the desired internal appearance of the dwelling 10. These layers sandwich a central core of foam which provides the necessary insulation. The wall modules 120 are considerably stronger than conventional timber construction techniques.

5

The module 100 defines an internal living space for the dwelling 10. Therefore, a plurality of internal walls 130 is provided. In order to provide sufficient space within the dwelling 10 to enable, for example, compliance with local authority housing standards for lifetime use of the dwelling, or to provide for varying needs to enable specific furniture to be placed in particular rooms, relatively narrow internal walls 130 are required.

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In this regard, the minimum necessary width for rooms and stairways (for example, with regard to the future use of a chairlift, or for turning circles for wheelchair users), require the use of internal walls 130 formed from structural studs having an overall thickness of 100 mm.

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In this embodiment, the internal walls 130 comprise 50 mm square timber studs sandwiched between layers of 12.5mm thick ply which, in turn, is sandwiched between layers of 12.5 mm thick plasterboard. The internal walls 130 are arranged and located within the interior of the module 200 such that internal stresses and axial loads from the internal structure are transferred to the wall modules 120 of the perimeter walls 104, 106, 108, 110. This removes the need for the internal walls 130 to be taken down to the foundation 12.

20

The module 100 is designed such that it can be manufactured in a factory environment with a complete interior. Therefore, it is envisaged that all required internal fittings, such as doors, cupboards, paint finishings etc, are completed and fixed internally within the module 100 prior to transportation to the construction site.

25

During transportation, the module 100 will be exposed to a variety of stresses and vibrations. Lifting and movement of the module 100 will cause axial and shear stresses on the structure of the module 100. Further, vibration, substantially vertical oscillations

and wind shear of the module 100 are likely to occur during transportation of the module 100 to the site. Therefore, it is necessary for the structure of the module 100 to be sufficiently rigid to resist stresses and strains inherent in the transportation process.

Further, the relatively delicate internal fixings and paintwork must not become cracked and damaged in transit; otherwise additional man-hours would be required to repair any such damage which has occurred. Therefore, it is also necessary for the internal structural panels (such as the plasterboard layers on the internal walls 130) to be essentially isolated from external stresses such that damage does not occur.

Consequently, the module 100 is provided with a plurality of steel structural beams 140 operable to cradle structurally the ring beam 114 surrounding the perimeter of the module 100. The steel structural beams 140 are operable to spread the loads and forces exerted on the module 100 from point loads to uniformly distributed loads (UDLs).

The structural beams 140 are shown in Figures 3, 4, 8 and 9. . Figure 3 shows a cross-section of the structural beams 140 at floor level. Figure 4 shows a cross-section of the beams 140 taken at ceiling level. Figure 8 shows a schematic view of the floor surface 102 comprising floor cassettes 116 and the structural beams 140. Figure 9 shows a schematic exploded view of the entire housing module 100.

The structural beams 140 are constructed from steel, or more particularly, box section steel (sometimes known as structural hollow section or SHS) having a thickness of 5 mm and sides of length 80 mm x 80 mm. In this embodiment, four structural beams 140 are provided, each beam 140 being spaced along a respective side wall 106, 108 at a distance of 2.4 m from the respective front or rear wall 102, 104 of the module 100, and, along a particular side wall 106, 108, spaced a distance of 6.6 m apart. This arrangement enables the moments of each portion of the module 100 to be balanced with respect to each structural beam 140.

With reference to Figure 9, the components of the ground floor module 100 are

shown in exploded form. Each of these components is operable to ensure that the structure of the module 100 is sufficiently rigid and is able to spread transportation or lifting loads evenly about the structure to prevent damage to the module 100 and internal fittings thereof.

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As shown, the structural beams 140 are connected to, and cradle, the ringbeam 114 as described below. Further, the structural wall modules 120 abut and are connected to the structural beams 140 and the ringbeam 114. The structural wall modules 120, whilst having internal resistance to stress and strain, are also functional to distribute loads evenly throughout the structure of the module 100.

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In addition, the internal walls 130 comprise structural studs such that they are able to resist loads themselves and transfer loads evenly throughout the structure of the module 100. Effectively, by making the internal walls 130 structural, the rigidity of the module 100 is greatly increased. In other words, the internal walls 130 form a honeycomb-like reinforced structure which reduces flexing of the module 100 during transportation, lifting or installation.

