(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 043 223**
A1

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: **81302820.6**

(51) Int. Cl.³: **E 04 B 1/348**

(22) Date of filing: **23.06.81**

(30) Priority: **24.06.80 US 162501**

(43) Date of publication of application:
06.01.82 Bulletin 82/1

(84) *Designated Contracting States:*
BE DE FR GB IT NL

(71) Applicant: **Teron, William**
7 Crescent Road
Rockcliffe Park Ontario(CA)

(72) Inventor: **Teron, William**
7 Crescent Road
Rockcliffe Park Ontario(CA)

(74) Representative: **Abbie, Andrew Kenneth et al,**
A.A. THORNTON & CO. Northumberland House 303/306
High Holborn
London, WC1V 7LE(GB)

(54) **Modular building system comprising building module, construction therefrom and method of erecting building construction.**

(57) A building module, modular building constructions and methods for erecting same are disclosed. The module (10a to 10e) is of deep U-shape configuration, defining a space which is able to enclose various facilities within a building structure. A typical module includes a top channel (62) and an internal conduit system (110, 114) for power and/or communications systems etc. Preset-levelling (136) and self-centering devices (130, 140) provide for quick erection of the modules in a wide variety of arrays and configurations to provide exterior walls and to enclose and define interior space.

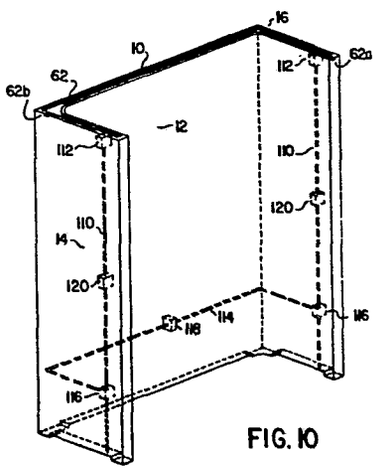


FIG. 10

EP 0 043 223 A1

MODULAR BUILDING SYSTEM COMPRISING BUILDING MODULE, CONSTRUCTION THEREFROM AND METHOD OF ERECTING BUILDING CONSTRUCTION

This invention relates to improvements in construction modules, to building constructions utilizing such modules, and to improved methods for erecting such building constructions.

In sharp contrast to the rapidly developing technology in many other fields, construction technology has proceeded at a relatively slow pace over the last half-century. Although numerous techniques have been developed, these have not been adopted widely by the construction industry with the result that construction has remained labour-intensive and of a handicraft nature. Accordingly, housing and building costs have remained very high.

Prefabrication has been cited as one of the potential answers to the problem, but many of the proposals to date have not proven to be commercially successful and relatively few prefabrication techniques have been adopted by the industry. Prefabrication techniques fall under two major categories, namely, light wood and aluminum frame prefabrication, and concrete or like product pre-casting.

Wood and aluminum frame prefabrication is limited to low density suburban housing. Concrete prefabrication is more appropriate for urban buildings due to fire and structural safety requirements.

The majority of prior concrete pre-casting prefabrication systems, many of which were designed in Europe, have not been commercially successful, particularly in North America. Most are structural systems and not housing or building systems, and do not incorporate functional features to suit the needs of the user. These known systems tend to be costly, requiring expensive prefabrication factories and relatively expensive handling and erection equipment and techniques. To be viable such concepts usually require a very high degree of repetition.

Many patents have issued over the years relating to various types of prefabricated units or slabs intended to be assembled into a building or other structure, see for example United States Patent No. 3,952,471 Mooney issued April 27th, 1976 and United States Patent No. 4,142,340 Howard issued March 6th, 1979. One common problem which remains largely unsolved is that the prior art systems provide only limited architectural and space flexibility.

The present invention provides a building module formed by a pre-cast concrete monolithic unit comprising: a rectangular planar main panel having a

planar flange extending outwardly at right angles from at least one side edge thereof and defining with the main panel a generally L-shaped configuration over the entire height of the module; said module having top and bottom ends lying in spaced parallel planes normal to its height the ratio of the overall length of the module taken along the main panel to its overall width taken along the flange being from about 4:3 to about 16:2.5, and preferably from about 4:3 to about 8:2, whereby such module possesses a substantial degree of lateral stability when positioned vertically on a horizontal support surface.

The module preferably has a flange at each vertical edge of the main panel to define a U-shaped configuration, whereby when positioned vertically on a horizontal support surface such U-shaped configuration defines a space enclosure for housing, offices, retail buildings etc., or enclosing appurtenances or facilities within a building construction.

Preferably, the module contains an internal conduit system providing for multiple access points for junction boxes, electrical switches or electrical or other outlets at the major surfaces of the flanges and/or the major surfaces of the main panel of the module, with the distribution being so arranged as to allow electrical and telephone and/or cable and/or intercom to be wired in the module. The module may have a trough or channel cast in its top end to allow the connection of power or communication sources within the module and to allow module-to-module electrical or com-

munications connections.

Preferred embodiments of the invention provide a flexible form of modular building construction which allows custom design solutions for a wide variety of building types. The modules are relatively small in size thus resulting in efficiency and economies in casting, transporting, erecting and connecting because of the elimination of the need for large or special factory or handling equipment. The self-standing modules can be erected quickly and directly and can incorporate levelling and centering means which may be positioned prior to placement of the modules thereby to further accelerate the building erection process and to provide accuracy of placement of the modules.

Preferably the modular building system is an "open" system to allow the use of the builders' choice of local standard windows, doors, roofs and other equipment. These local standard windows and doors are preferably set between the modules, although they can, if desired, be cast in the modules. Windows and doors set adjacent to the modules provide the advantage of connecting them to the modules on-site using standard connection details and further to provide the construction tolerances required. Moreover, the connection of building modules to each other, to floors and roofs, also requires only the use of standard on-site connection details and local practices.

The modules can be designed to be of sufficient depth to define multi-purpose functional containers capable of enclosing or delineating kitchens, bathrooms, closets, fireplaces, rooms of domestic proportions or any other appurtenances and facilities, in housing or filing, machines, storage, retail shelving and show space for offices and retail buildings.

The modules may be of a height which is a multiple of the normal floor-to-ceiling height of residential and commercial constructions. In multi-storey applications, such modules can retain their structural, self-supporting and self-standing capabilities while serving as full height exterior wall systems or as interior wall systems of a divider nature. Such modules desirably have the capability of using normal concrete inserts to support floors of prestressed/ pre-cast slabs, or floors of a wood or steel structure.

The modules can be made with final finished surface by casting in a single process. Normally, they are cast in an open steel mold, vibrated, and the back surface of the main panel trowelled. This produces a high quality final finish on all surfaces. The modules are thus ready for paint or wallpaper without further finishing, avoiding the need for secondary wall surfacing. The electrical and communications conduits can be cast in place during this single process.

The number of sizes of modules required for wide design flexibility is small e.g. from 3 to 5. Where required, L-shaped modules can be made simply by blocking of a portion of the mold for a U-shaped module. Moreover larger U-shapes can be created by linking L-shape modules. Therefore the basic three to five sizes of modules can be interrelated, as large U-shapes created by two L-shapes, or as L-shapes, to create a virtually limitless set of room or enclosure configurations.

As noted above, the modules' unique shape results in a self-standing or self-supporting characteristic. This allows the modules to be erected without scaffolds, shoring, bracing, etc. This characteristic is accentuated through the use of the above-noted levelling and centering means which facilitates quick and easy on-site erection. The bottom of a preferred module is provided with bearing pads which mate with centering and levelling means installed on the floor. This system eliminates the need to constantly lift and adjust the module vertically and horizontally during erection. Rather the module can be lowered downwardly and positioned true and level in a single motion. Therefore, the erection process is significantly speeded up, and costly crane and equipment staff are utilized more efficiently. The need for skilled labour is greatly reduced as compared with traditional methods, this being a great advantage in regions where there is a shortage

of skilled labour or where labour costs are exceedingly high.

The various features and advantages of the invention will become more apparent from the following description of preferred embodiments of same with reference to the accompanying drawings, wherein:-

Figure 1 is an isometric view of a typical module of U-shape configuration;

Figure 2 is a plan view of a selected set of typical modules;

Figure 3 shows a typical floor plan illustrating the positioning of the modules in a single storey application;

Figure 3A is a plan view showing portions of adjacent modules and illustrating a joint sealing means therebetween;

Figure 4A and 4B are top plan and section views respectively a connection used to join a straight wall panel to a module;

Figure 4C is a top plan view of a typical floor plan configuration for an apartment unit;

Figure 5 is a frontal view of a typical single storey construction;

Figure 6 is a top plan view illustrating the use of a U-shaped module as a closet;

Figure 7 is a top plan view illustrating the use of two opposed U-shaped modules in a bathroom facility;

Figure 8 is a vertical section taken along line 8-8 of Figure 7;

Figure 9 is a top plan view illustrating the use of an opposed pair of U-shaped modules in a kitchen facility;

Figure 10 is an isometric view of a module;

Figure 10A is a fragmentary vertical section view taken through a flange of the module of Figure 10;

Figure 10B and 10C are respectively an isometric view of the module and a fragmentary section of a flange of a modified module;

Figure 11 is a partial isometric view of a module illustrating the bottom end surfaces thereof;

Figures 12A through 12E illustrate the various stages in the installation of a module levelling and centering device to a floor;

Figures 13A through 13E illustrate a typical module positioning and erection sequence;

Figure 14 is a simplified isometric representation of a two-storey building;

Figure 15 illustrates a modified two-storey structure; and

Figure 16 illustrates the use of the modules in a structure incorporating traditional beams, columns and floors.

Figure 1 illustrates a construction module 10 comprising a precast concrete monolithic unit that

includes a rectangular planar main panel 12 having planar flanges 14 extending outwardly at right angles to each of its opposing side edges to define a generally U-shaped configuration in plan. The opposed major surfaces of both the main panel 12 and flanges 14 lie generally parallel to one another. The top and bottom ends 16 and 18 of the module lie in spaced parallel planes normal to the height. The ratio of the overall length of the module taken along the main panel 12 to the overall width of the module taken along the flanges and as measured in directions normal to the height is selected such that the module possesses a substantial degree of lateral stability when positioned vertically on a horizontal support surface.

