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King et al.

[11] **3,885,368**

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[54] **PREFABRICATED BUILDING STRUCTURE**

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[52] **U.S. Cl.** **52/79;** 52/236; 52/73

[51] **Int. Cl.** **E04h 1/00**

[58] **Field of Search** 52/79, 236, 75, 234, 283

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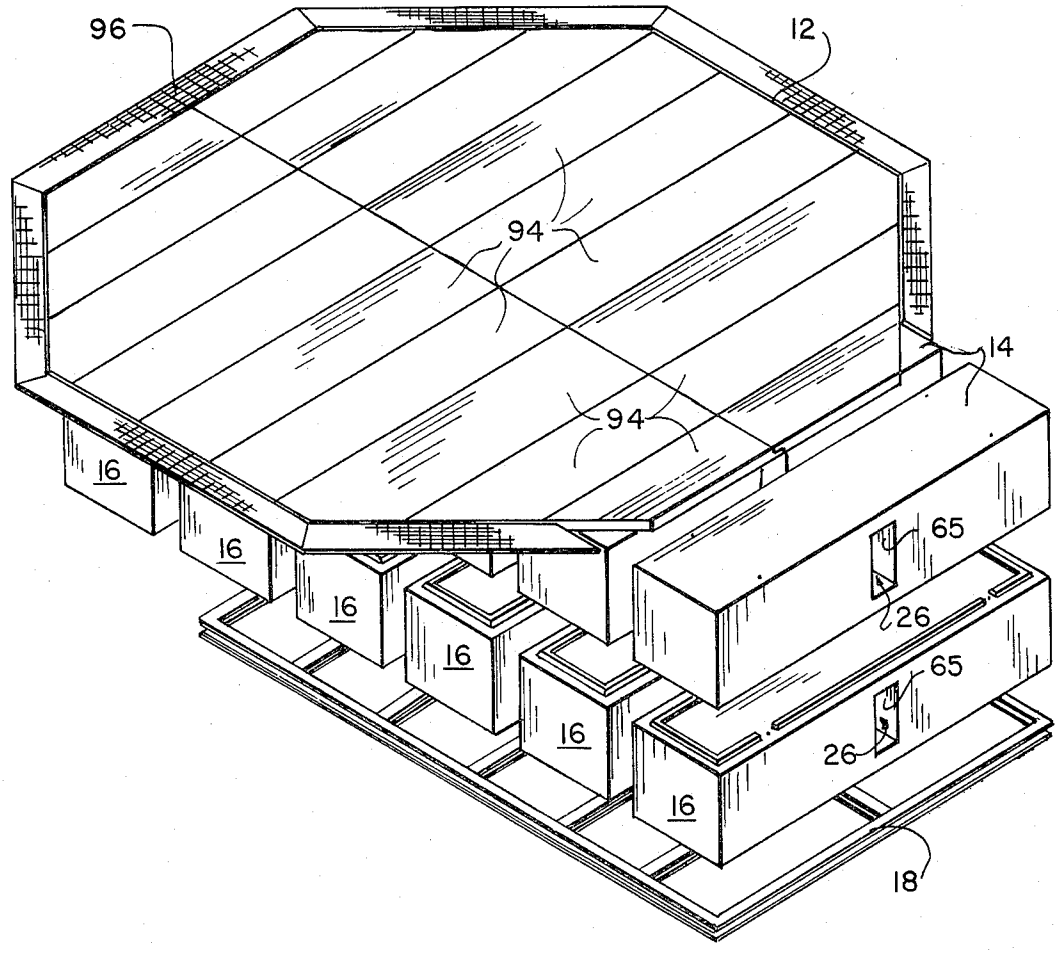
Assistant Examiner—Carl D. Friedman

[57] **ABSTRACT**

A prefabricated building structure is comprised of a series of upper and lower level modular units, the units in each level arranged in side-to-side, connected, mutually reinforcing relation to one another, and the upper level of units is superimposed on the lower level so that when assembled the units will cooperate in supporting a flight deck in offset relation to the assembled roof of the upper level. In each unit, the floor panel is vertically spaced from the lower edges of the side and end panels so as to define living quarters above the floor panel and a raceway for utilities beneath the floor panel; and when assembled, preformed hallways through each unit establish a continuous hallway that passes through each series of upper and lower level modular units in a direction parallel to the length of the assembly but normal to the length of the individual units. A laminated flight deck comprised of prefabricated sections is secured in offset relation to the roof of the assembled upper units and overhangs the units without the need of gusset-type supports while the lower edges of the lower level units are secured directly to a preassembled base gridwork whereby skid members between the units and the base gridwork are not needed.