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An individual structural beam 140 is shown in more detail in Figures 10 to 12. Figures 10 and 11 show schematic side views of the structural beams 140 (Figure 10 showing an internal-facing surface and Figure 11 an external-facing surface) and connections thereto to the ring beam 114. Figure 12 shows a section of a ground floor module 100 showing a structural beam 140. The lengths shown in Figures 10 and 11 are not to scale and only the upper and lower ends of the structural beam 140 are shown in these figures.

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With reference to Figures 8 to 12, each structural beam 140 comprises a base plate 142. The base plate 142 is welded to the base 144 of the structural beam 142 and provides connections to enable the structural beam 140 to be connected to the ring beam 114. In this embodiment, the base plate 142 comprises a 300 x 150 x 8 mm flat plate which is welded to the base of the structural beam 140 and is arranged to cradle the

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ringbeam 114. This provides a degree of support to spread lifting and transportation loads evenly across the module 100 through the ringbeam 114 and wall modules 120.

The base plate 142 is attached to the ring beam 114 by means of a gang nail arrangement comprising a flat plate comprising a plurality of nails to which the ring beam 114 is connected. Alternatively, the base plate 142 may be connected to the ring beam 114 by means of galvanised coachscrews. The skilled person would be readily aware of variations of fixing mechanisms which would be suitable for the present invention. The base plate 142, as shown in Figure 12, is operable to rest on the foundation 12.

As best shown in Figures 10 to 12, at the upper end 146 of the structural beam 140 is located a corresponding plate 148 to which the upper ring beam 114 is connected. The plate 148 is welded to the internal top flange of the structural beam 140.

Further, at the upper end 146 of the structural beam 140 is located a connection 150. The connection 150 comprises a receiving portion operable to receive a long 16 mm ring bolt 150a. This is shown in Figure 12. The connection 150 has a dual function. Firstly, the location, spacing and construction of the structural beams 140 enable the connections 150 to be utilised as a lifting points for the module 100 when a ring bolt 150a is attached thereto. The lifting operation may utilise chains or straps which connect to the ring bolt by lifting hooks which are received by the ring bolt 150a. The spacing of the structural beams 140 are such that there is no resultant moment when the four structural beams 140 are used to lift the module 100.

Once the module 100 is located in place in the foundation 12, then the ring bolts can be removed and the connections 150 can be used as locating points for the module 200 to be installed above. The connection 150 can be then be utilised as a connection point to anchor the upper module 200 to the lower module 100 as will be described later. This can be done using appropriate bolts connected to the nut. The designed torque can then be set as required to secure the upper module 200 to the lower module 100.

The upper floor module 200 is shown in Figures 13 and 14. Figure 13 shows an exploded view of components of the upper floor module 200 similar to Figure 9. Figure 14 shows a view of the floor cassettes and structural beams of the upper floor module 200 similar to the view shown in Figure 8.

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It is envisaged that the module 200 will have a similar construction to the module 100. However, differences in internal structure will be required; for example, the lower module 100 requires an opening 202 to be formed in the ceiling structure to enable a staircase to mate with a corresponding opening 172 (shown in Figure 9) in the floor surface of the module 200.

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Additionally, the room layout, structure and fittings of the module 200 will be different from those of the lower module 100; for example, by the layout comprising bedrooms and a bathroom, as opposed to a living room and kitchen for the lower module 100.

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Figure 15 shows a sectional view of the structural sections 140 when the module 200 is in place above the module 100. As shown, the ring bolt 150a has been removed from the connection 150 in the lower module 100 and corresponding fixings have been put in place such as bolts or screws of appropriate diameter.

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In order to locate the module 200 above the module 100 correctly and securely, lower location units 180 are provided on the upper corners of the module 100. The lower location units 180 are arranged to mate with corresponding upper location units 280 formed on the lower corners of the module 200. The location units are described in more detail with reference to Figures 16 to 20.

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Figure 16 shows a side view and a plan view of a lower location unit 180 for use with the module 100. The location unit 180 is locatable at an upper corner of the module 100 and is connectable to the wall modules 120. It is envisaged that a location unit 180 will be located at each upper corner of the module 100. Therefore, four location modules

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180 will be provided in this embodiment. However, any number of location modules 180 may be provided; for example, two location modules 180 in opposing corners, or six location modules 180 with one location unit 180 per upper corner and an additional two location modules 180 centrally positioned on the upper wall of the module 100.