The construction module 10 is suitably reinforced by having conventional reinforcing members (not shown) embedded therein. The reinforcing members may comprise conventional steel reinforcing rods and steel mesh embedded within the concrete in a manner which will be quite apparent to those skilled in this art. The module 10 may also be pre-stressed if desired.

Figure 2 is a plan view of a selected set of typical modules. These modules can be linked either in their basic U-shape or provided as part-channel shapes, i.e. L-shape to provide any desired shape or size of room or enclosure. In Figure 2, five basic sizes of U-shape module have been shown together with typical L-shaped modules 20 and 20a.

The modules are shown in Figure 2 laid out on a common rectangular grid in order to more clearly demonstrate their relative dimensions and proportions. It will be seen that each module is dimensioned such that its length taken along the main panel in the horizontal direction is substantially equal to a whole number multiple of a common grid or modular dimension M. In like manner the width of each module is also equal to a multiple of the common modular dimension M. For typical North American applications this common modular dimension M is 32 inches. In other countries the basic modular dimension is based on a suitable metric multiple of about 90 centimeters. The modular dimension is chosen to give a flange length that completely encloses most appurtenances and facilities, i.e. countertops, sinks, household equipment, office equipment, retail showcases, etc. The modules in Figure 2 have been laid out indicating a floor layout grid of 1/2 M or 16 inches to show a finer grid which may be used for design purposes. The distance between the solid lines is the common modular distance or dimension M of 32 inches noted above.

The common rectangular grid dimensioned as a multiple of or as a division of the basic modular dimension M allows for relatively straightforward modular co-ordination at the design and construction stages. The dimensioning is done relative to the grid; therefore the grid provides a discipline, not a constraint.

In Figure 2, the smallest U-shape module shown, designated 10a, has an overall length substantially equal to 2 M while its overall width is equal to M. Thus, its overall nominal length is 5 feet 4 inches while its nominal overall width is 2 feet 8 inches. However, in practice, the modules are dimensioned such that their outer surfaces are typically spaced inwardly of the grid lines by a distance of about 1/8 of an inch. Hence, in this instance, module 10a has an overall actual length of 5 feet 3-3/4 inches and an overall width of 2 feet 7-3/4 inches. The same considerations apply to each of the remaining modules illustrated. The thickness of the main panels and flanges of the several modules illustrated are the same in each case, typically being about 4-3/4 inches; however, the flanges are desirably provided with a small degree of draft of their inwardly facing major surfaces to allow for ease of stripping from the molds without affecting the basic "squareness" of the module flanges relative to the main panel. A suitable radius or fillet 22 is also provided between the interior major surfaces of the flanges 14 and the main panel 12 to provide added strength, a more pleasing appearance, and ease of cleaning the module surface particularly in cases where the module is used as a part of a kitchen or bathroom facility.

The relative proportions and dimensions of the modules shown in Figure 2 are chosen primarily to satisfy user requirements while also providing each module with a

substantial degree of lateral stability when standing on a level surface. The degree of lateral stability is such as to allow the modules to be positioned on a horizontal surface, each in a self-standing condition. Lateral stability is the resistance of the individual modules to a force tending to topple the same, but is not readily capable of precise definition since a very large number of variables are involved. However, for all practical purposes, it has been found that the various forms of U-shaped modules 10a-10e shown in Figure 2 and in the length to width proportions or ratios there given, possess sufficient self-standing capability as to allow them to be erected on-site and to stand alone without the need for braces or side connection elements in heights of up to approximately 25 feet. In the most commonly used heights, namely 8 feet, the U-shaped modules shown all possess a sufficient degree of resistance to tipping as to satisfy normal safety standards. Hence, it can be said for the U-shape configurations depicted in Figure 2, that a sufficient degree of lateral stability is achieved when the ratio of the overall length of the module taken along the main panel to the overall width of the module taken in the flange direction and measured in the horizontal direction is from about 4:3 to about 8:2, or even as much as 16:2.5. This range of ratios is applicable primarily to the U-shaped modules. The L-shaped modules 20, 20a illustrated in Figure 2, although having only one flange, have also been found to possess a sufficient degree of resistance to tipping as to satisfy normal safety standards during construction.

Figure 3 is a typical floor plan illustrating the positioning of the various modules depicted in Figure 2 in a single storey application. The modules are positioned on a horizontal surface 30 which in a typical case would be provided by a concrete slab on grade. For purposes of illustration, the horizontal surface 30 is shown as having an imaginary grid consisting of two series of parallel lines intersecting one another at right angles, the lines being spaced apart by a distance corresponding to the common modular dimension M. A first group of the modules 10 are positioned relative to one another on the support surface 30 adjacent perimeter portions of such surface as to define portions of the side walls of the building. A further group of the modules are positioned interiorly on the support surface 30 to define at least portions of the interior partitions. An inspection of Figure 3 will readily show how the various modules 10a, 10b, 10c, 20 etc. serve to provide partial space enclosures to house or partly enclose the various facilities within the building construction. For example, end wall 32 of the structure is defined by a single 10c module together with two L-shaped modules 20 a. The opposing end wall 34 is defined by a pair of L-shaped modules 20 in conjunction with the flanges of back-to-back U-shaped modules 10c. These modules 10c also provide an interior partition between bedrooms 36 and 38. A bathroom facility 40 is defined in part by a module 10d located at the perimeter and an opposed interior module 10e. The

flanges of modules 10e and 10d are directed generally toward an intermediate region to define a substantial portion of the enclosure for bathroom 40. A partial enclosure for a kitchen facility 42 is provided by interiorly disposed modules 10c disposed in opposing relationship to a special module 10c' disposed at the building perimeter. The flanges of these latter two modules are directed toward each other to provide a partial space enclosing function. Module 10c' is of a special construction in that it includes a rectangular window opening 44. A typical window opening is illustrated in dashed lines in module 10 of Figure 1. The modules 10 do not commonly require window openings to be formed therein except to satisfy a users' preferance.

Normally, standard local windows and doors are set between modules. This allows design flexibility for a greater variety of sizes of openings than would be possible if they were cast into the modules.

In another instance of a somewhat specialized use of a module, an exteriorly disposed fireplace and chimney arrangement 46 is defined by a further module 10a. A conventional fireplace and chimney constructed on-site can of course be used, but the amount of on-site work is reduced by using a module in this fashion.

The remaining modules perform various types of space-defining and space-enclosing functions as, for example, in closets 48 which are provided with suitable add-on shelving and doors, with others of the modules providing

simple space enclosures facing into the dining-room area 50 and the living-room area 52. These partial space enclosures may be used to house desks, book-cases, entertainment centers, built-in furniture and any other desired appurtenances. Still others of the modules, including portions of the modules already referred to, serve to frame and define doorway entrances and hallways, none of which need to be described in detail here.

As noted previously, the individual modules 10a, 10d, etc., as well as L-shaped modules 20, 20a being self-standing on the horizontal surface 30, do not require the provision of connector elements therebetween to achieve the required degree of structural stability. All that is needed between modules, either when they form part of the exterior wall or as interior bearing and dividing walls, is a suitable joint seal, which seal can employ standard industry techniques. Figure 3A is a plan view illustrating a typical joint sealing means which can be used both in an exterior and an interior joint between adjacent modules 10. For the exterior seal the rain screen method may be employed which uses a flexible rain shield, such as a P.V.C. strip or bead 66 disposed in the small gap between the modules, in conjunction with an exterior caulking 67, both of which extend vertically along the joint. For the interior condition normal taping, plastering and sanding will result in a smooth finished joint 67a. The above basic form of joint seal can also be used in the joint configuration illustrated

in Figures 4A and 4B.

Referring back to Figure 3 this shows the use of a special L-shaped module 20' in conjunction with the flange of a regular U-shaped module to define a small closet 70. These special short L-shaped modules could be used in other instances as well. In manufacturing the L-shaped modules 20, 20a and 20', all that is required is that a block be placed in the mold which is used to manufacture the U modules, appropriate adjustments being made to the lay-out of the reinforcing members and the conduit system hereinafter described. As noted previously, all of these modules may be cast in an open steel mould, vibrated and trowelled thereby enabling the production of a high quality final surface finish. Thus, the surfaces of the modules exposed to the building interior can be simply painted or wallpapered as desired while the exterior surfaces may be left as is, painted, providing a smooth stucco-like finish or the exterior can have any desired cladding of wood, brick or stone. Indeed for inexpensive buildings light weight concrete will provide some insulation without the need for add on. When additional cladding is incorporated, side wall insulation can be provided as required. The exterior surfaces of the modules at the perimeter of the building will be provided with a vapour barrier and a layer of insulation 68 (Figure 3A), preferably a rigid insulation board. Any desired exterior siding 69 (Figure 3A) can be applied over the insulation using techniques well known in the art.

This is in contrast to normal precast construction. Because precast is intended to be the exposed exterior finish, the mass is outside and the insulation is inside, which is the wrong place for maximum effectiveness. In contrast the modular system described places the mass inside because of the interiorly disposed finished surface, allowing the insulation to go outside where it achieves its full effectiveness.

In Figure 3 it will be seen that the various modules are located such that their main panels 12 and their associated flanges 14 extend along predetermined ones of the grid lines and, having regard to the described modular dimensioning it will readily be appreciated that a commonly used spacing of adjacent modules located in this fashion is a distance equal to M x N... where M is the common modular dimension and N is a number equal to 0, 1, 2, 3,...N. Some of the modules on the perimeter are also spaced apart by distances equal to N x M to provide spaces of common modular lengths for receiving door units 56, and window units 58. Figure 3 also reveals how the interiorly disposed modules 10a, 10c, etc. are also spaced apart to provide hall-ways, door openings and the like, each having a width based on the common modular dimension.

Figure 3 demonstrates the kind of simple module co-ordination that can be achieved using a grid equivalent to the basic modular dimensions. In this instance the modules and all between-module spacings, either for windows, doors or passageways are of a modular dimension.

This allows a builder to use door and window units of a size which are co-ordinated with the modular dimension. In construction it also achieves simplicity in lay-out, and erection.