6 Claims, 8 Drawing Figures



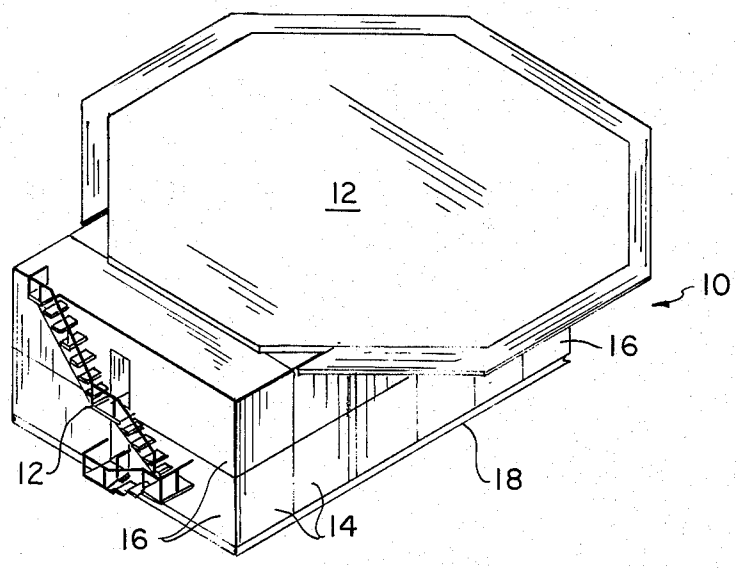


Fig. 1

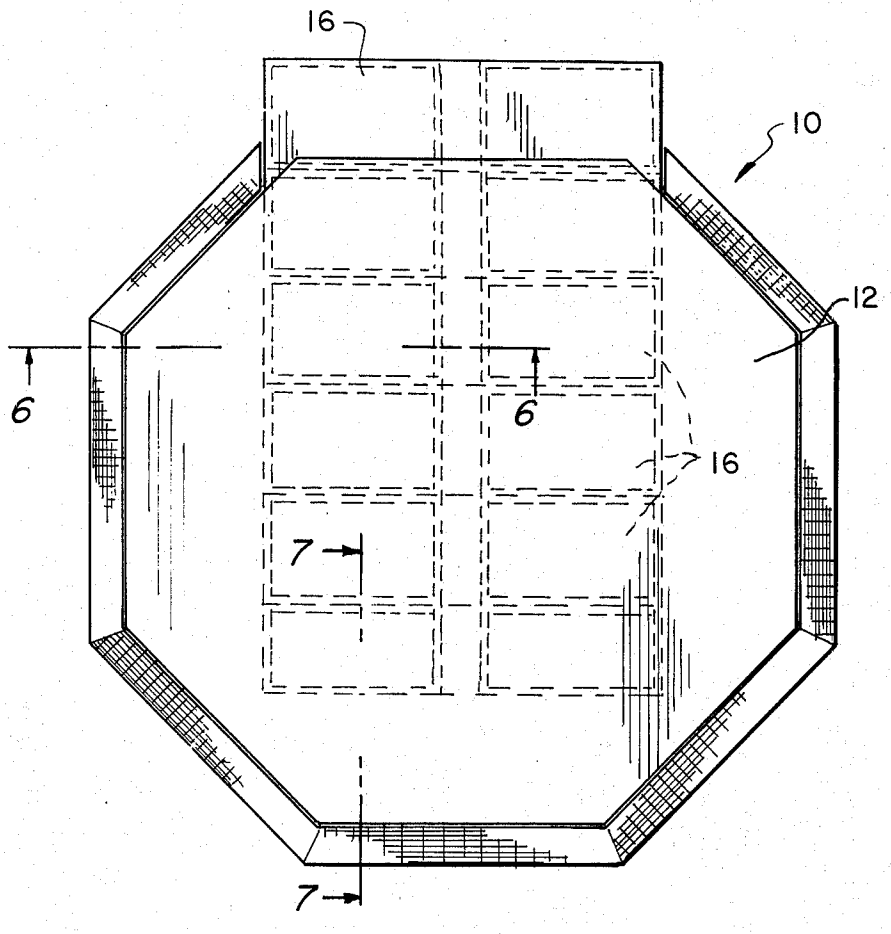


Fig. 2

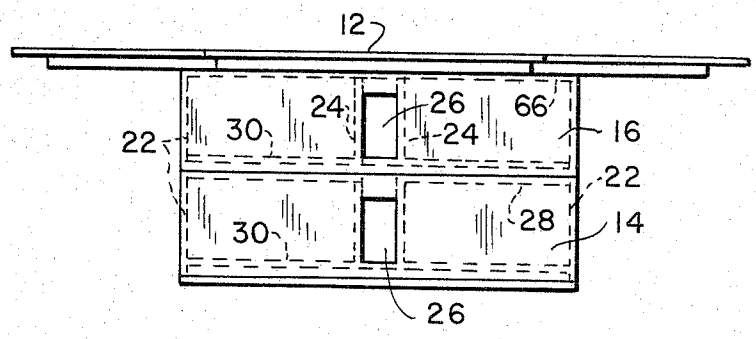

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Fig_ 3

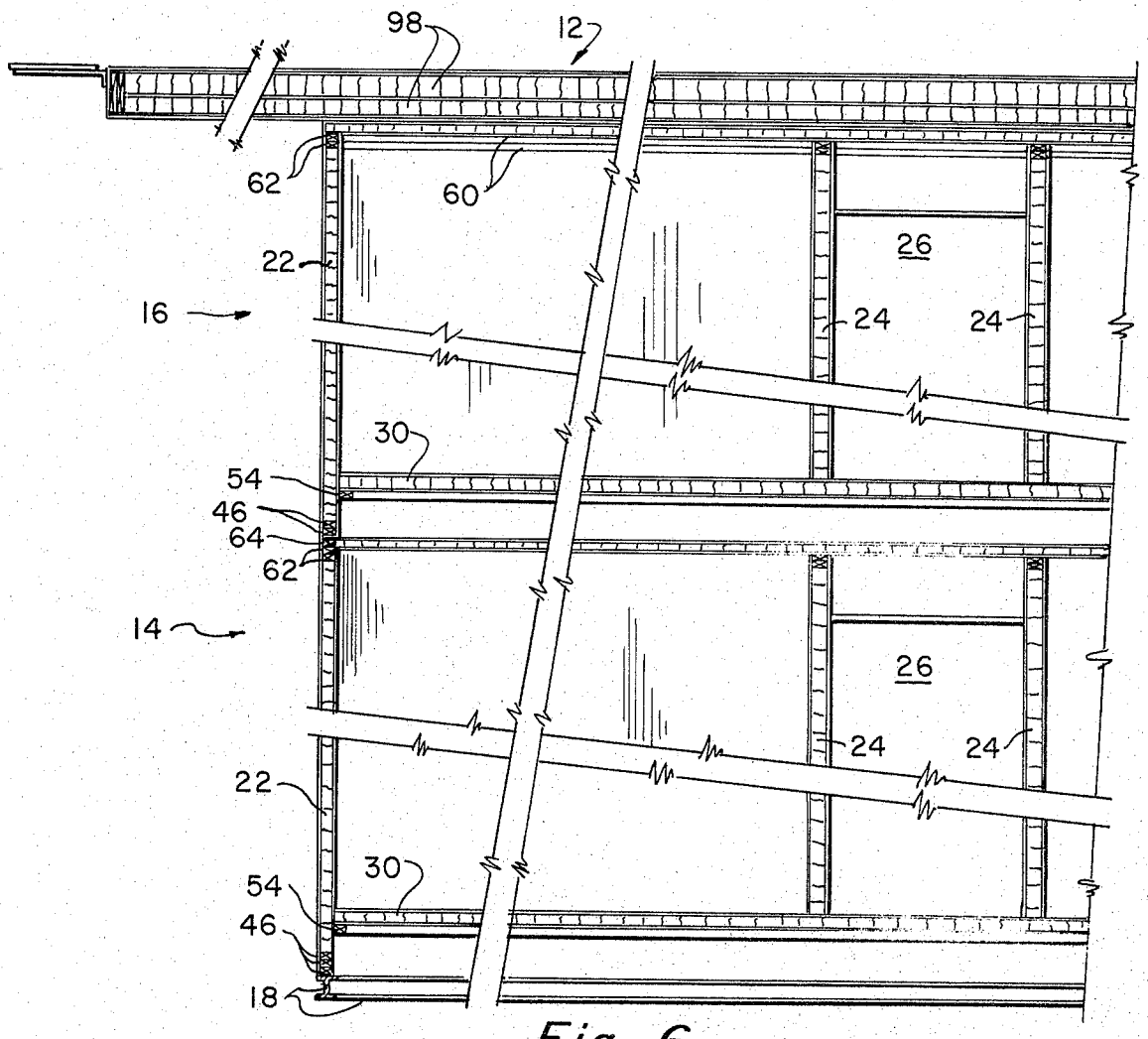
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Fig_ 6