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The location unit 180 comprises a substantially square base 182 having a length of 260 mm (in this embodiment) and which includes securing means 184. In this embodiment, the securing means comprise four equi-spaced holes such that the location unit 180 can be secured to an upper corner of the module 100 using screws or other fixing devices. However, other securing means may be used with the present invention.

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A locating flange 186 is formed on the base 182. The locating flange 186 comprises a substantially rectangular, raised portion 188 having a height, in this embodiment, of 52 mm. The raised portion 188 contains a frustoconical centre section 190 therein. The frustoconical centre section 190 comprises a recessed cone with decreasing diameter in a downward direction. The maximum diameter of the centre section 190 is approximately 80 mm in this embodiment. The frustoconical centre section comprises an opening 192 having a diameter of 16 mm. The function of this element will be described later.

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Each location unit 180 is formed from pressed galvanised mild steel. An example of the location unit 180 in place on an upper corner of the module 100 is shown in Figure 18. When in situ, each location unit 180 contributes to the structural rigidity of the module 100 as a whole, and additionally contributes to the structural rigidity of modules 100, 200 when attached together.

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Referring now to Figure 17, this figure shows a side view and a plan view of an upper location unit 280. The location unit 280 comprises a substantially square base 282 which includes securing means 284. In this embodiment, the securing means comprise four equi-spaced holes such that the location unit 280 can be secured to a lower corner of the module 200 using screws, bolts or other fixing means. However, other securing

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means may be used with the present invention.

A locating flange 286 is formed on the base 282. The locating flange 286 comprises a substantially rectangular, raised portion 288 with a frustoconical centre section 290 contained therein. The frustoconical centre section 290 comprises a recessed cone with decreasing diameter in a downward direction. The frustoconical centre section 290 is shaped to correspond to the frustoconical centre section 190 of the lower location unit 180. The maximum diameter of the centre section 290 is, therefore, approximately 80 mm in this embodiment. This is such that, when mated, the lower surface of the frustoconical centre section 190 will conform to the upper surface of the frustoconical centre section 190 and mate in close abutment therewith.

The frustoconical centre section 290 comprises a protrusion 292. The protrusion 292 is welded in place at the centre of the frustoconical centre section 290 and projects downwardly. The protrusion 292 is formed from solid circular section steel and has a smooth nose portion at the distal end thereof to facilitate mating with the opening 192 of the lower location unit 180.

Figures 19a to 19c show different stages of the process for mating the module 100 to the upper module 200. As shown, as the upper module 200 is lowered onto the lower module 100, a degree of mismatch may occur. However, provided the mismatch is less than the radius of the frustoconical portions 190; 290, then the location units 180, 190 provide a form of auto-location as shown.

In Figure 19a, a degree of mismatch between the position of the upper module 200 and the lower module 100 is shown. However, as the upper module 200 is lowered, the interaction between the protrusion 292 and the upper wall of the frustoconical portion 190 causes a lateral force to be exerted on the upper module 200 (which is suspended by chains or cables and, as such, is movable) which will bring the upper module 200 into alignment. This process is shown in Figures 19b. Then, as shown in Figure 19c, the protrusion 292 locates in the opening 192 and can be secured thereto.

Figure 20 shows a section illustrating the completed mating of the lower and upper location units 180, 280 when connected to lower and upper modules 100, 200. As shown, the two location units 180, 280 abut one another in close relation, ensuring accurate and straightforward location of the modules 100, 200 above one another. The modules 100, 200 can then be secured together through use of screws or bolts attached to the protrusion 292.

Figures 21 to 23 show side sectional views of an alternative structure of dwelling in the form of a dwelling 50. In this embodiment, the dwelling 50 is a semi-detached dwelling comprising two individual dwellings 50a, 50b located side by side. Each dwelling 50a, 50b shares a common party wall 52 (Figure 23) and a common roof structure 54. The foundation 12 of the dwelling comprises a concrete slab base 160 and mounting posts 162 at each corner. The mounting posts 162 are operable to receive the base of the module 100 and to provide a 150 mm ventilated void between the module 100 and the foundation 12.

The foundation 12 also comprises service connections 164 (shown schematically in Figure 21). The service connections 164 comprise electrical connections to the mains electrical supply and water services such as tap water and sewerage.

The service connections 164 are located to connect directly to complementary service connections 166 located on the module 100. This enables straightforward connection of services to the module 100 and, thus to the dwelling 50.

The module 100 has service connections 168 to connect to the module 200. The module 200 has complementary service connections 170 to enable power and water services to be carried through to the upper module 200.

