United States Patent [19]

Feldman et al.

[11] **3,874,134**

[45] **Apr. 1, 1975**

[54] **MODULAR BUILDING UNITS**

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[22] Filed: **May 29, 1973**

[21] Appl. No.: **364,980**

Related U.S. Application Data

[63] Continuation of Ser. No. 115,276, Feb. 16, 1971, abandoned, which is a continuation-in-part of Ser. No. 53,675, May 1, 1970, abandoned.

[52] **U.S. Cl.** **52/79,** 52/251, 52/340

[51] **Int. Cl.** **E04h 9/06,** E04h 1/12

[58] **Field of Search** 52/250, 251, 252, 602, 52/79, 745, 410, 326, 380, 381, 338, 378, 333, 319, 340

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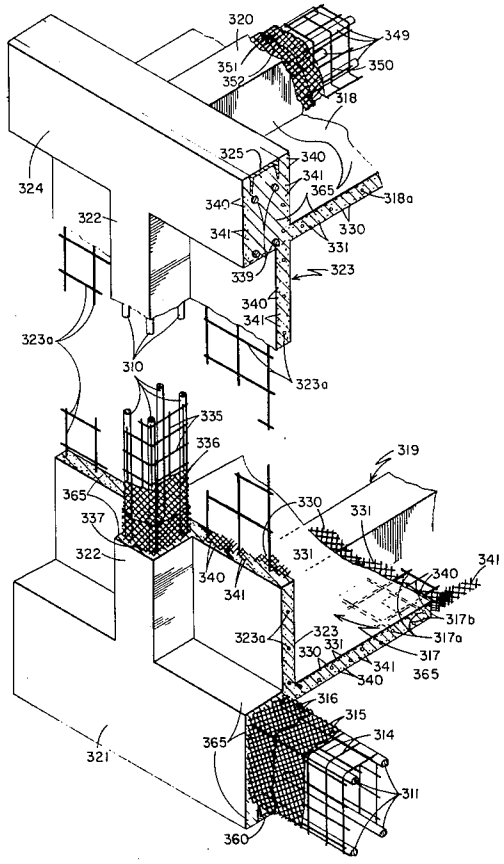
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Primary Examiner—John E. Murtagh
Attorney, Agent, or Firm—Joseph Zallen

[57] **ABSTRACT**

The modular building unit comprises an integral frame of floor, ceiling and wall elements, covered on its interior surface with an integral cover member anchored to the frame. The cover member is made up of an apertured core such as wire mesh and spaced rods embedded in cementitious material. The exterior is completed where exposed to the atmosphere by inserting finishing elements between adjacent frame members and by a variety of exterior covers as may be desired.