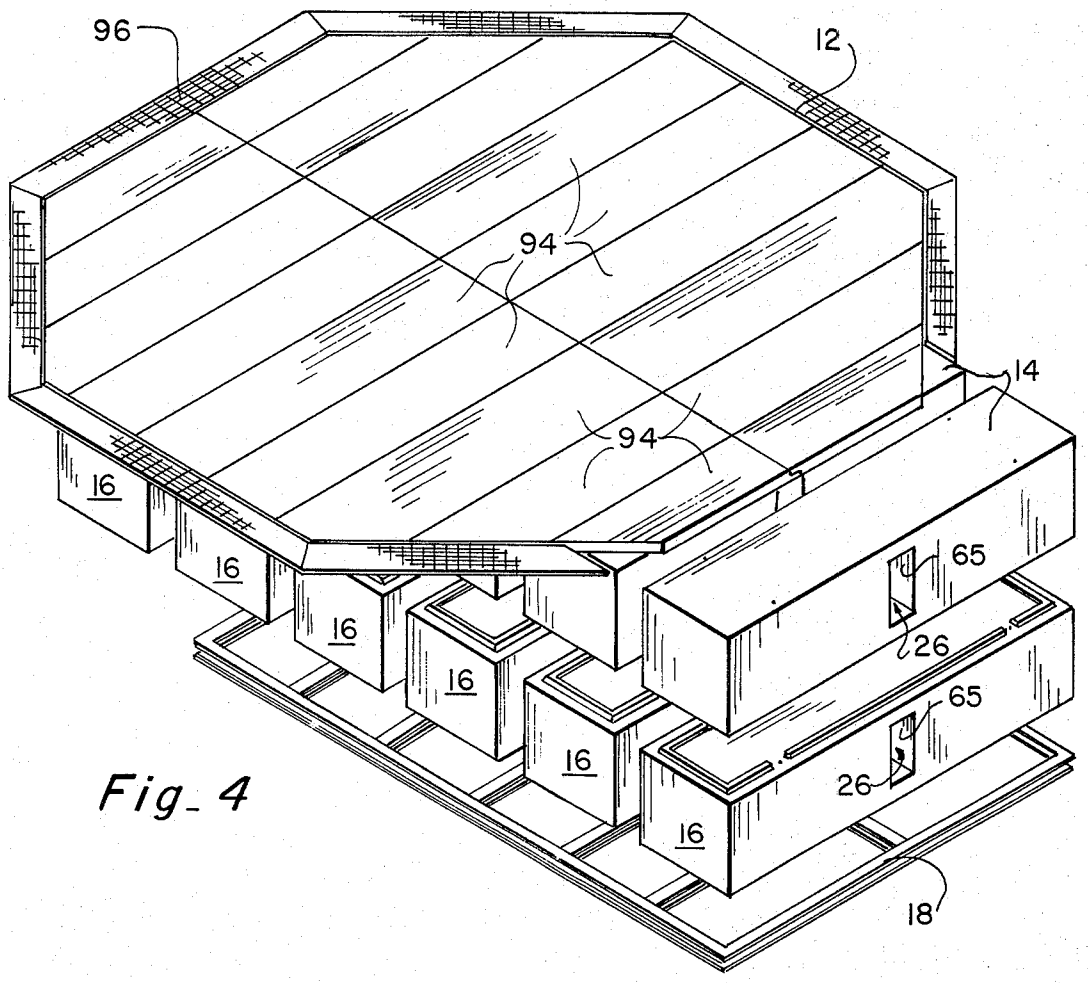

Fig_4

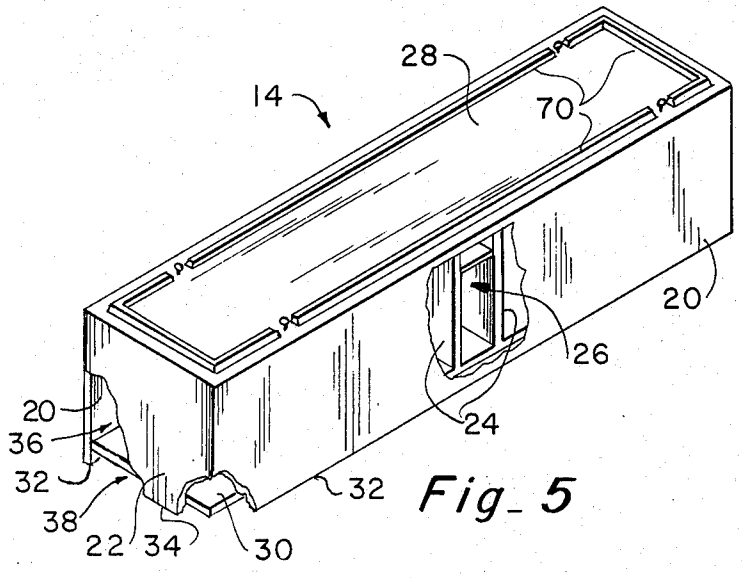

Fig_5

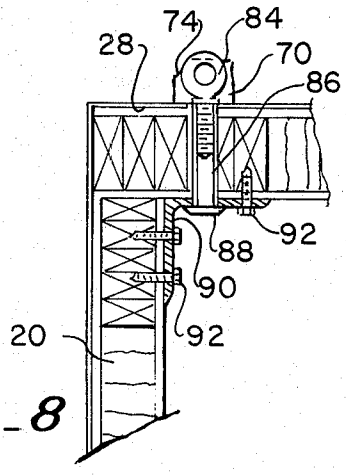

Fig_8

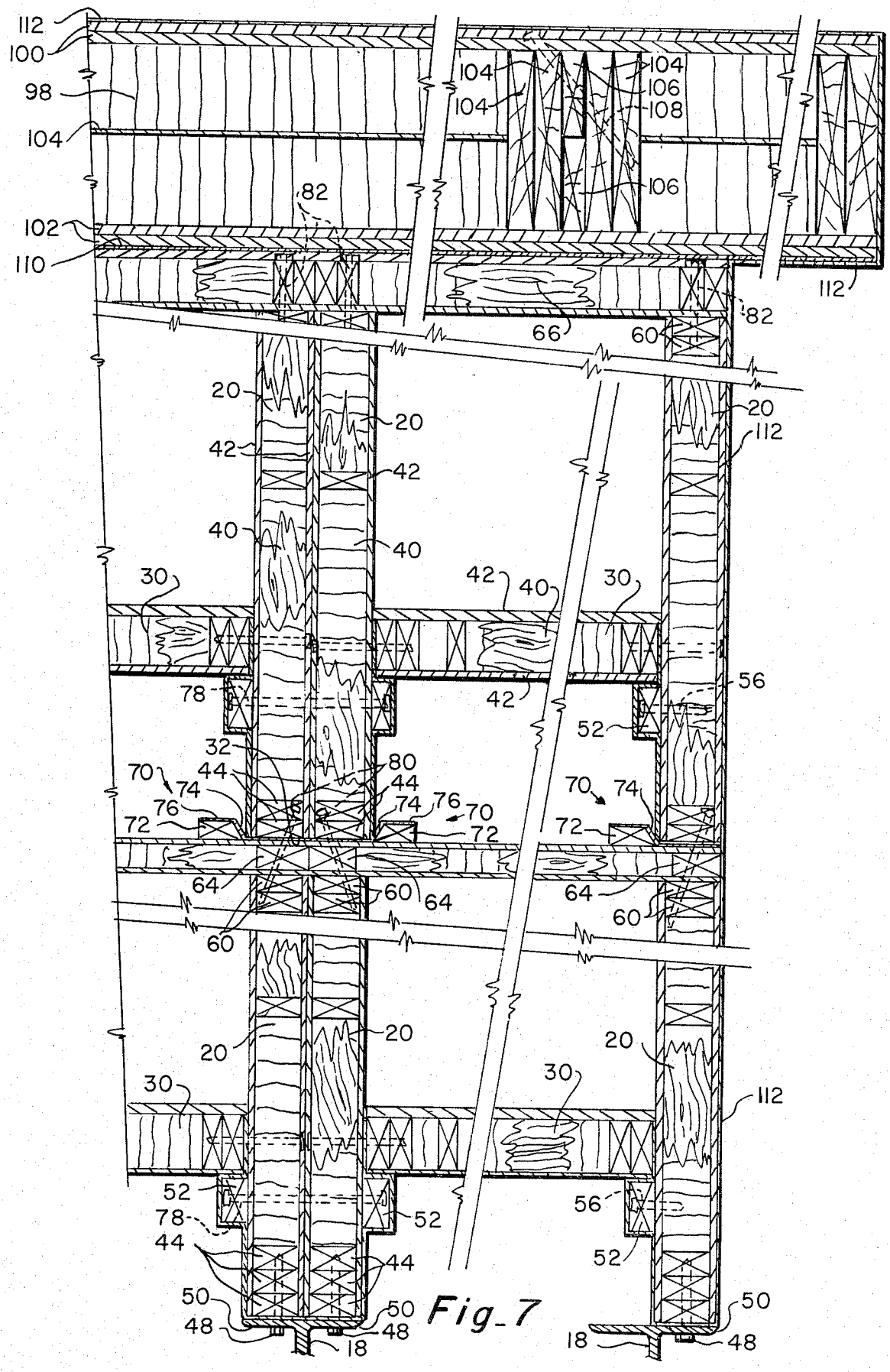
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Fig_7

PREFABRICATED BUILDING STRUCTURE

The present invention relates generally to building structures and more particularly to novel and improved prefabricated modular building units which are transportable to the intended site and can be quickly and efficiently assembled into a multi-room structure such as for example, crew quarters for offshore drilling operations.