Alternatively, depending upon user preferences or the sizes of local standard windows and doors the dimensioning can be done relative to the grid. However, it is to be understood that the invention is not limited to positioning modules either strictly on the grid or even relative to the grid. Rather the modules can be dimensioned with total freedom using any suitable form of layout.

The walls need not be composed entirely of U-shaped and L-shaped modules as shown in Figure 3, but may include flat in-fill panels 70. These in-fill panels 70 may be connected to the adjacent modules utilizing the connection technique illustrated in Figures 4A and 4B. Figure 4A shows a plan view of a 1/4 inch rod 73 which ties the flat wall panel 70 to a module flange 14. Figure 4B is a section view showing the bent rod 73 having one downwardly angled end held in a channel 62 (to be described) in the flange 14 while the other end of rod 73 is inserted in a 3/8 inch drilled hole 75 of the wall panel 70. This device serves to hold the wall panel 70 in place until a roof assembly is put on, or, in the case of a multi-storey structure, until the next floor slab is positioned on the upper ends of the modules.

Figure 4C is a top plan view of a floor plan

configuration suitable for apartment application. The layout provides a kitchen 42', dining-room 50', living-room 52', bedrooms 38' and 38'', bathrooms 40' and 40'', numerous closets 48', as well as balcony areas 51a through 51d, together with various hallways, doorways, window openings etc., none of which need be described in detail here. Figure 4C again illustrates the great flexibility of the modular system in providing virtually any desired lay-out.

Figure 5 is a frontal view of a bungalow utilizing the modular system and employing a conventional truss-roof structure. A truss-roof structure (not shown) is supported directly upon the uppermost extremities of the various modules and is connected thereto by an industry standard connector means (not shown). A layer of insulating material 68 is applied to the exterior surfaces of the modules and is covered by an exterior surface of a suitable cladding material 69. It will be realized that in certain instances it may be desirable to provide the bungalow with a simple flat roof made from a slab or slabs of concrete laid directly upon the upper extremities of the self-standing modules. In this instance, as a result of the great weight of the slab concrete roof, no special connecting means for attaching it to the modules will be required other than mortar between the top of the module and the bottom of the slab.

Figures 6-9 illustrate the volumetric space-defining functions of the modules 10. Figure 6 shows a module 10 providing a clothes-closet structure. A suitable

support rail or trackway (not shown) extends between the outer extremities of flanges 14 and support a pair of sliding doors 80 in a generally conventional fashion. A clothes hanger bar 82 extends between the flanges 14.

Figures 7 and 8 illustrate the application of the modules to a bathroom facility. A pair of modules 10 are arranged in opposed spaçed relation with their associated flanges 14 directed toward an intermediate region to define the bathroom enclosure. In modules for bathroom facilities it is quite common to employ at least one module which is of a relatively "deep" variety, i.e. having a relatively low length to width ratio. The construction illustrated shows a shower compartment 84 connected directly to one of the modules 10 and attached to the inwardly facing major surfaces of main panel 12 and flanges 14 using any suitable concrete fastener elements. It will be quite apparent that a bathtub may be substituted for the shower enclosure and connected directly to the module. The opposing module 10 has a built-in vanity and wash-basin assembly 88. A suitable in-fill panel 92 is positioned intermediate the opposed ends of one pair of the flanges 14 while a door unit 94 is positioned intermediate the opposed ends of the other pair of flanges 14, the various connections etc. being made in a conventional fashion. A toilet assembly 96 is positioned on the floor of the bathroom area. The bathtub 84 and the vanity and washbasin 88 can be pre-installed in their respective modules at the factory to reduce the amount of on-site work.

Figure 9 is a plan view of a typical kitchen facility. As shown, each of two modules 10 has a kitchen counter assembly 100 attached thereto and extending a selected distance along the major surfaces of the main panels 12. Suitable kitchen cupboard assemblies 102 (indicated in broken lines) are disposed above the kitchen counters 100. Suitable spaces are provided between the ends of the counters 100 and the flanges 14 of the modules to receive standard-sized stoves and refrigerators. The kitchen is closed by a window assembly 104 spanning the outer extremities of the flanges 14 of the opposed modules. The kitchen counters may be continued beneath the window assembly 104 or alternatively other kitchen facilities of any desired nature may be located in this position. The kitchen counters and cupboards 100, 102, may be prefabricated and installed in their respective modules 10 at the factory to reduce the amount of on-site labour. It bears noting that in Figures 6-9 the flanges 14 of the modules are sufficiently deep to completely enclose the respective counters, appliances, vanities, shower compartments or tubs.

Figures 10, 10A and 10B, 10C illustrate two alternative methods to provide a pre-powered module.

Figures 10 and 10A illustrate a top trough-like channel or recess as well as an interior conduit and outlet/junction box configuration. The top end wall 16 of the module is provided with a trough-like channel or recess 62

which extends along the top end wall of both the main panel 12 and the flanges 14. A similar arrangement is used for the L-shaped modules 20 but is not illustrated here. The channel may be about 1-1/4 to 2 inches in depth and of a sufficient width to accommodate one or more electrical cables. It will be seen from Figure 10 that the module flanges are each provided with a respective vertically extending internal conduit 110, with the top ends of each communicating with respective junction boxes 112, the latter in turn communicating with opposing end portions of channel 62. A transverse conduit 114 extends horizontally through the flanges 14 and the main panel 12, and has opposing ends entering junction boxes 116 in communication with the vertical conduits 110. The lowermost ends of conduits 110 and open at the bottom ends of the module flanges. The horizontally disposed conduit 114 includes an outlet/junction box 118 intermediate the opposed major surfaces of main panel 12 while the vertically disposed conduits 110 each include an associated outlet/junction box 120 disposed at a convenient height so as to be useable with a wall switch or appliance outlet etc. The individual conduits and the outlet/junction boxes need not be described in further detail here since such devices are well known, per se, in the art and they will, in any event, be selected to satisfy the electrical and wiring codes in the jurisdictions in question. It will readily be seen from Figure 10 that the various outlet/junction boxes are accessible from both of

the opposed major surfaces of the main panel 12 and the flanges 14. This affords great flexibility in design since, virtually regardless of how the individual modules are arranged in any particular building construction, the junction boxes will be readily accessible.

Figure 10A shows the conduit 110 disposed approximately mid-way between the opposing major surfaces of the flange with the top junction box communicating directly with the top channel 62. The outlet/junction box 120 is disposed such that its sides are spaced from the major surfaces of the flange by relatively short distances with relatively thin layers of concrete overlying the box. Thus, when the electrical contractor desires to gain access to this box, he can readily chip away the thin concrete cover, remove a side plate from the box and effect the necessary electrical connections.

The conduit and outlet/junction box arrangement illustrated in Figures 10 and 10A can be utilized to accommodate both power supply wiring and the wiring system for an intercom arrangement, cable television and/or telephone cables etc. The module can be pre-wired to reduce the amount of on-site work.

When modules are located closely adjacent to one another and one wishes to electrically connect one module to the other, it is a relatively simple matter to extend the channel 62 such that it communicates with the channel 62 of the adjacent module by chipping away a portion of the edge of

the channel as illustrated in broken lines in Figure 10 at 62a and/or 62b following which the cables can extend between the adjoining channels. Where it is desired to supply electrical power between isolated modules, electrical cables are simply passed along the lintels over windows or through dropped ceiling spaces of the structure.

Figures 10B and 10C illustrate an alternative method of providing a pre-powered module. The difference in application is that the electrical wiring is primarily within the internal conduit network in the module, while telephone and/or intercom wiring is carried in the top channel. This provides for more strict separation of the two systems. The top end wall 16 of the module is provided with a cast in channel 62C of about 3/8 inch in depth and about 1 1/4 to 1 3/4 inches in width. Figure 10B shows that the channel 62C is in communication with a conduit 121 which in turn is linked to a junction/outlet box 122 and then with a junction/outlet box 123.

Figure 10B shows a transverse conduit 62d extending in the horizontal direction through flanges 14 as well as through the main panel 12, the opposing ends of conduits 62d entering into junction boxes 112a disposed in the respective flanges and the latter junction boxes being in communication with a set of vertical conduits 110a, containing further junction boxes 120a and 116a. A further transverse conduit, like 114 of Figure 10 could be included if desired (not shown).

Figure 11 shows the bottom end wall of the module 10 provided with a plurality of integrally formed bearing pads 124, 126, spaced apart along the main panel 12 and the flanges 14. The bearing pads 126 are disposed adjacent the free outer end portions of flanges 14 while bearing pads 124 are common to both one flange and the main panel 12. The elongated recessed regions 128 extending between the bearing pads 124, 126, provide room for a grouting compound to be inserted between the module and the floor on which it is standing to satisfy various codes relating to fire, water and insect resistance, as well as to improve the structural stability of the upright module. Each of the bearing pads 124 is provided with an aperture 130 to receive a portion of a self-levelling and self-centering arrangement.

The self-levelling and self-centering arrangement is illustrated in Figure 12 which shows the various steps in the procedure. The first Step A is to drill a hole 132 of the appropriate depth and diameter in the concrete slab at a preselected location. In Step B a stud-like insert 134 is then driven into the hole with its upper threaded end projecting above the floor surface. In Step C, a transit or level is used in order to determine the number of shims 136 required to provide a level support for the module. A nut 138 is then applied to the insert. In Step D a frusto-conically shaped centering element, 140, preferably of plastics material, is positioned over the nut. The module is then lowered into its final position with the centering

element 140 entering into the aperture 130 provided in the associated bearing pad 124, 126. Shims (not shown) may also be positioned beneath the bearing pads 126 as required to achieve a level support for the module.

