

[54] MODULAR STRUCTURE

[76] Inventors: **Morris M. Cymbrowitz**, 63-61 Yellowstone Blvd., Forest Hills, N.Y. 11375; **John C. Mudgett**, 201 Clinton Street, Brooklyn, N.Y. 11201

[22] Filed: **June 30, 1971**

[21] Appl. No.: **158,379**

[52] U.S. Cl.....**52/79, 52/236, 52/DIG. 10, 52/237, 52/648**

[51] Int. Cl.....**E04h 1/00, E04h 1/04**

[58] Field of Search.....**52/79, 236, 237, DIG. 10, 648**

[56] References Cited

UNITED STATES PATENTS

2,839,841	6/1958	Berry.....	52/DIG. 10
2,645,114	7/1953	Amirikian	52/236
3,527,002	9/1970	Mead	52/79
3,587,197	6/1971	Renfro	52/236
3,646,718	3/1972	McKenna.....	52/79

FOREIGN PATENTS OR APPLICATIONS

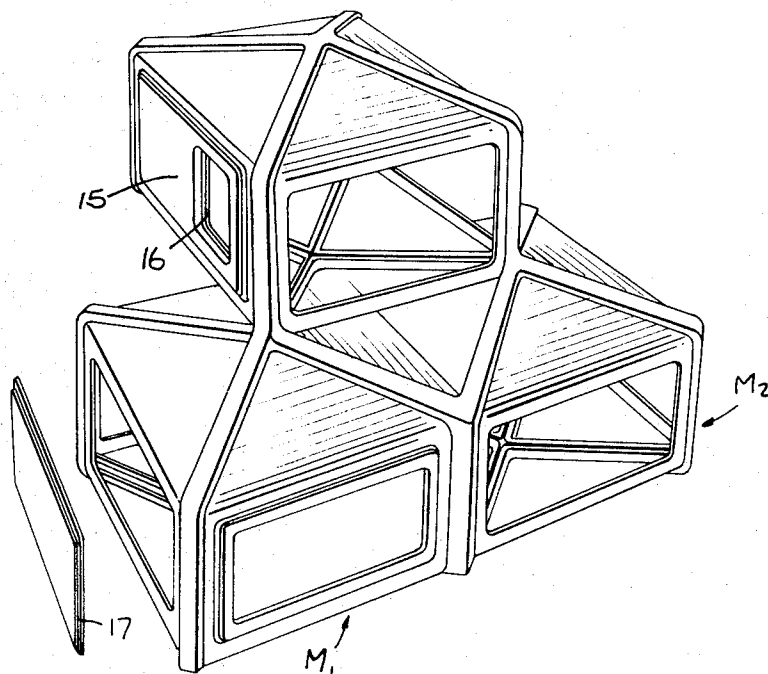
174,067	4/1922	Great Britain.....	52/237
985,338	3/1965	Great Britain.....	52/79
1,460,880	12/1966	France	52/236
1,518,818	3/1968	France	52/79