Modular building structures have attracted considerable attention because of their factory assemblage and the resultant savings in costs per structure. One highly desirable feature of modular construction is in the assemblage of offshore building structures, such as of the type utilized as crew quarters for offshore drilling operations. Inasmuch as the modules must be transferred to the offshore location, simplicity of construction and assembly as well as weight become critical factors in the prefabricated modular units.

The prefabricated building structure of the present invention is of simplified design and composed of upper level units and lower level units with self-contained hallways, the units in each level arranged in side-to-side connected, mutually reinforcing relation to one another, and the upper level units being superimposed on the lower level units so that when assembled the units will cooperate in supporting a flight deck and in forming a continuous hallway transversely through adjacent modular units on each level of the structure. The modular units are primarily connected together by bonding with a suitable polyester resin and are also joined by secondary mechanical fasteners. Guide means are provided on modular units to be based as lower level units whereby upper level units are guided and properly positioned as they are lowered into place on top of a lower level unit. The flight deck overhangs the units but is of high strength construction so as to need no gusset-type supports.

Each modular unit is comprised of light-weight but durable and high strength panels and includes side wall panels, end wall panels, hall panels normal to the side wall panels defining a hallway therebetween, a top wall panel and a floor panel, the floor panel being spaced vertically from the lower edges of the side and end wall panels so as to define living quarters above the floor panel and a raceway for utilities beneath the floor panel of each modular unit. Modular units in each level are connected with their side wall panels in flush abutting relationship so that they are mutually reinforcing and a rigid unitary assemblage of the units is effected which may be four to six stories tall. Modular units in the upper level are super-imposed on modular units in a lower level and are positively connected with the side wall panels and end wall panels of the respective units in vertical alignment to further rigidify the building structure. The side and end wall panels of the lower level units are anchored to a base gridwork which positively maintains and anchors the entire assemblage of modular units and with the floor panel vertically spaced from the lower edges of the side and end wall panels, no skids or other elevating supports are required between the base gridwork and the modular units.

Accordingly, it is an object of the present invention to provide a modular building structure having modular units with self-contained hallways such that a continuous hallway is established through adjacent units when assembled.

It is another object of the present invention to provide a modular building structure having modular units including guide means for assisting alignment of superimposed units whereby the units can be quickly and easily stacked in desired position during assemblage.

It is another object of the present invention to provide a modular building structure having modular units with a floor panel vertically spaced from the lower edges of the units thereby defining upper living quarters and a lower raceway in which utilities for the modular units may be placed so that skids for spacing the units from a base gridwork are not necessary.

It is still another object of the present invention to provide a modular building structure which can be quickly and easily assembled at a remote location and including an overhanging flight deck which can be easily secured to the top surface of the structure without the use of gusset-type supports.

Other objects, advantages and capabilities of the present invention will become more apparent as the description proceeds taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a diagrammatic perspective view of a preferred form of the modular building structure of the present invention.

FIG. **2** is an enlarged top plan view of the modular building structure of FIG. **1**;

FIG. **3** is a side elevation of the modular building structure of FIG. **1**;

FIG. **4** is an enlarged diagrammatic exploded perspective view of the building structure of FIG. **1** with parts removed for clarity;

FIG. **5** is a further enlarged diagrammatic perspective view of a lower modular unit of the building structure of FIG. **1** with parts broken away for clarity;

FIG. **6** is an enlarged fragmentary section taken along line **6—6** of FIG. **2**;

FIG. **7** is an enlarged fragmentary diagrammatic section taken along line **7—7** of FIG. **2**; and

FIG. **8** is a fragmentary section taken through a corner of a lower level modular unit showing lifting means for transporting the modular units.

Referring to the drawings in FIGS. **1** through **4**, there is shown an exemplary two-story, twelve module building structure **10** including an aircraft landing deck **12** on its top surface. While the prefabricated structure **10** could find numerous useful applications, with or without the aircraft landing deck **12**, it will be appreciated from the detailed description hereinafter that the prefabricated structure is particularly well suited for use as offshore living quarters and the like. The structure **10**, shown in FIGS. **1** through **4**, is seen to include six lower level modular units **14** and six upper level modular units **16** which in combination form an elongated assemblage of the units with the units extending transversely of the structure. The lower level modular units **14** are disposed to be positively anchored to an iron I-beam base gridwork **18** to suitably unify the entire structure as will be explained in more detail hereinafter.

A lower level modular unit **14** is shown in FIG. **5** broadly including elongated spaced parallel side wall panels **20** and spaced parallel end wall panels **22** connecting the side wall panels at their longitudinal ends. Inner wall or hall panels **24** are disposed intermediately of the end wall panels in adjacent spaced relation to one another and normal to and connecting the side wall

panels so as to define a hallway **26** passing transversely through a center portion of the module. A top panel **28** forms a ceiling for the unit **14**, and a floor panel **30** interconnects the side and end wall panels so as to define with the other outside panels, an oblong box-shaped housing structure. The floor panel **30** is spaced from the lower edges **32** and **34** of the side and end wall panels, respectively, defining living quarters **36** above the floor panel and a raceway **38** for utilities and the like beneath the floor panel.