The method for erecting the modules is illustrated in Figures 13A-13E. With reference to Figure 13A, the floor slab 142 is provided, which may be poured on the site or alternatively may comprise a pre-cast slab or slabs of a conventional nature. The square grid pattern 144 is then laid out on the floor and the module locations are marked. With reference to Figure 13B, a module template 146 is then positioned at each of the desired locations, such template being used to enable the holes 132 to be accurately drilled at the required locations, following which the stud-like inserts 134 are driven in. A transit or level is used to determine the number of shims required at the bearing pad locations. The various centering inserts 140 are then applied. It might be noted at this point that the module is provided with lifting hooks (not shown) anchored in suitably located apertures positioned in its top end wall such that when the module is lifted up it hangs plumb. Thus, the lifting device shown in Figure 13C lifts the module upwardly and then swings it to a position directly over its pre-assigned location on the floor following which it is lowered, being carefully guided over the last stage such that the conically shaped centering inserts 140 enter the apertures 130 in the module bearing pads and the

module seats firmly on the pre-positioned levelling shims. The module is thus very accurately positioned and levelled at its desired location. This procedure is repeated until the desired array of modules is positioned on the floor, as illustrated in Figure 13D, following which a roof structure or alternatively a flat set of slabs 150 as shown in Figures 13E are positioned on top of the modules for support thereby.

Virtually all of the construction techniques and structural arrangements previously described in conjunction with single storey arrangements are also applicable to multi-storey structures. Thus, in Figure 14, the support for the first storey comprises a horizontal footing 160 of conventional construction. All of the modules 10 on both storeys are of the same height. The modules of the first storey are supported on the horizontal floor slab 160 and serve to support on their upper extremities a further horizontal floor 162. Floor 162 comprises the support for the modules 10 of the second storey with the upper extremities of the modules 10 of the uppermost storey supporting a suitable roof structure which, as illustrated in Figure 14, is a flat slab roof 164. The load of the horizontal floor and roof slabs etc. is thus carried downwardly to the lowermost floor or footing via both the modules positioned around the perimeter and those positioned interiorly. The lower ends of the modules are secured to the floor slabs by means of the inserts 134 previously described while industry standard moment connections are

provided at points 166 and 168 between the upper ends of the perimeter modules and the floor slab or roof slab positioned thereon. A multi-storey building structure as shown in Figure 14 can thus be quickly erected storey-by-storey, until the desired height is reached. Modules can be stacked on intervening floors up to their maximum bearing capacity. The number of floors permitted depends on the span length of the floor slabs, the live loads expected and the type of connections provided. These follow normal engineering and job considerations.

A modified configuration is shown in Figure 15. In this configuration, the modules 10 which are positioned at the perimeter portions extend the full height of building. A floor structure 170 is disposed at each level of the building and its peripheral edges are supported by the full height modules at the perimeter. The modules 10 which are located interiorly of the perimeter serve to support the remaining interiorly disposed portions of the floor structure at each level of the building and to carry these loads down to the bottom floor or footing. Standard angle brackets 172 are utilized to attach the perimeter portions of the floor 170 to the extremities of the flanges 14 of the full height modules. This configuration requires the use of additional in-fill floor panels 174 to bridge the gap between the edge of floor and the main panel 12 of each full height module. These panels can be pre-fabricated and inserted in place and held or secured to the module with

standard angle connectors, or alternatively such slabs can be poured in place and secured by suitable reinforcing bars and other means well known in the industry.

Another variant is shown in Figure 16 which shows a conventional support structure comprising poured in place vertical columns 180, and horizontally disposed beams 182 supported by the columns at each level of the building and serving to support conventional reinforced concrete floor slabs 184. A series of exterior modules defining the side walls of the buildings are attached to and supported by the perimeter portions of the floors 184 while the interiorly disposed modules are supported on the floors thereby to define the interior partitions and volumetric enclosures for facilities utilizing any desired floor plan or lay-out. Essentially the same technique can be used with steel floor assemblies. It is believed that the above illustrations will show the great flexibility of the modular building construction provided by the present invention; those skilled in this art will readily be able to visualize other applications of the modular structure in the light of the foregoing illustrative examples.

The levelling and centering arrangement used for erection of the modules, as described in relation to Figures 11 and 12, can be replaced by other suitable systems. For example steel inserts (not shown) could be provided in the floor slabs at the desired erection locations and welded to steel inserts cast into the lower ends of the modules. The inserts in the floor could be provided by any suitable means, such as being cast in place, or carried by an underlying module and projecting upwardly through apertures in the floor slabs.

It will be understood that numerous changes and modifications can be made to the embodiments described herein without departing from the spirit and scope of this invention.

CLAIMS:

1. A building module formed by a pre-cast concrete monolithic unit comprising: a rectangular planar main panel having a planar flange extending outwardly at right angles from at least one side edge thereof and defining with the main panel a generally L-shaped configuration over the entire height of the module; said module having top and bottom ends lying in spaced parallel planes normal to its height the ratio of the overall length of the module taken along the main panel to its overall width taken along the flange being from about 4:3 to about 16:25 whereby such module possesses a substantial degree of lateral stability when positioned vertically on a horizontal support surface.

2. A module according to claim 1 wherein a planar flange extends outwardly at right angles from each of an opposing pair of side edges thereof and define with the main panel a generally U-shaped configuration over the entire height of the module; whereby when positioned vertically on a horizontal support surface such U-shape configuration defines a space enclosure for housing or enclosing appurtenances or facilities within a building construction.

3. A module according to claim 1, having a top end wall provided with a trough-like channel extending therealong and in communication with at least one preformed

elongated conduit within the module, said conduit, in turn, communicating with at least one outlet/junction box formed in the module between the major surfaces thereof, the channel, conduit and box being adapted to accommodate an electrical wiring system or communication wiring system.

4. A module according to claim 3 including a pair of said flanges to define a U-shape, the module being provided with a plurality of said elongated conduits each extending within a respective one of the flanges, a plurality of outlet/junction boxes positioned to communicate with associated ones of said conduits and said boxes being accessible from the opposed major surfaces of the flanges.

5. A module according to claim 3 including a pair of said flanges to define a U-shape in plan, the module being provided with a plurality of said elongated conduits including a first conduit extending vertically in each said flange with the top ends thereof communicating with said channel, a transverse conduit extending through the flanges and the main panel and communicating with said first conduits, and a plurality of said outlet/junction boxes positioned to communicate with associated ones of said conduits, said boxes being accessible from either one or both of the opposed major surfaces of the main panel and flanges.

6. A module according to claim 5 wherein said top ends of said first conduits communicate with said channel via respective junction boxes disposed immediately adjacent said channel.

7. A module according to claim 3, 4, 5 or 6 wherein each said outlet/junction box is spaced inwardly of the opposing major surfaces of the module and covered by a thin layer of concrete which can be broken away to gain access to such box from either of said major surfaces.

8. A module according to claim 5, or 6, including a second transverse conduit extending through the flanges and main panel in the region lying between the first transverse conduit and the bottom end wall of the module and communicating with the vertical conduit in each of the said flanges.

9. In a building construction having a horizontal support surface, a plurality of construction modules according to any of claims 1 to 8 vertically positioned thereon in free-standing condition, said modules possessing sufficient lateral stability as to eliminate the need for side connector elements between any two adjacent modules, with said modules either singly or in combination defining space enclosures for housing or enclosing appurtenances or facilities within the building construction.

10. A construction according to claim 9 wherein the upper extremities of said modules terminate in a common plane, and including a horizontal slab or slabs lying in said common plane and supported by said modules.

11. A construction according to claim 9 or 10 wherein at least one pair of said modules is arranged in

opposed spaced relation to one another with their associated flanges being directed toward a region lying intermediate such pair whereby to define a room-sized enclosure.

12. A construction according to claim 11 wherein said opposed pair of modules define a kitchen facility, at least one of said modules having a kitchen counter assembly attached thereto and extending a selected distance along that major surface of the main panel which faces inwardly of the space enclosure by such module.

13. A construction according to claim 11 wherein said opposed pair of modules define a bathroom facility, one said module having a shower or bathtub and/or sink and vanity counter facility attached thereto and disposed within the space enclosure defined by the U-shaped module.

14. In a building construction having a horizontal support surface, a plurality of construction modules according to any of claims 1 to 8 vertically positioned thereon in free-standing relation, wherein the bottom end of a module is provided with a plurality of integrally formed bearing pads which are spaced apart along the main panel and said flanges, levelling inserts disposed between at least some of said bearing pads and the support surface on which the modules are positioned to compensate for unevenness in the support pads or horizontal support surface,

and locating elements extending between at least certain of the bearing pads and said support means and acting to locate said modules at predetermined horizontal locations on the support surface.

15. The construction of claim 14 wherein said locating elements each comprise a stud-like insert extending into the support surface and having its upper end disposed in a recess provided in a lower surface of the associated bearing pad.

16. The construction of claim 15 including a conical centering element on said upper end of the insert which fits in said recess in the bearing pad.

17. In a building construction having a multiplicity of side walls and a plurality of interior partitions the combination of:

(a) a plurality of upright free-standing construction modules according to any of claims 1 to 8;

(b) support means on which the construction modules are positioned;

(c) a first group of said modules being positioned relative to one another on the support means adjacent perimeter portions of the building construction to define portions of the side walls of the building construction;

(d) and a second group of said modules being positioned on said support means interiorly of said

perimeter portions to define at least portions of said interior partitions;

(e) said modules of the first and second groups being positioned on said support means to provide space enclosures whereby to house or enclose appurtenances and facilities within the building construction.

18. A construction according to claim 17 wherein the lengths of the modules taken along the main panels in the horizontal direction are substantially equal to a whole number multiple of a common modular dimension (M).

19. A construction according to claim 18 wherein the widths of the modules taken along the flanges of the modules in the horizontal direction are substantially equal to a multiple of the common modular dimension (M).

20. A construction according to claim 17, 18 or 19 wherein a plurality of said modules each has a pair of said flanges thereon so that each such module has a U-shaped outline in plan, the remaining modules each having a single flange and defining an L-shaped outline in plan.

21. A construction according to any one of claims 17 to 20 wherein said support means comprises a horizontal surface having an imaginary grid defined thereon consisting of two series of parallel lines intersecting one another at right angles, the lines being spaced apart by a distance corresponding to the common modular dimension M, said

modules being located such that their main panels extend parallel to said grid lines with their associated flanges extending parallel to other ones of the grid lines.

22. A construction according to anyone of claims 17 to 21 wherein selected modules of the first group are spaced apart along the perimeter by the distances required to provide spaces for receiving door units and/or window units and/or flat wall sections.