15 Claims, 16 Drawing Figures



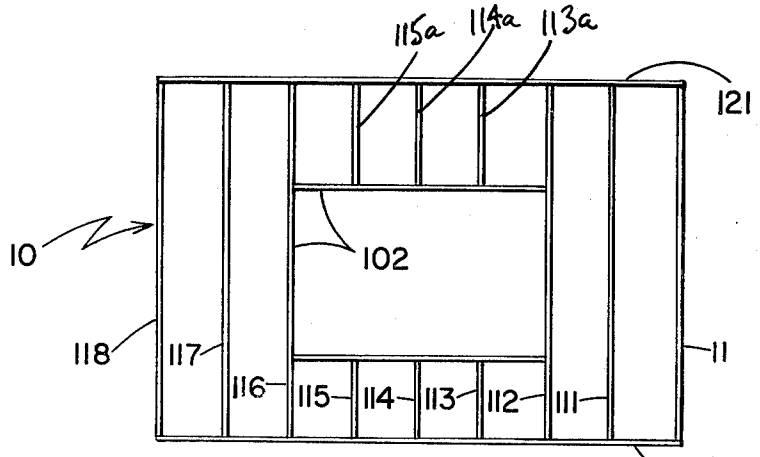


FIG. 1

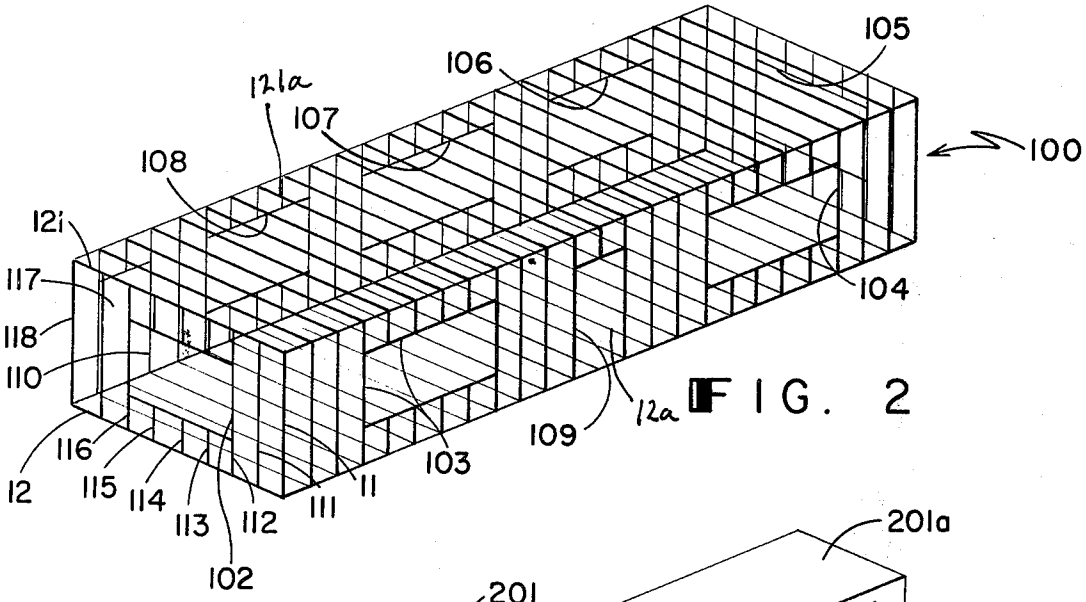


FIG. 2