More particularly, the construction and interconnection of the modular units **14** and **16** is clearly shown in FIGS. **6** and **7**. The side, end, top and floor panels of each modular unit are fabricated from a composition core **40** of honeycomb interspersed with laminated wood strips and a skin **42** of a fiberglass-resin combination so that each panel is of light weight but durable and high strength construction defining a substantially flat sheet which is easy to handle. The honeycomb is preferably made of craft paper impregnated with phenolic resin to the extent of 15 percent by weight. The panels may be of the same composition as used and described in connection with the building structure disclosed in U.S. Pat. No. 3,636,667 which is of common ownership with the present application. Looking first at a lower modular unit **14**, it will be seen in FIGS. **6** and **7** that the lower ends of the side and end wall panels **20** and **22** respectively have three wooden beams **44** and **46** respectively stacked vertically on their widest sides. The wooden beams **44** and **46** extend along the entire length and width respectively of the modules. The stacked beams **44** and **46** rest directly on the I-beam base gridwork **18** and are bonded thereto. The stacked beams are also connected to the gridwork by mechanical fasteners **48** passing upwardly through the flanges **50** of the I-beams into the stacked beams of both the side and end panels to positively anchor the modules to the base gridwork.

Support beams **52** and **54** are bonded and mechanically connected with screws **56** to the inwardly directed faces of the side and end panels **20** and **22** respectively at a fixed elevation from the lower edges **32** and **34** of the respective panels to establish a supporting flange on which the floor panel **30** of the modular unit **14** is connected as by bonding with an adhesive medium. Additionally, lag screws **58** inserted through the side and end wall panels **20** and **22** respectively and into the edge of the floor panel **30** secure it in place.

The upper ends of the side and end wall panels have wood beams **60** and **62** respectively, stacked vertically on their widest sides, and the beams **60** and **62** are aligned with a single-layer wood beam frame **64** around the perimeter of the top panel **28**, the single-layer frame **64** composed of a single wood beam along each side of the top panel resting on its widest side. The top panel **28** is rigidly and positively secured to the side and end wall panels **20** and **22** respectively, with a bonding medium and mechanically fastened in a manner to be described later.

The inner panels **24** forming the hallway **26** of each modular unit **14** extend perpendicularly between the floor panel **30** and the top panel **28** and between the side wall panels **20**. Each side wall panel is provided with an opening **65** therethrough in alignment with the hallway **26** providing access to the structure **10** at the two sides thereof. Also, when modular units on one level are connected, the hallways are automatically aligned so that a continuous hallway through the units is established. When desirable, an acoustical ceiling panel **67** for the hallway can be suspended from the inner panels **24** thereby lowering the ceiling level in the hallway relative to the ceiling panel level in the living quarters **36**. Similarly, a ceiling panel, not shown, could be suspended in the living quarters.

To the extent thus far described, the lower modular units **14** are the same as the upper modular units **16** with like parts having been given like reference numerals except that the top panel **66** of the upper modular units **16** is thicker and has a double wood beam frame **68** composed of two wooden beams along each edge, the wooden beams resting on their short sides. The additional thickness of the top panel **66** of each upper unit **16** gives the top panel **66** more strength than the top panel **28** of the lower modular units **14** whereby it will safely support the aircraft landing deck **12** and consequently heavy traffic and supplies that may be stored on the deck **12**. Additionally, the lower ends of the side and end wall panels of the upper level units only have two wood beams **44** and **46** respectively inasmuch as they do not support as much weight as the lower level units.

The lower level modular units **14** have a guide curb **70** affixed to the upper surface of the top panel **28**, the function of which is to properly align and position the side and end panels **20** and **22** respectively of an upper level **16** when the upper level unit is lowered onto the lower level unit during assemblage of the structure and to maintain the alignment while assembled. The guide curb **70** consists of peripherally disposed wooden beams **72** resting on their widest sides and having their outermost sides **74** beveled to properly guide the upper level unit **16** into position and correct for any misalignment. The guide curb **70** is spaced from the outer edge of the top panel **28** a distance substantially equal to the thickness of the side and end wall panels **20** and **22** respectively, of an upper level unit and thereby also serves to hold the upper unit in vertical alignment with the lower unit after assemblage. It can be seen in FIG. **7** that the wooden beams **72** forming the guide curb **70** have an outer coating **76** of a fiberglass material to protect the wood and also to establish a low friction surface on which the side and end panels of the upper unit will easily slide if slightly misaligned when being placed in position.

With particular reference to FIG. **7**, modular units on both the upper and lower levels have their adjacent side walls **20** in flush abutting relationship and are connected with a bonding medium applied to the interface together with mechanical fasteners **78** which are adapted to pass through the respective side walls and the associated wooden support beams **54** beneath the floor panels **30** of each unit. In this manner, adjacent units on each level of the building structure are positively connected together into a unitary assemblage.

Modular units in the upper level are superimposed on units in the lower level and are connected thereto with a bonding medium applied between the top panel **28** of a lower unit **14** and the lower edges **32** and **34** of the side and end panels **20** and **22** respectively of an upper unit **16**. The upper level units are also connected to the lower level units by mechanical fasteners **80** which are passed diagonally through the wood beams **44** and **46** along the lower ends of the side and end wall panels respectively of the upper unit, the wood beam frame **64**

around the top panel 28 of the lower unit, and the wood beams 60 and 62 along the upper ends of the side and end wall panels respectively of the lower unit. The top panel 66 of each upper unit in addition to being bonded to the associated side and end walls 20 and 22 respectively, is mechanically fastened with a fastener 82.

To facilitate lifting of the modular units 14 and 16 into proper position, eye-bolt lifting hooks 84 are removably anchored in the top panels 28 and 66 of the lower and upper level modular units respectively at four spaced locations. The lifting hooks are designed to cooperate with conventional cranes or other lifting equipment in establishing a four-point pick up so that the crane can quickly and easily place the modular units in position in the structure 10. Once positioned, the lifting hooks may be removed, especially from the upper level units so as not to interfere with the positioning of the landing deck on the units.