23. A construction according to anyone of claims 17 to 22 wherein selected modules of the second group are spaced apart to provide hallways, door openings and the like.

24. A construction according to any of claims 17 to 23 wherein a further plurality of said upright construction modules each comprisesa pair of flanges at right angles to one another to define a generally L-shaped outline in plan, each of said further plurality of modules being positioned on said support means to define portions of the side walls and/or the interior partitions of the building construction.

25. A construction according to any of claims 17 to 24 wherein all of said upright construction modules are of essentially the same height, said support means comprising a horizontal foundation of concrete, and a roof structure supported on the upper extremities of said construction modules to define a single storey structure.

26. A construction according to any of claims 17 to 24 comprising a multi-storey construction wherein the support means for the first storey comprises a horizontal footing.

27. A multi-storey construction according to claim 26, wherein all of said upright construction modules are of essentially the same height, the modules of the first storey being supported on said horizontal footing and supporting on their upper extremities a horizontal floor, the latter comprising the support means for the modules of the second storey, and the upper extremities of the modules of the uppermost storey supporting a roof structure.

28. A multi-storey building construction according to claim 26 wherein those modules which are positioned around the perimeter portions of the building extend the full height of the building, there being a floor structure at each level of the building and having its peripheral edges supported by the full height modules at the perimeter, and those modules which are located interiorly of the perimeter serving to support the remaining portions of the floor structures at each level of the building.

29. A multi-storey building construction according to claim 26 wherein there are provided a plurality of floors supported in spaced apart relation by a plurality of vertical columns, the side walls of the building being provided in part by said modules which are positioned at the perimeter portions of the building and are supported

by the floors while the interiorly disposed modules are supported by said floors to define said portions of the interior partitions.

30. A method of erecting a building construction including the steps of:

(a) providing a plurality of construction modules capable of free-standing on a horizontal support surface, each module being a monolithic unit defined by a main panel having flange means extending laterally outwardly therefrom, said modules being each provided at their lower extremities with a plurality of bearing pads which are spaced apart along the main panel and said flange means;

(b) providing a generally horizontal support surface on which said modules are to be positioned;

(c) indicating on said support surface the predetermined locations where the modules are to be positioned;

(d) providing locating means at said predetermined locations, which, after the modules are positioned in their respective places, extend between certain of the bearing pads and said support means and act to locate said modules accurately at their predetermined locations on the support surface;

(e) placing levelling inserts in positions such as to become disposed between certain of said bearing pads and the support surface after the modules are positioned thereon thereby to accommodate for any unevenness in the support surface and allow the vertical positioning of the modules;

(f) positioning said modules over their predetermined locations such that certain of said bearing pads come into engagement with said levelling inserts and said locating means thereby to accurately locate said modules at said predetermined locations in vertical positions.

31. The method according to claim 30 wherein the modules are positioned on the support surface by individually lifting each module to a place over its predetermined location and lowering the same downwardly until the bearing pads come into contact with the levelling inserts and/or the support surface, with the module thereafter remaining at such location in essentially a self-standing condition.

32. The method according to claim 30 or 31 wherein each said locating means includes a generally conical element which enters into a correspondingly shaped aperture in respective ones of the bearing pads of the module so that as each module is lowered downwardly the conical elements co-act with said apertures to provide a self-centering action which accurately positions the modules at said predetermined locations.

33. The method according to claim 30, 31, or 32 wherein a grid having two series of parallel lines intersecting one another at right angles is initially marked on

said support surface, said lines being spaced apart by a common modular dimension M, said grid in turn being marked to indicate the predetermined locations of the modules.

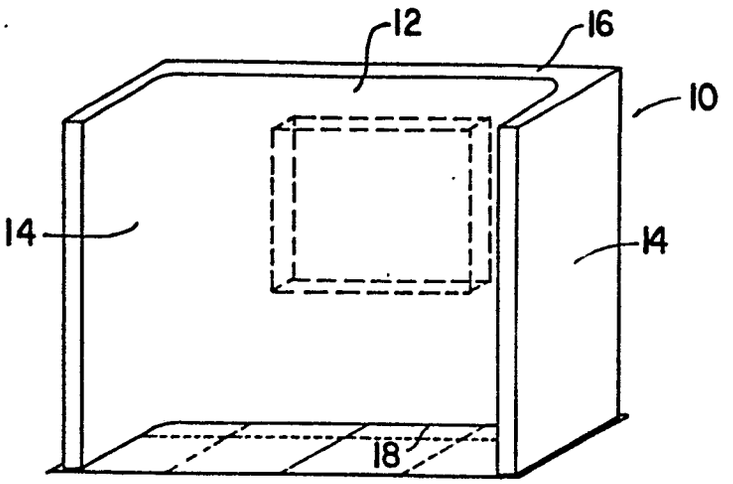

12
16
10
14
14
18

FIG. 1

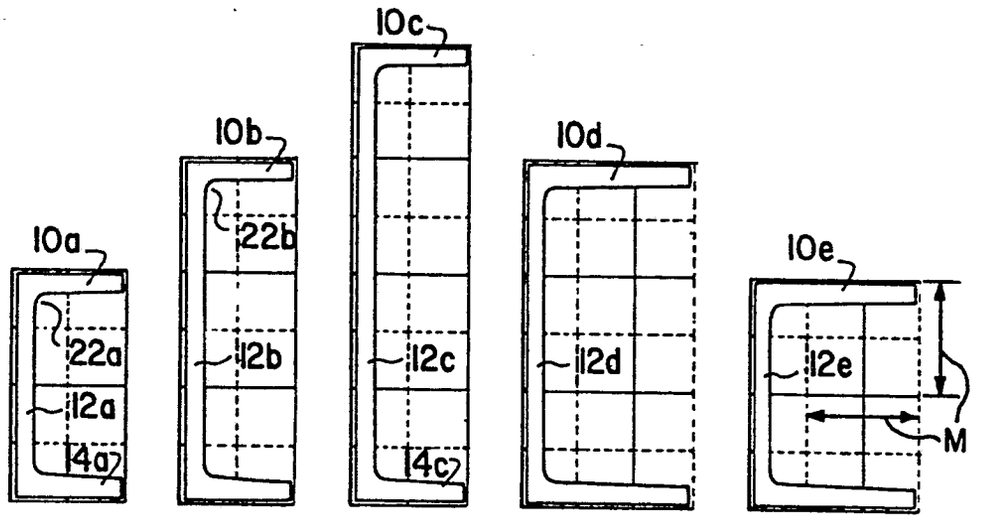
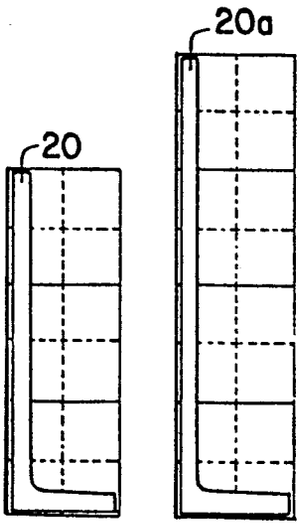

10a
22a
12a
14a
10b
22b
12b
10c
12c
14c
10d
12d
10e
12e
M

FIG. 2


20a
20

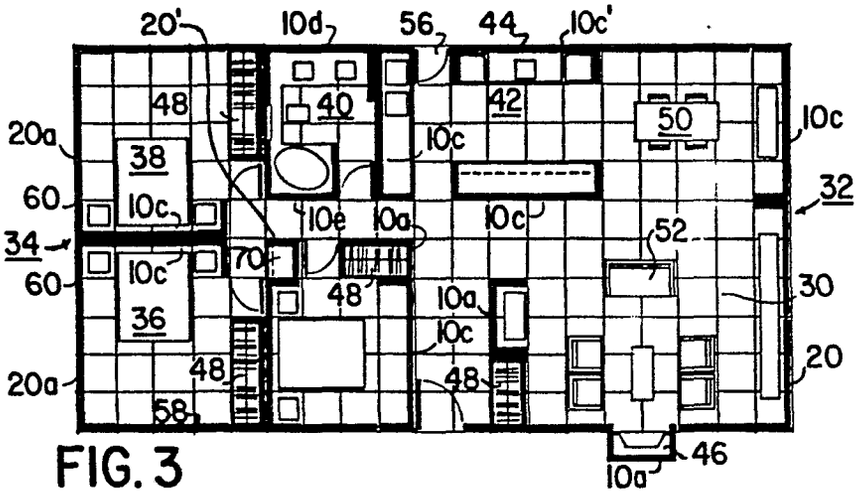

20'
10d
56
44
10c'
48
40
42
50
10c
20a
38
10c
60
10c
10e
10a
10c
32
34
52
60
10c
70
48
10a
30
36
10c
48
48
20a
58
20
46
10a