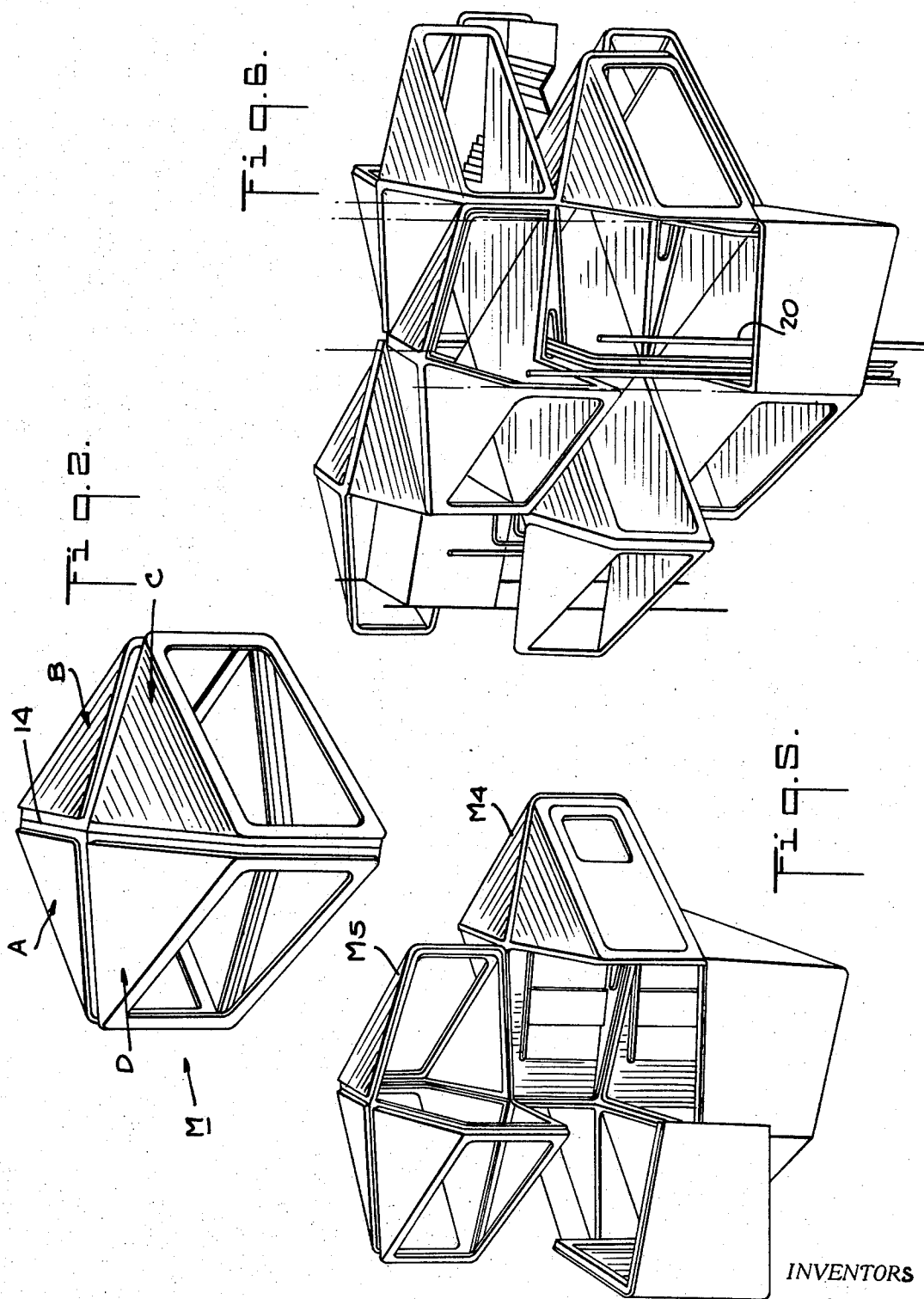
Primary Examiner—Frank L. Abbott
Assistant Examiner—Henry E. Raduazo
Attorney—Michael Ebert

[57] ABSTRACT

A building formed by an array of identical modules held together in a space frame, each module being constituted by four quadrants, having a wedge-like formation. Each quadrant is provided with a rectangular wall section, a triangular head section, and a triangular base section, the head section being sloped upwardly relative to the wall section, and the base section being sloped downwardly relative thereto, such that when the quadrants are joined together, the head sections thereof define a four-sided pyramidal dome and the base sections define an inverted pyramidal base of the same geometry. Channels are formed at the junctions of the quadrants to establish a four-branched channel network whose terminals are the vertexes of the head and base pyramids, such that when the modules are arrayed in side-by-side and stacked relation to create a multi-unit building they are locked together into a unitary structure by filling the channels with a moldable material that bridges the modules at their coincident channel positions to develop a space frame.

8 Claims, 6 Drawing Figures





INVENTORS

MORRIS M. CYMBROWITZ
BY JOHN C. MUGGETT

Michael J. ...
ATTORNEY

MODULAR STRUCTURE

BACKGROUND OF THE INVENTION

This invention relates generally to housing structures, and more particularly to structures formed by interconnected modules of identical form, and to techniques for erecting such structures.