The electrical connections between the modules 100, 200 comprise a single "plug and play" connection. Once connected, a consumer unit can be installed in both of the modules 100, 200. "Smart" wiring may be provided in each module 100, 200 to

accommodate any manner of future smart metering, off site control and/or monitoring of heating controls. The smart wiring enables one switch to operate all lighting within the modules 100, 200 at front and rear doors.

5 Other connections may be located on the modules 100, 200 in corresponding relation to ease production thereof. For example, the Soil-vent pipe (SVP) connection may be positioned vertically in exactly the same position on both modules 100, 200 to allow ease of installation as part of the commissioning process on site. The heat recovery and ventilation ducting is also one joint in the service riser.

10 As shown in Figures 21 to 23, the module 200 sits in direct vertical relation to the module 100 and is secured thereto with the connections 150 on the top of the module 100 and corresponding securing points on the base of the structural beams 140 of the module 200. The module 200 may be secured to the module 100 by means of ties, bolts or other
15 structural elements. Once the modules 100, 200 are in place, then the roof structure 56 can be completed and the outer structural walls 58 added to form a complete dwelling.

 The modular arrangement can be “life proofed”. By this is meant that a dwelling constructed from the housing modules can be modified as the inhabitant of the property
20 ages and requires different services. Therefore, for example, the living area can be dimensioned such that a bed can be installed at a later date should this be required.

 Other configurations enable the fitment of a stair lift for the elderly or less able. A provision for a lift in the bathroom area may be added to enable infirm or disabled people
25 to be lifted from a bath or bathing area. By use of the modular structure, parts of the dwelling can be modified or replaced during the life of the structure without alteration to the structural shell of the dwelling.

 Variations of the above embodiments will be apparent to the skilled person. The
30 precise configuration of hardware components may differ and still fall within the scope of the present invention. For example, whilst the above embodiments have been described and illustrated in the context of a domestic dwelling, other dwellings or residences may

fall within the scope of the present invention; for example, business or office accommodation or industrial accommodation.

Embodiments of the present invention have been described with particular
5 reference to the examples illustrated. While specific examples are shown in the drawings and are herein described in detail, it should be understood, however, that the drawings and detailed description are not intended to limit the invention to the particular form disclosed. It will be appreciated that variations and modifications may be made to the examples described within the scope of the present invention.

CLAIMS

1. A housing module for forming a part of a dwelling, the module comprising:
a floor surface comprising a plurality of floor modules; and
5 a plurality of external walls substantially perpendicular to said floor surface, said
external walls being formed from wall modules each having a composite structure
comprising at least one structural layer and at least one insulating layer;
a plurality of internal structural walls configured to transfer structural loads to
said external walls;
10 a ring beam extending around a perimeter of the wall modules and connected
thereto; and
a plurality of metallic structural beams extending substantially vertically between
a lower edge of said walls and an upper edge of said walls, each structural beam being
connected to at least one wall module and comprising a base plate connected to the ring
15 beam.
2. A housing module according to claim 1, wherein each structural beam further
comprise a connection at an upper end to enable the module to be lifted.
- 20 3. A housing module according to claim 1, wherein said connection is further
operable to enable a further housing module to be connected and secured thereto.
4. A housing module according to any one of the preceding claims, wherein said
housing module has a front wall, a rear wall and two side walls, said structural beams
25 forming part of said side walls.
5. A housing module according to any one of claims 1 to 4, wherein at least four
structural beams are provided.
- 30 6. A housing module according to claim 5, wherein said structural beams are
equispaced about the centre of mass of the housing module.

7. A housing module according to any one of the preceding claims, wherein said structural beams have a square cross section.

5 8. A housing module according to any one of the preceding claims, wherein said structural beams are substantially hollow.

9. A housing module according to claim 1, wherein said wall modules comprise structural insulating panels including a central mineral fibre or foam layer surrounded by
10 structural layers.

10. A housing module according to claim 9, wherein said structural insulating panels have a width between 100 – 150 mm.

15 11. A housing module according to claim 1, wherein the internal walls are connected to said floor surface and operable to transfer structural loads to said metallic structural beams.

12. A housing module according to claim 11, wherein said internal walls comprise
20 structural insulated panels.

13. A housing module according to claim 12, wherein said internal walls have a thickness of 100 mm or less.

25 14. A housing module according to claim 1, wherein said module is up to 5 m wide.