FIG. 3

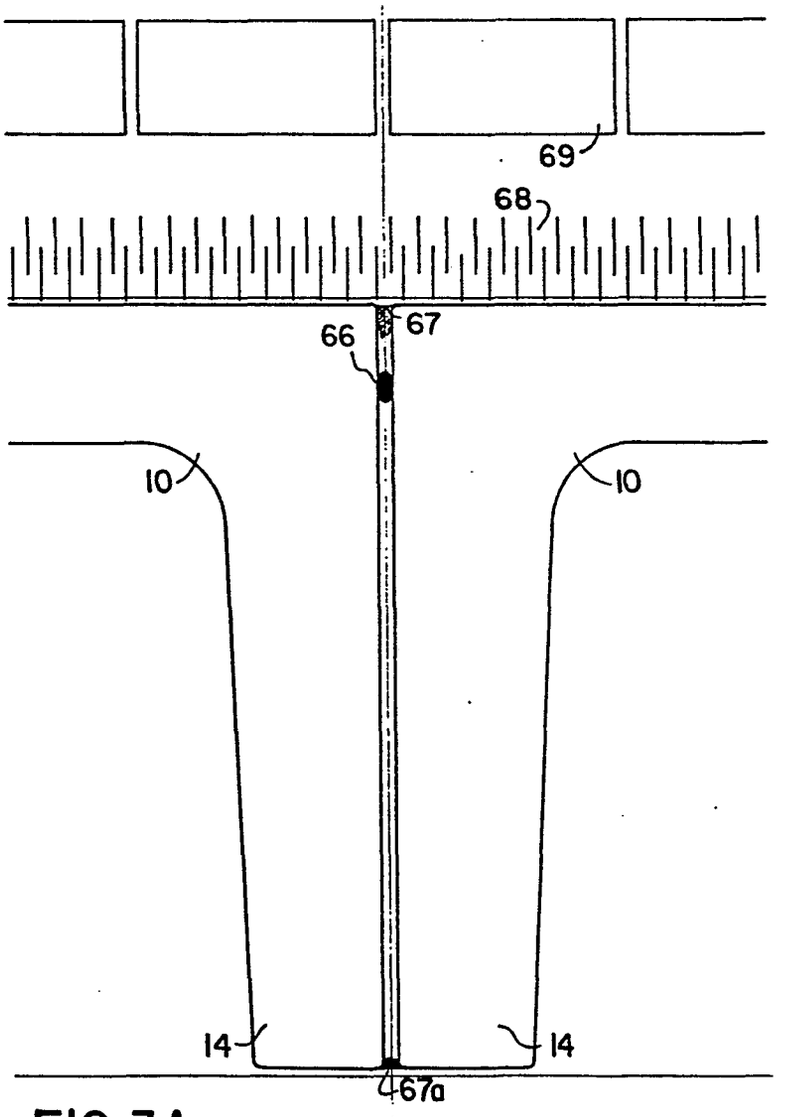

69
68
66
67
10
10
14
14
67a

FIG. 3A

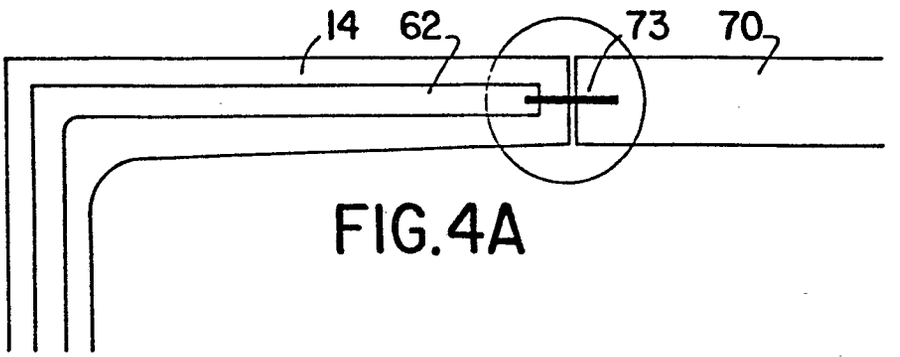


FIG.4A

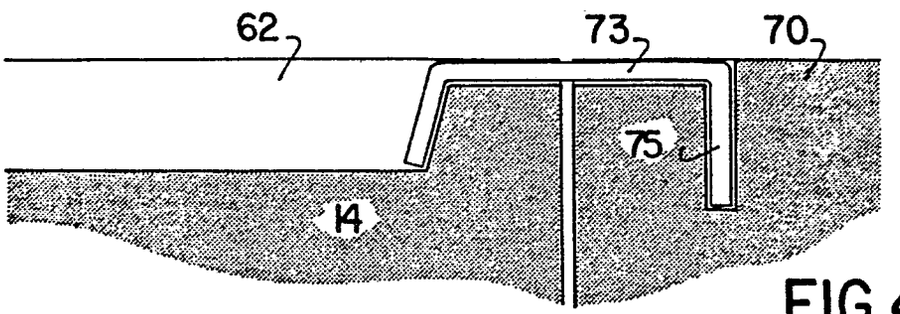


FIG.4B

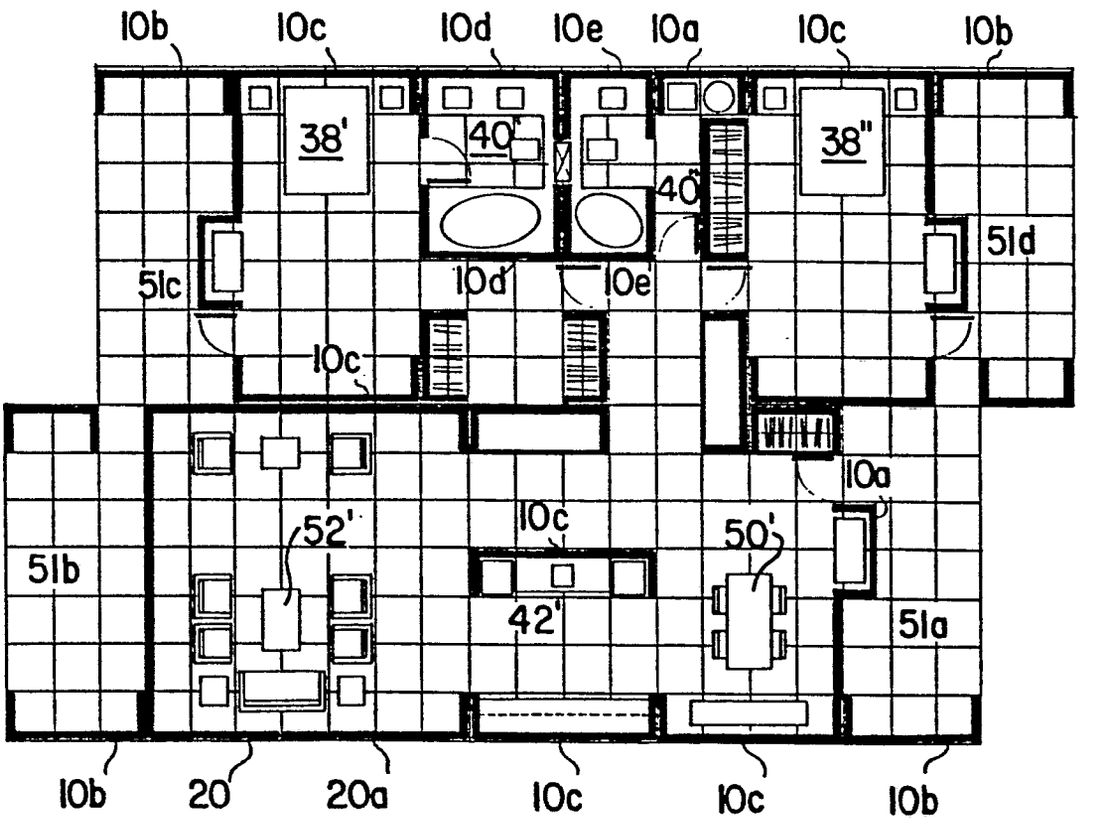


FIG.4C

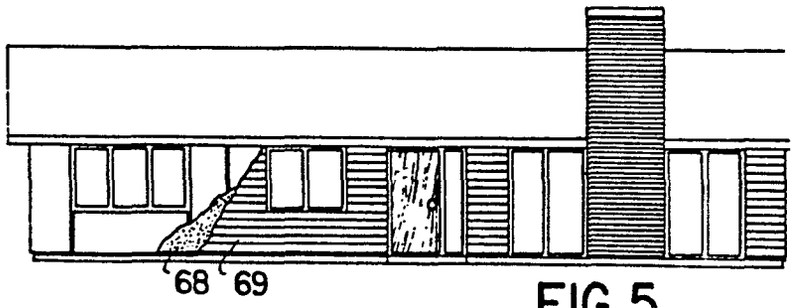


FIG.5

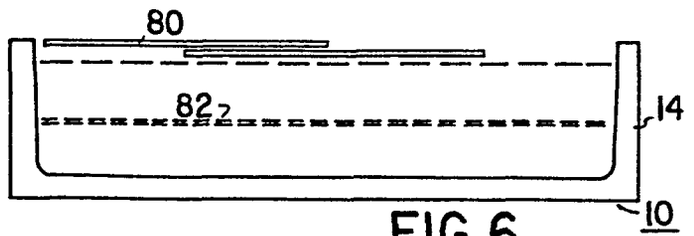


FIG.6

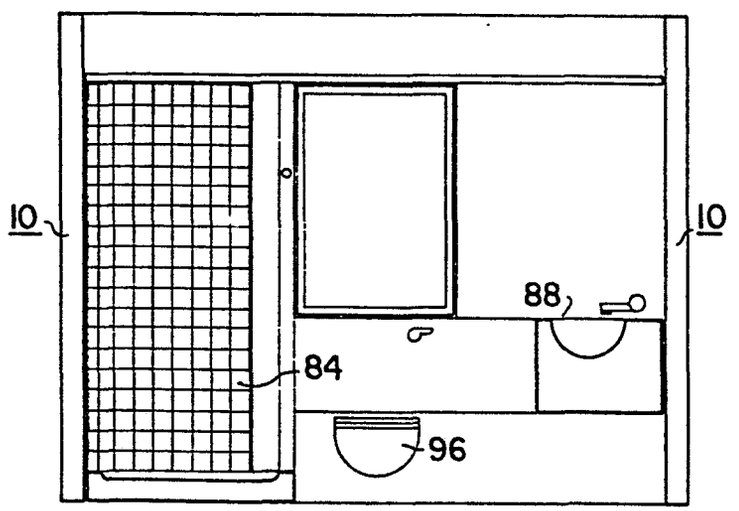


FIG.8

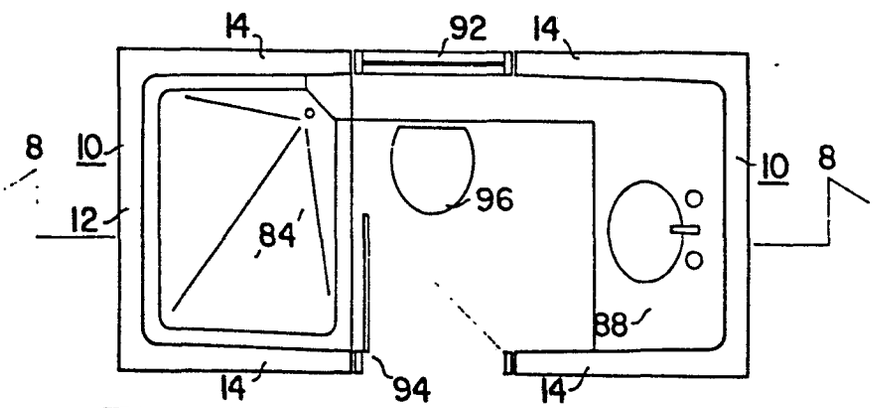


FIG.7

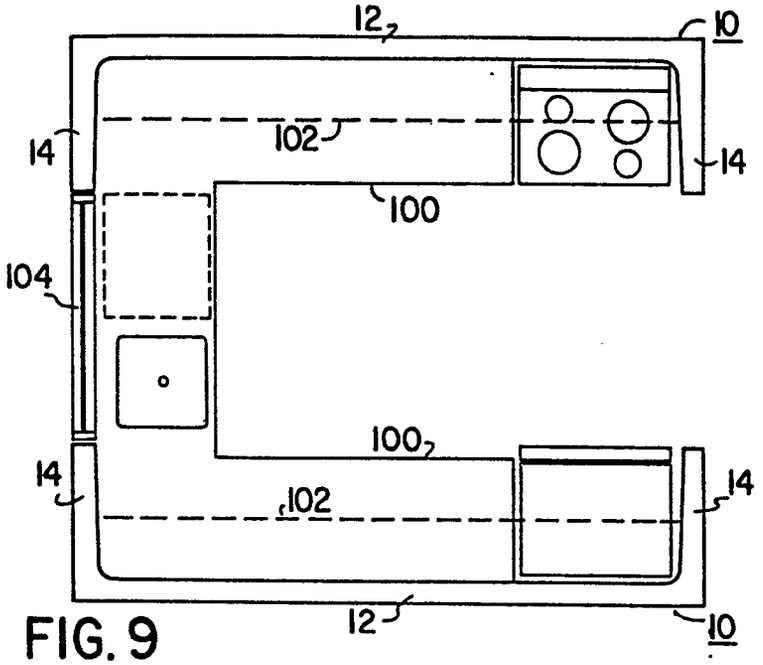

12
10
14
102
14
100
104
100
14
102
14
12
10

FIG. 9

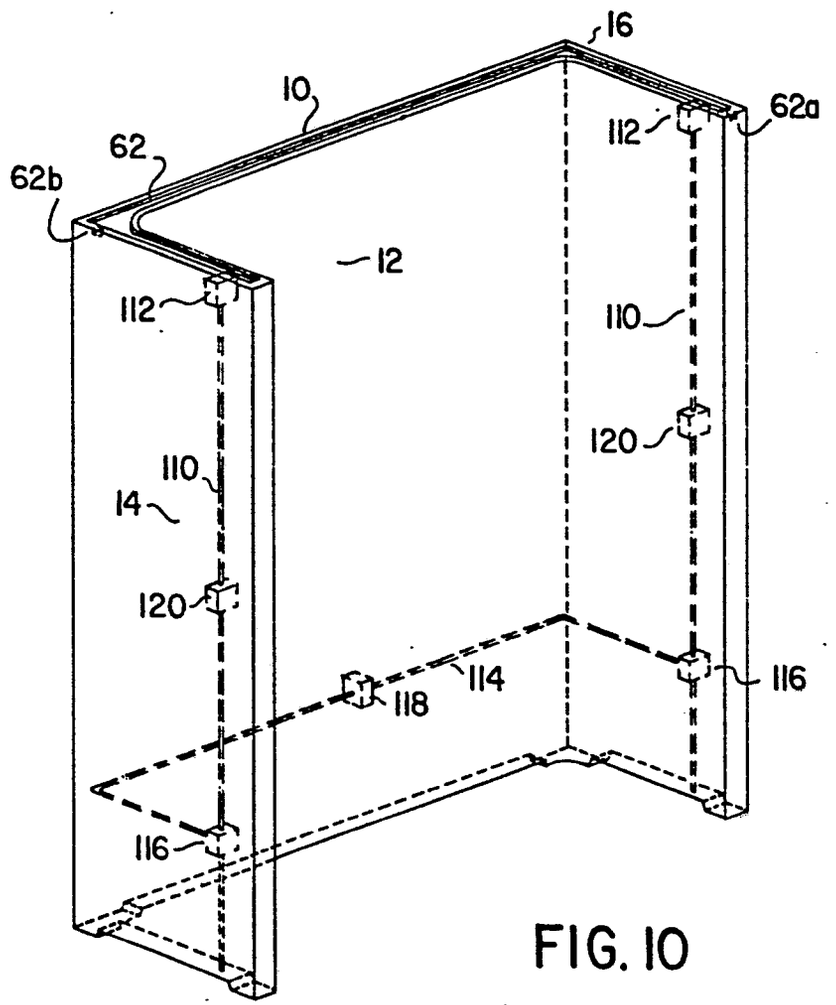

16
10
62a
112
62
62b
12
112
110
120
110
14
120
114
116
118
116

FIG. 10

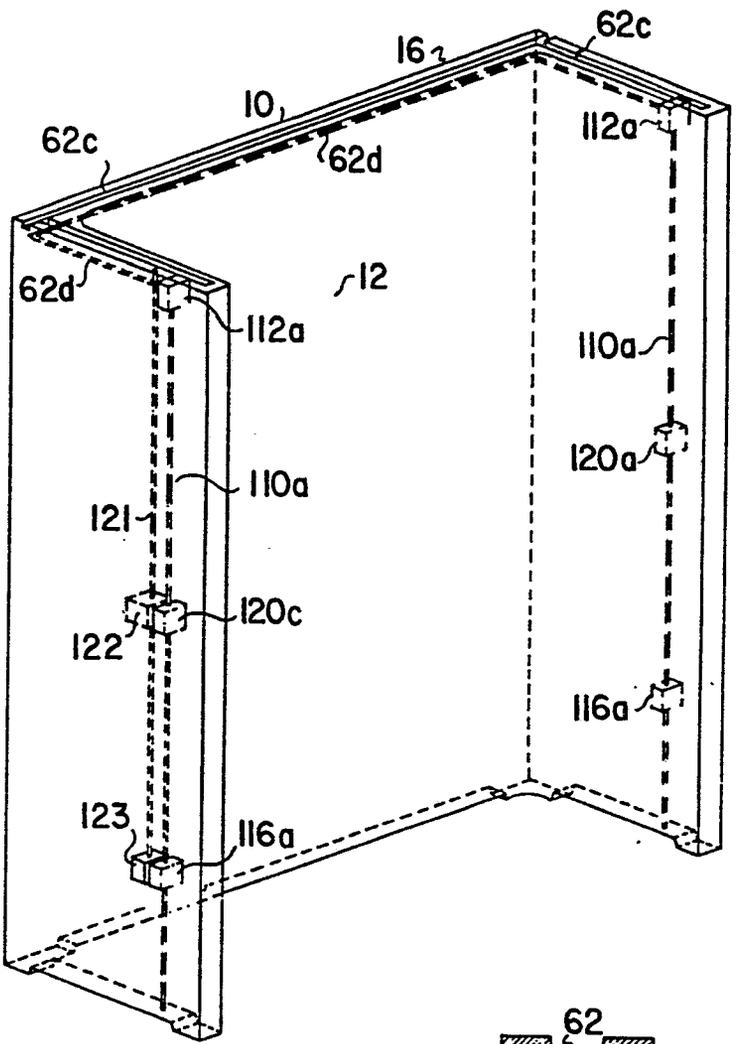


FIG. 10B

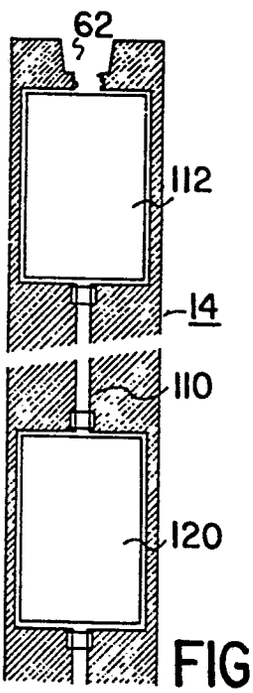


FIG. 10A

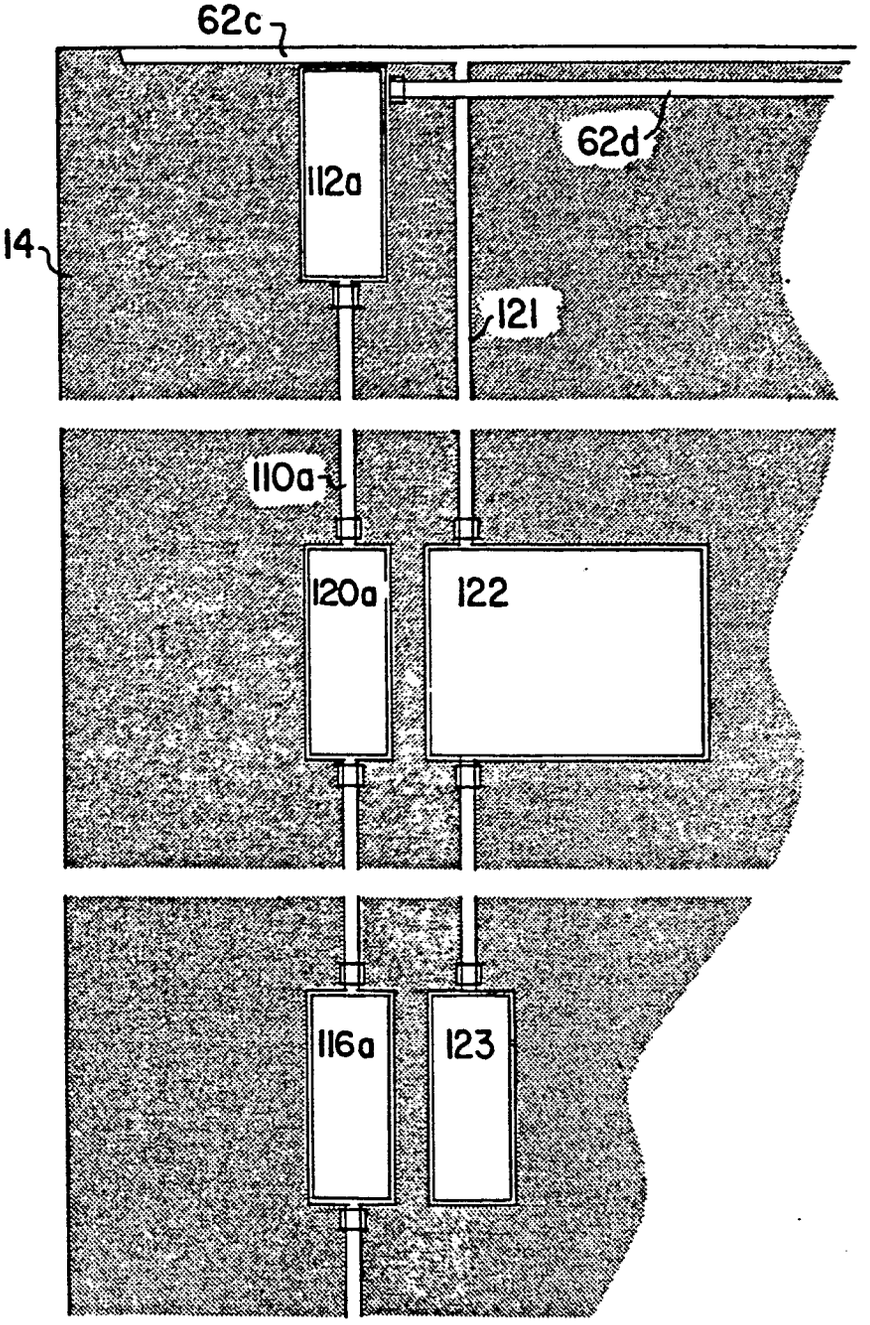


FIG. 10C

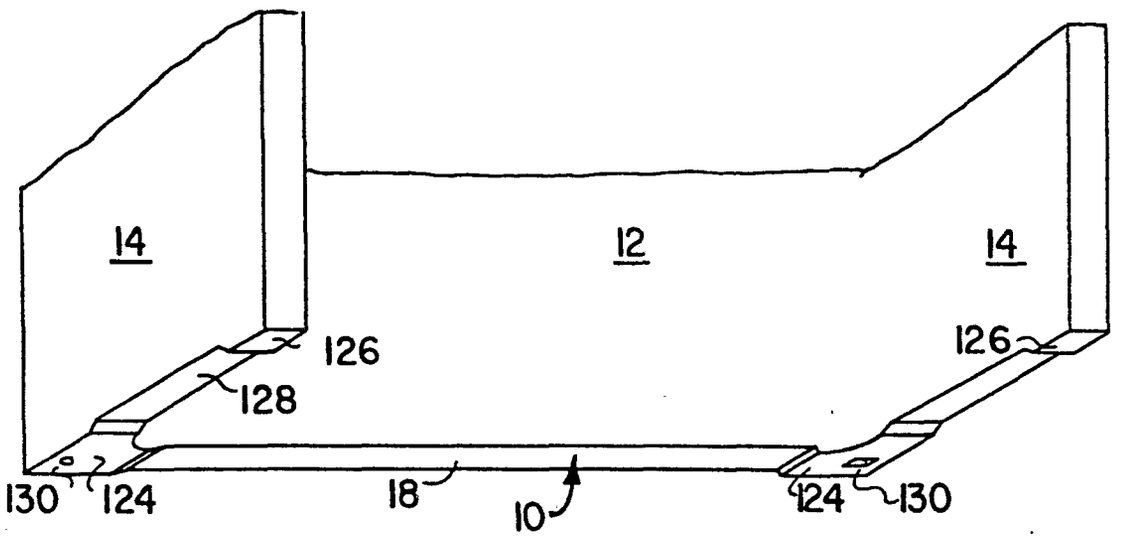

14
12
14