Wood, clay, stone, concrete, and ferrous metals constitute the primary structural materials for buildings. Included in the multitude of structural forms into which these materials may be arranged, are the solid bearing wall, the post and lintel, columns and beams, the arch, the vault and dome, and the frame which is usually a repetitive column and beam or a column and rib system. Stone in its natural state and clay baked into bricks are best adapted to the construction of bearing walls and arches, while wood and iron, for the most part, are restricted to framed structures.

The plasticity of concrete makes it available for a large range of structural uses, but its most economical use lies in continuous forms such as flat slabs. Other common building materials such as sheet metal, tile, slate and plastic are generally used for protection and decoration, rather than structural purposes.

In traditional construction techniques, the assembly of the primary structural materials to create an edifice takes place entirely on the site. Consequently, the usual construction process is slow, inefficient and costly. Considerable economics in construction may be effected by the use of modular components, for this type of construction facilitates the preassembly of major parts of the structure at the factory, only final assembly of the modules taking place on the site.

There are two basic theories of modular construction. The first, which we shall call "pure modular construction," is based on the concept of stacking modules one on top of the other to define a complete structural array. This requires that each module serve both as a structural element and as a dwelling unit.

In a "pure" system, the structural requirement imposed on each module depends on its position in the structural array; hence the structural demands vary from module to module, for a module on the bottom of the array, onto which other modules are loaded, must obviously be stronger than a top module which is unloaded. Thus in a "pure" modular construction system, as exemplified by the renowned "Habitat" in Montreal, the several modules forming the total system are structurally dissimilar.

The second theory of modular construction, which we shall call "quasi-modular," makes use of a structural skeleton or frame adapted to support an array of non-structural modules. While in this instance, the modules forming the array may all be identical, thereby making possible mass production of units at low cost, the system requires that a complete and balanced structural skeleton exist on the site before one can begin to set up the dwelling units, so that again, one is faced with the on-site difficulties experienced in traditional construction techniques. Hence this is not a "pure" modular system and lacks the advantages thereof.

SUMMARY OF THE INVENTION

In view of the foregoing, it is the main object of the invention to provide an industrialized housing system

which makes use of identical modules held together in a space frame which does not come into existence until the modules are put in place.

More specifically, it is an object of the invention to provide identical non-structural modules which may be arrayed in side-by-side, and in stacked relation in symmetrical or asymmetrical patterns to create a multi-unit building, the modules incorporating channel networks, which when filled with a moldable material that bridges the modules at their coincident channel positions, acts to establish a space frame that locks the modules together into a unitary structure.

Also an object of the invention is to provide modules of the above-identified type which make it possible to construct multi-unit edifices at high speed and at low-cost. These edifices, despite the fact that they are composed of identical modules, may be caused to assume highly diversified patterns or building formations. Because the basic modules may be interrelated in various ways, and at various angles, this affords a high degree of flexibility in the ultimate architectural formation assumed by the structure.

Briefly stated, these objects are accomplished by a non-structural module constituted by four-like quadrants, each having a wedge-like formation. Each quadrant is provided with a rectangular wall section which is open, whereby blank panels or panels containing windows or doors may be secured thereto, a triangular head section and a triangular base section, the head section being sloped upwardly and the base section being sloped downwardly relative to the wall section. Thus when the quadrants are joined together, the head sections thereof define a four-sided pyramidal dome and the base sections define an inverted pyramidal base of the same geometry.

Channels are provided at the junctions of the four quadrants to establish a four-branched channel network whose terminals are the vertexes of the pyramids. When the modules are arrayed in side-by-side and in stacked relation to create a multi-unit edifice, they are locked together into a unitary structure by filling the channels with a moldable material that bridges the modules at their coincident network positions to develop a space frame of high strength.

OUTLINE OF THE DRAWINGS

For a better understanding of the invention as well as other objects and further features thereof, reference is made to the following detailed description to be read in conjunction with the accompanying drawing, wherein:

FIG. 1 is an exploded perspective view of the four quadrants of a module in accordance with the invention;

FIG. 2 shows the four quadrants joined together to complete the module;

FIG. 3 illustrates an array of three modules to form an elementary structure in which the modules are held together by a space frame;

FIG. 4 shows the space frame of the modular arrangement illustrated in FIG. 3, the modules being omitted;

FIG. 5 shows a more complex array of modules; and
FIG. 6 shows a still more complex multi-angled array of modules.