FIG. 8 illustrates the manner in which the lifting hooks are secured to the top panel 28 of a lower level unit 14 and it can there be seen that a sleeve 86 having internal threads is inserted through the top panel 28 of the unit and welded at its lowermost end 88 to an angle iron bracket connector 90 secured to the side wall 20 and the top panel 28 of the unit as by bonding and with screws 92. The lifting hook is then simply screwed into the internally threaded sleeve 86 when it is desired to lift the modular unit and screwed out of the sleeve if necessary.

Looking now at the aircraft landing deck 12, it can be seen in FIG. 4 to be comprised of a plurality of elongated adjacent sections 94 connected together edge-to-edge in the disclosed form to form an octagonal landing surface in offset and overhanging relationship with the underlying structure. It will be appreciated, however, that the landing deck could be positioned in a variety of locations on the building structure due to its high strength and overhanging capabilities to be explained in more detail hereinafter. For safety purposes, a screen fence 96, such as the type disclosed in detail in U.S. Pat. No. 3,636,667, which is of a common ownership with the present application, is affixed in a conventional manner along the outer perimeter of the landing deck 12.

Each section of the landing deck 12, as shown in FIGS. 6 and 7, extends parallel to the length of the underlying modular units and includes a double layer core of honeycomb-wood reinforced panels 98 of the type used to form the wall panels of each modular unit. Additionally, double outer layers of plywood panels 100 and 102 are laminated on the upper and lower surfaces respectively of the sections 94 after they have been interconnected. The honeycomb-wood reinforced panels 98 are separated by an inner plywood layer 104. The peripheral edges of each section 94 are provided with large wooden reinforcing beams 105. The beams 105 extend the entire depth of the two core panels 98 of honeycomb reinforced material. Along the edges of the sections 94 which abut an edge of an adjacent panel, a third smaller extension wooden beam 106, one-half the depth or thickness of the large beams 105, is secured either along the top or the bottom to the outer face of the outermost beam 105 so that on adjacent sections, the third wooden beams 106 are in vertical overlapping alignment when the adjacent sections are moved into abutting edge-to-edge relationship. A mechanical fastener 108 is passed diagonally through the joint between each section 94 so as to be embedded in the large and small wooden beams 105 and 106 respectively of each of the adjacent sections to provide a panel splice joint in positively connecting the sections in the landing deck. Due to the thickness and strength of the aircraft landing deck 12, which is approximately four times as thick as the top panel 66 of the upper level modular units, it can overhang the side and end walls of the modular units up to ten to fourteen feet without the need of supporting gussets or the like along the underside of the overhang. The only means needed to secure the landing deck 12 to the underlying assemblage of modular units is a coating 110 of adhesive bonding material between the top panels of the upper level modular units and the undersurface of the landing deck. It will be appreciated that the landing deck would be well suited for use on various landing structures and is not limited in use to the particular building structure described herein. The sections 94 are prefabricated and transfered to the building site where they are assembled and fastened together while being bonded to the top panels of the upper level modular units in offset and overhanging relationship with the building structure.

A stairway 12 is erected along the side panels 20 of the modular units on one or both ends of the structure and extends between the openings 65 in the associated side panels and also up to the top of the building structure. The plywood panels 102 on the bottom of the flight deck may be extended over the end-most upper level modular unit to establish a suitable walkway from the stairway to the landing deck. A similar stairway, not shown, could be erected within a pair of vertically aligned modular units providing passage between the hallways in the upper and lower levels of the structure.

After the modular units 14 and 16 are assembled and united as previously described with the landing deck 12 bonded to the top surface 66 of the upper level units, a thin protective layer or skin 112 of a fiberglass-polyester resin composition or other similar material is sprayed or otherwise applied in bonded relation to the outer surface of the assembled structure along each joint so as to cover each joint between adjacent modular units as well as between the upper modular units and the landing deck. In this manner, the structure is reliably protected from the environment, particularly the salt water/salt spray atmosphere or environment which would be present if the structure was used at an offshore drilling site.

By way of illustration and not limitation, a typical modular unit found to be of convenient size, shape and weight for both transportation and use is approximately forty-three feet long, eleven feet wide, and ten feet high. The top panel of the upper level units is approximately four and one-half inches thick and the top panel of the lower level units two inches thick. The height of the living quarters in each unit is approximately eight feet-ten inches and the landing deck approximately one foot thick and overhanging the end wall panels of the underlying units about ten to fourteen feet so as to be approximately sixty-three to seventy-one feet from side-to-side.

It will, therefore, be appreciated that a prefabricated modular building structure 10 has been described which can be easily and quickly assembled at a remote location. When assembled, the modular units in the structure are disposed and positively secured in abut-

ting relationship forming a desirable unified monolithic structure with hallways extending transversely through each modular unit and automatically forming a continuous hallway through each level of the structure. This system alleviates the previously tedious and difficult task of appropriately spacing adjacent modules during assemblage to establish hallways between modules since the hallways are preformed and the length of each unit extends the entire width of the structure. In this manner, there are a minimum number of joints in the structure so as to obtain maximum strength, and where side-by-side units are joined, the thickness of the joint is double that of a wall panel of a single unit so that a plurality of reinforced supports are established enabling the construction of four to six story structures. When desired, openings can be cut in the side wall panels of the units beneath the floor level so that the utility lines can be passed between units on one level. Additionally, the utilities on one level could be connected to the utilities on the other level by passing connecting lines through the floor panel, a portion of the living quarters and the top panel in a selected modular unit on the lower level. It is also important to note that the top and floor panels of the modular units serve as spreaders for each unit whereby the units are structurally sound for shipping purposes; also, due to the fact that the side and end walls extend downwardly beyond the floor panel, skids or other elevating supports are not required to elevate the floor panel of the module from the supporting base gridwork. Further, due to high strength design of the aircraft landing deck, no gusset-type supports are required and the landing deck is bonded directly to the upper surface of the upper level units.