15. A housing module according to any one of the preceding claims, wherein said module further comprises at least one location unit locatable at an upper or lower surface thereof.

16. A housing module according to claim 15, wherein said location unit comprises a tapering section operable to receive, or to be located in, a complementary tapering section on another housing module.

5 17. A housing module according to claim 16, wherein said tapering section is conical or frustoconical.

18. A housing module according to claim 17, wherein, when located on an upper surface, the tapering section is conical and comprises an aperture for receiving a
10 projection located at a distal end of the complementary tapering section.

19. A housing module according to claim 18, wherein, when located on a lower surface, the tapering section further comprises a projection arranged to extend into the tapering section of a location unit located on an upper surface of another module.

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20. A housing module according to any one of claims 15 to 19, wherein said location unit is located at an upper or lower corner thereof.

21. A set of a first housing module and a second housing module located vertically
20 above said first housing, said first housing module comprising at least one lower location unit comprising a lower tapered locating portion, and said second housing module comprising at least one complementary upper location unit comprising a complementary upper tapered locating portion, said lower tapered locating portion being operable to receive said upper tapered locating portion in close relationship thereto.

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22. A set according to claim 21, wherein said tapered portions comprise frustoconical portions.

23. A set according to claim 21 or 22, wherein said upper tapered locating portion
30 comprises a protrusion operable to mate with a corresponding opening formed in said lower tapered locating portion.

24. A set according to claim 23, wherein said protrusion is arranged to receive a securing means to secure the lower location unit of the first housing module to the upper location unit of the second housing module.

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25. A set according to any one of claims 21 to 24, wherein four location units are provided on each module.

26. A dwelling comprising a foundation, a first housing module located on said
10 foundation and a second housing module located vertically above said first housing module, said first and second housing modules being configured as set out in any one of the preceding claims.

27. A dwelling as claimed in claim 26, further comprising a further set of a first
15 housing module located on a foundation and a second housing module located vertically above said first housing module, such that said dwelling comprises a semi-detached house.

28. A dwelling according to claim 26 or 27, further comprising outer structural walls
20 surrounding the modules.

29. A dwelling according to any one of claims 26 to 28, further comprising a roof structure.

25 30. A method of constructing a dwelling, the method comprising:
preparing a foundation comprising service connections;
locating a first housing module as claimed in any one of claims 1 to 20 on said foundation, said first housing module having complementary service connections;
connecting said two sets of service connections;
30 locating a second housing module as claimed in any one of claims 1 to 20 in vertical relation to said first module;

securing said second housing module to said first housing module;
providing an outer structural layer surrounding said first and second modules; and
providing a roof structure above said second module.

5 31. A method of constructing a dwelling, the method comprising:

preparing a foundation;

locating a first housing module on said foundation, said first housing module
comprising at least one upper location unit comprising an upper tapered locating portion;

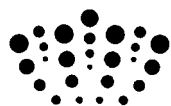
10 locating a second housing module above said first housing module, said second
housing module comprising at least one complementary lower location unit comprising a
complementary lower tapered locating portion, said step of locating a second housing
module comprising:

lowering said second housing module so that said lower tapered locating portion
is adjacent said upper tapered locating portion on said first housing module such that said
15 upper and lower location units enable automatic location of said first and second housing
modules in relation above one another; and

securing said second housing module to said first housing module.

32. A method according to claim 31, further comprising:

20 providing an outer structural layer surrounding said first and second modules; and
providing a roof structure above said second module.



Application No: GB1107313.7 **Examiner:** Eleanor Wade
Claims searched: 1 to 20, 26 to 29 when **Date of search:** 31 August 2011
appended to any of claims 1 to
20, and 30

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

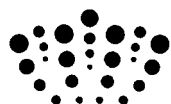
Category	Relevant to claims	Identity of document and passage or figure of particular relevance
Y	1-14,26-30	JP57066101 U see abstract and figures
Y	1-14,26-30	WO2005/007540 A ABLER see whole document
Y	1-14,26-30	US4275534 A PORTER see whole document
Y	1-14,26-29	US4455792 A PASCO see whole document
Y	1-14,26-30	GB2115037 A GROCOTT see whole document
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^X :



Worldwide search of patent documents classified in the following areas of the IPC

E04B; E04H

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
E04B	0001/348	01/01/2006
E04B	0001/24	01/01/2006
E04H	0001/02	01/01/2006