DESCRIPTION OF THE INVENTION

Referring now to FIGS. 1 and 2, there are shown four identical wedge-like quadrants, A,B,C,D, which when joined together form a single non-structural module in accordance with the invention. In practice, the quadrants, since they are non-structural, may be fabricated of fiber-glass reinforced plastic material, plastic-plywood laminates or any other relatively low-cost material which may be readily fabricated into quadrants of the type shown.

Each quadrant is constituted by a triangular head section 10, a rectangular wall section 11 which lies in the vertical plane, and a triangular base section 12, the head section being sloped upwardly and the base section being sloped downwardly relative to the wall section. Head section 10 is closed by a triangular panel serving as a ceiling element, whereas both wall section 11 and base section 12 are initially open.

Thus when the four quadrants A,B,C & D are fastened or bonded together by any suitable means for this purpose, the head sections thereof define the faces of a pyramidal dome having a square base plane, while the base section defines an identical pyramid in inverted form. It is to be understood that while the invention is described in terms of a module made up of four quadrants which are fastened together, in practice the module may be made in a single piece.

Each quadrant is provided with a depressed rim extending along the periphery thereof, so that when the four quadrants are joined together, the peripheral rims at the junction of the quadrants combine to define a network of open channels 14. The channel network is composed of four mutually perpendicular U-shaped branches. The profile of each branch conforms to the junction of adjoining quadrants, the four branches terminating at the vertexes of the head and base pyramids.

In one actual embodiment of a module assembled from quadrants in accordance with the invention, the module is 14 feet square in plane, the open rectangular wall sections measures 8 feet by 14 feet, and the distance between the base and head vertexes measures 12 feet. Thus each pyramid is 2 feet high.

Each module functions as a dwelling unit or room in the overall structure, the unit having a pyramidically domed ceiling. Since the base is in the form of an inverted pyramid, it cannot serve as the floor. The floor may be provided simply by means of a square panel placed over the base sections so that the space below the floor panel is usable for utility lines and other facilities. Preferably the floor panel is in the form of a one-foot thick honeycomb grid that is level with the lower reach of the open rectangular wall sections.

The open-wall sections of the quadrants may be fully or partially enclosed to afford windows, doors or unbroken wall surfaces, as desired. Thus as shown in FIG. 3, one may attach a panel 15 having a window 16 therein to a wall section of any quadrant of the module, or one may secure a solid panel 17 thereto. In practice, a great many types of panels may be combined with the wall sections, or the wall sections may be kept open to provide access between adjoining modules.

The geometry of the modules is such that the modules may be combined in a variety of ways in the fashion of building blocks to create structural arrays

having a great many different geometric patterns. This is made possible by the fact that any triangular base section of one module will complement any triangular head section on a module placed thereabove, and any side wall section of one module will match any side wall section of another module, when the modules are placed in side-by-side relation.

It is important to note that the four corner points (upper and lower) of each module are equidistant from each other, for they are the corners of a square, and that the peaks or vertexes (upper and lower), are centered and raised relative to the corner points. Hence it becomes possible, as shown in FIG. 3 to place modules M_1 and M_2 in side-by-side relation and to straddle a module M_3 thereabove, so that the upper peaks of modules M_1 and M_2 abut the front lower corner points of module M_3 , and the lower peak of module M_3 abuts the adjoining upper rear corner points of modules M_1 and M_2 .

The channel networks embracing the modules constitute molds or forms which are fillable with a moldable structural material to establish a structural space frame. In practice, pumped into the network is a fiber-reinforced concrete in flowable form, which when cured and hardened, produces a network of concrete beams 17 of high structural strength. And since the networks of the modules touch each other at certain peaks and corner points, depending on how they are assembled, the moldable material when pumped into the channel networks, bridge the modules at their points of contact. Also, where the networks of adjoining modules have coincident branch portions or beams, the ultimate frame formed by the moldable material includes such common beams, thereby creating an integrated frame for supporting the various modules in the array.