Accordingly, to assemble the modular building structure **10** of the present invention, the lower level modular units **14** are positioned on the base gridwork **18** in side-by-side abutting relationship and fastened together by bonding and with mechanical fasteners as previously described. The lower edges **32** and **34** of the side and end walls respectively of the lower level modular units are anchored to the I-beam base gridwork with mechanical fasteners so that the lower level units are positively tied together and anchored to the base. Next, the upper level units **16** are positioned in vertical alignment with the lower level units **14** and are guided into place by the guide curb **70** around the perimeter of the top panel **28** of the lower level units. When each of the upper level units has been positioned in abutting side-by-side relationship, they are bonded and mechanically fastened as were the lower level units through the side and end walls as described hereinbefore and the landing deck **12** is assembled by uniting the various sections **94** of the deck into the desired configuration as previously described while bonding the entire deck to the upper surface of the top panels of the upper level units.

Although the present invention has been described with a certain degree of particularity, it is understood that the present disclosure has been made by way of example and that changes in details of structure may be made without departing from the spirit thereof.

What is claimed is:

1. An offshore prefabricated building structure comprising:

a preassembled elongated rectangular base gridwork;

a plurality of modular units arranged with a plurality of upper units superimposed on and coextensive with an equal number of lower units, said lower modular units anchored directly to said base gridwork;

each modular unit containing spaced elongated side panels, spaced end panels, spaced inner panels substantially normal to said side panels and defining a hallway therebetween, a top panel interconnecting said side and end panels;

a floor panel interconnecting the side and end panels, said floor panel being vertically spaced from the lower edges of said side and end panels so as to define living quarters above the floor panel and a raceway for utilities below the floor panel, said lower and upper modular units being assembled in side-by-side relation with the side walls of adjoining said units being positively connected in flush relationship to establish a plurality of vertical reinforced supports, said upper and lower units extending transversely across the full width of said base gridwork to form an elongated assemblage of transversely extending modular units along the full length of said structure, said hallways in the upper units and in the lower units opening through the side panels and being aligned with the hallway in an adjacent unit so that a continuous hallway through the units on each level of the structure is established; and

each said lower modular unit having guide means on the upper surface of its top panel for aligning and positioning each upper unit upon the top panel of a lower unit, said guide means comprising a raised curb extending peripherally around the upper surface of a lower unit and including a beveled surface for guiding the end and side panels of each upper unit into alignment with the end and side panels of each unit, and fastening means co-operating with said guide curbs to secure said upper units in coextensive aligned relation to said lower units.

2. In the prefabricated building structure of claim **1**, further including a flight deck secured to the top panels of the upper units, said flight deck comprising a plurality of elongated flat laminated surfaces each secured to the top of a respective said upper unit and having a portion thereof freely overhanging the end wall of the said upper unit to which it is attached, and fastening means for securing said flat surfaces in edge-to-edge relationship along the length of the elongated assemblage of said modular units, said sections extending parallel to the underlying modular units.

3. In the prefabricated building structure of claim **1**, said flight deck comprising a flat laminated surface secured to the top panels of upper units and freely overhanging the end walls of the units.

4. In the prefabricated building strucuture of claim **1**, said flight deck consisting of inner layers of honeycomb with strips of wood integrated therewith and outer layers of wood panels with a covering of a fiberglass-resin combination.

5. In the prefabricated building structure of claim **1**, said flight deck comprised of a plurality of elongated flat sections, and fastening means for securing said flat sections in edge-to-edge relationship, said sections extending parallel to the underlying modular units.

6. An offshore prefabricated building structure comprising:

an elongated generally rectangular preassembled base gridwork;

a plurality of elongated self-supporting modular units arranged with a plurality of upper units superimposed on and coextensive with an equal number of lower units, said upper and lower modular units assembled in superimposed relation to one another with the units on each level in side-by-side abutting relation and extending transversely of the length of said base gridwork, and said lower modular units anchored directly to said base gridwork;

each modular unit having elongated spaced side panels extending the entire width of said base gridwork, spaced end panels normal to said side panels, spaced inner panels normal to said side panels and defining a hallway therebetween passing transversely through and intermediately of said upper and lower modular units in a direction parallel to the length of said base gridwork, said hallway in each upper unit and in each lower unit opening through the side panels of the associated units and establishing continuous hallways through the upper units and through the lower units, each of said panels being composed of a laminated honeycomb structure mounted within a perimeter frame;

a top panel interconnecting the side and end panels of said modular units and a floor panel interconnecting the side and end panels of each modular unit and being vertically spaced from the lower edges of the side and end panels so as to define living quarters above the floor panel and a raceway for utilities below the floor panel, support beams spaced from the lower edges of the side and end panels and affixed to said side and end panels to support the floor panel, at least one side wall of each modular unit being flush with the side wall of an adjacent unit, and attachment means for attaching the flush walls whereby the lower units will be unified and the upper units will be unified in establishing reinforced vertical supports for the structure, a guide curb extending upwardly and spaced inwardly from the outer peripheral edge of the top panel of each lower unit to position the side and end panels of the upper units on the lower units, and attachment means cooperating with said guide curbs for securing said upper units in superimposed relation to said lower units; and

a flight deck, said flight deck comprising a plurality of laminated sections, a wooden frame around the perimeter of each section, said wooden frame including an extension portion such that when adjacent sections are moved into edge-to-edge relationship the extension portions of the adjacent sections will overlap, mechanical fastening means connecting adjacent sections through said extension portions along the substantial length of the assemblage of said modular units, said adjacent sections extending parallel to each of said modular units.

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