126
126
128
130
124
18
10
124
130

FIG. 11

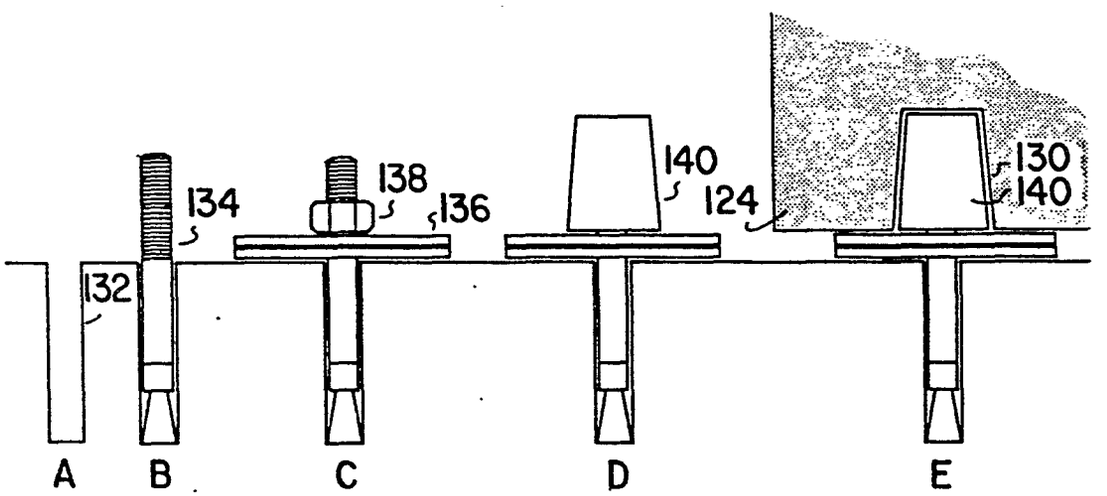

134
138
136
140
124
130
140
132
A
B
C
D
E

FIG. 12

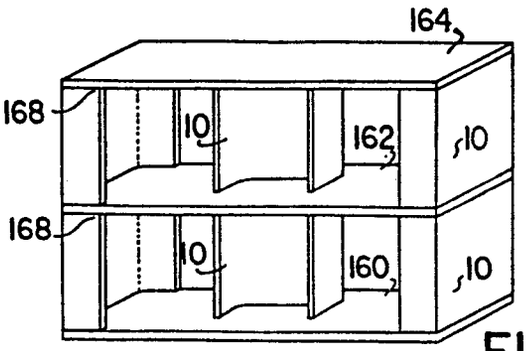


FIG. 14

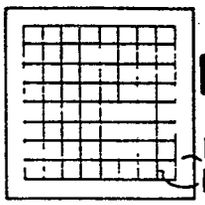


FIG. 13A

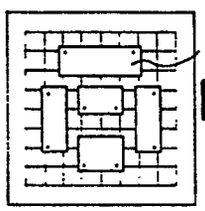


FIG. 13B

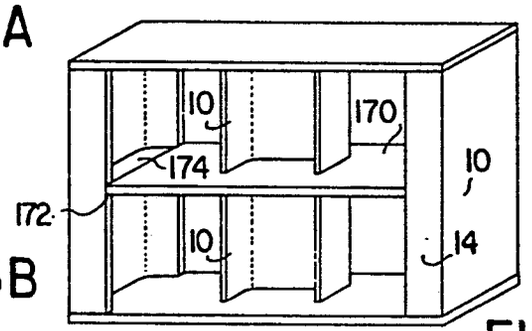


FIG. 15

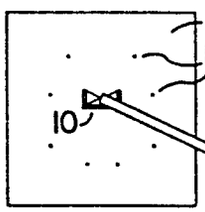
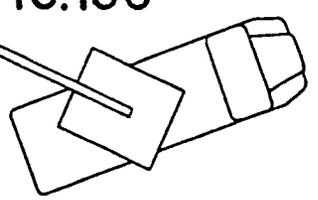


FIG. 13C



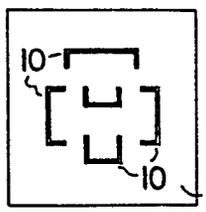


FIG. 13D

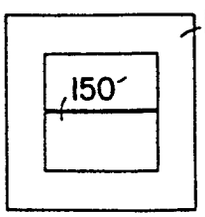


FIG. 13E

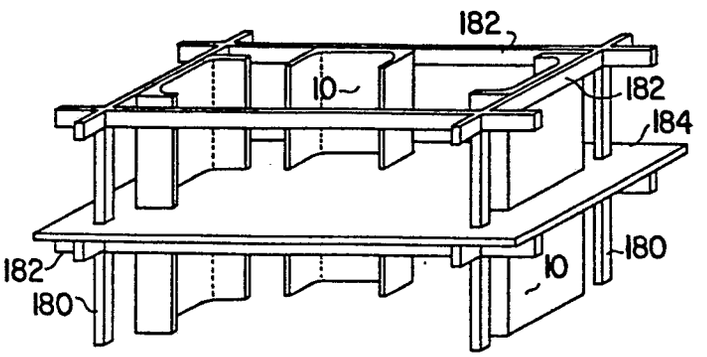


FIG. 16

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 81 30 2820

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.³)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	FR - A - 2 381 870 (TEKTON) * The whole document * --	1,11, 17-19, 21-25, 30,33	E 04 B 1/348
	FR - A - 2 104 967 (FILLOD) * Page 2, line 38 - page 3, line 2; page 3, lines 31-39; page 4, lines 1-12, 25-31; figures 2,5 * --	2,10, 12,13	
	US - A - 4 195 453 (KOMENDANT) * Column 1, lines 61-64; column 2, lines 19-60; claim 7; figures 1,2,3 * --	2,10, 11,27, 28,31	TECHNICAL FIELDS SEARCHED (Int. Cl.³) E 04 H E 04 B
	FR - A - 1 336 456 (ELCON) * Page 2, column 1, line 44 - column 2, line 28, page 3, column 2, line 38, paragraph 4; figures 1,2,10 * ----	4	

CATEGORY OF CITED DOCUMENTS

- X: particularly relevant
- A: technological background
- O: non-written disclosure
- P: intermediate document
- T: theory or principle underlying the invention
- E: conflicting application
- D: document cited in the application
- L: citation for other reasons
- &: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	05-10-1981	CAVALERI

EPO Form 1503.1 06.78