Thus in FIG. 4 it will be seen that module M_1 is provided with a four-branch network N_1 , having a vertical wall beam 18 common to network N_2 for the module M_2 . It will also be seen that the base beam 19 of of network N_3 for module M_3 is common to a head beam of network N_2 , and that connecting bridges are formed at all points of contact, such as the lower vertex 20 of network N_3 which is joined to a common corner of network N_1 and N_2 .

In FIG. 5, another array of modules is shown, in which one of the quadrants of the quadrant is omitted in order to create vertical shafts or towers, through which plumbing lines, elevators, stairways or other facilities may be extended in a multi-story structure. Thus a quadrant is omitted from Module M_4 and a quadrant is omitted from module M_5 to provide registered passages.

In the still more elaborate structure in FIG. 6, plumbing and electrical lines 20 pass through openings formed by omitted quadrants in an array of modules. It will be seen that because it is possible to orient the modules in the stack at various angles, the resultant array, rather than presenting the appearance of a uniform assembly of modules, affords a complicated asymmetrical pattern of modules, thereby obviating the architectural sameness frequently characteristic of standard modular systems.

In setting up an array of modules, construction proceeds are one story at a time. When the next story

of modules is seated on the first, the various coincident portions of the network branches form a closed channel. When the arrangement is such that certain channels of the modules are left exposed, auxiliary forms are added to complete the channel. Thus the concrete beams have a cross-section equal to that of two matching module channels. This system makes it possible to separate the structure from the module without an additional construction operation.

Once the modular array is erected, and floor grids placed within each unit, a system of interior walls and partitions may be fastened between the floor grid and a lowered ceiling panel. Between the module dome and the lowered ceiling panel, one may install ducts, ceiling lights, etc. As pointed out previously, circulation towers are created by omitting one quadrant from each module in a vertical stack thereof. To enclose the circulation towers, one simply adds panels to the quadrant sides banking the towers.

While there have been shown and described preferred embodiments of the modular structure in accordance with the invention, it will be appreciated that many changes and modifications may be made therein without, however, departing from the essential spirit of the invention. For example, in lieu of filling the channel networks with a moldable material such as poured concrete, one may create the necessary space frame by means of framed members placed in the channels and bolted or otherwise interconnected to define the required frame. These frame members may take the form of structural beams.

We claim:

1. A building formed by an assembly of identical modules held together in a structural-space frame, each module comprising four quadrants having a wedge-like formation, each quadrant having a rectangular wall section, a triangular head section and a triangular base section, the head section being sloped upwardly relative to the wall section, the base section being sloped

downwardly relative to the wall section, such that when the quadrants are joined together, the head sections thereof define a four-sided pyramidal dome and the base sections define an inverted pyramidal base of the same geometry, said quadrants having channels formed at the junctions thereof, to establish in each module a four-branched channel network whose terminals are the vertexes of the head and base pyramids thereof, such that when the modules are arranged in side-by-side and in stacked relation to create said building, they are locked together by filling the channel networks with a moldable material or beams that bridge the modules at their coincident channel positions to develop said space frame.

2. A building as set forth in claim 1 wherein said quadrants are fabricated from fiber-glass reinforced plastic material.

3. A building as set forth in claim 1 wherein said moldable material is fiber-reinforced concrete.

4. A building as set forth in claim 1, wherein said triangular head sections are enclosed by panels, and said rectangular wall sections are normally open and are adapted to receive placeable panels having doors, windows and other dwelling elements therein.

5. A building as set forth in claim 1, further including floor panels formed by a honeycomb grid and placeable over said base sections of the modules.

6. A building as set forth in claim 5, further including ceiling panels placeable under the domes of said modules to define a ceiling space for accommodating ducts and other utility components.

7. A building as set forth in claim 6 further including partitions supported between said ceiling and floor panels.

8. A building as set forth in claim 1 wherein one quadrant is omitted from each module in a vertical stack thereof to define a vertical passage for pipes, elevators, stairways and the like.

* * * * *