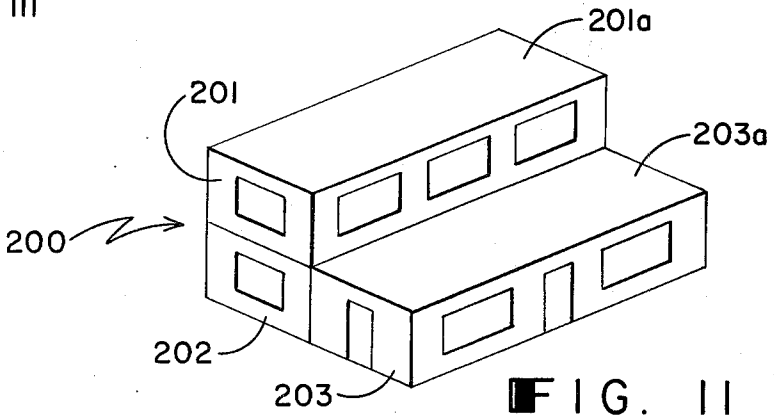


FIG. 11

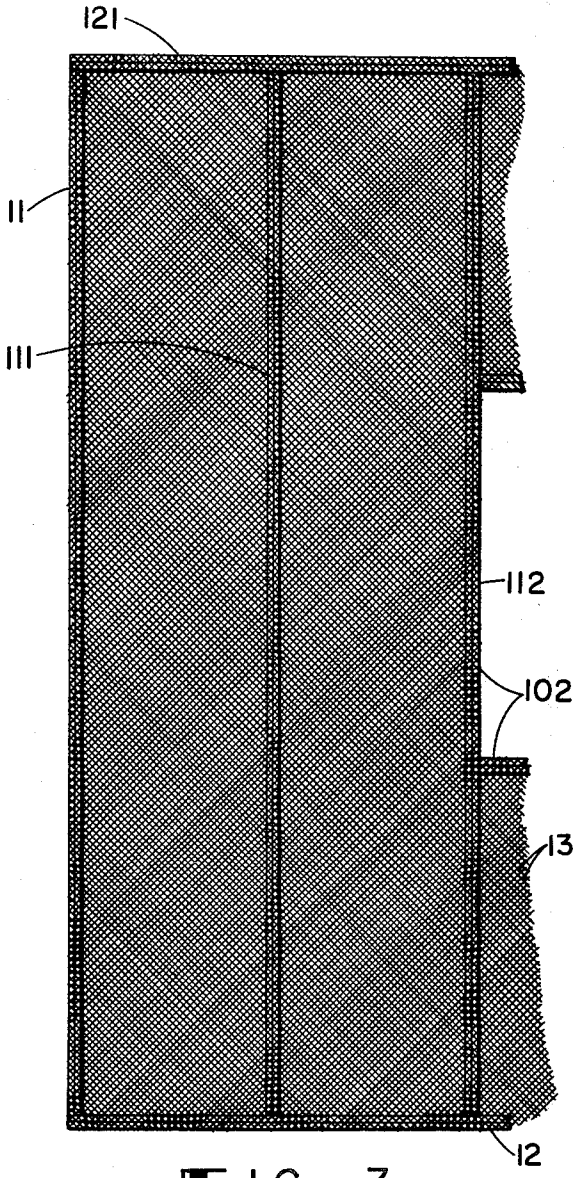


FIG. 3

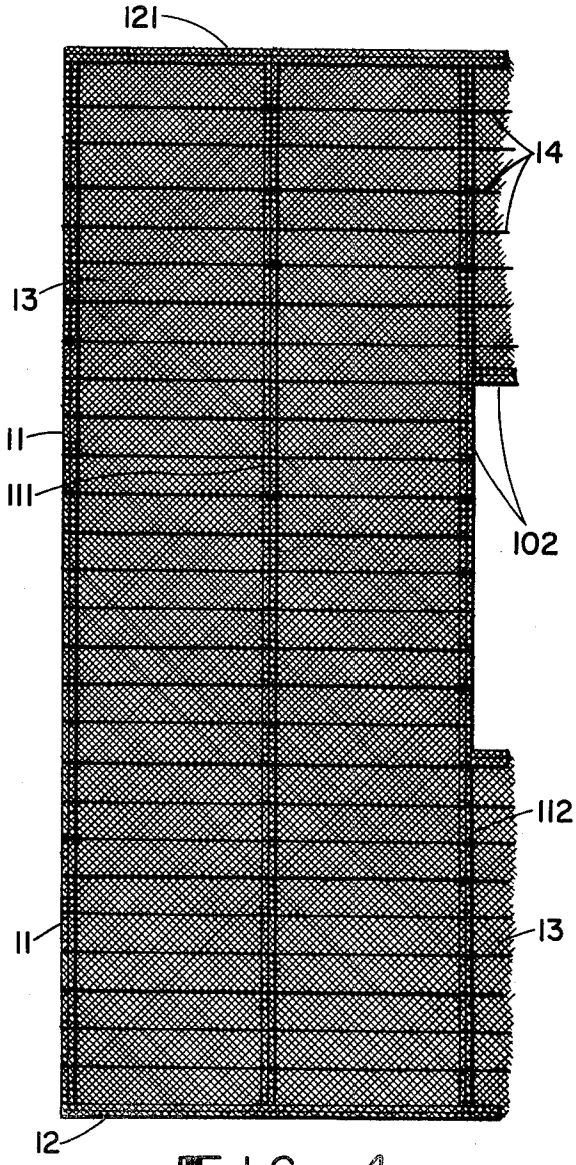


FIG. 4

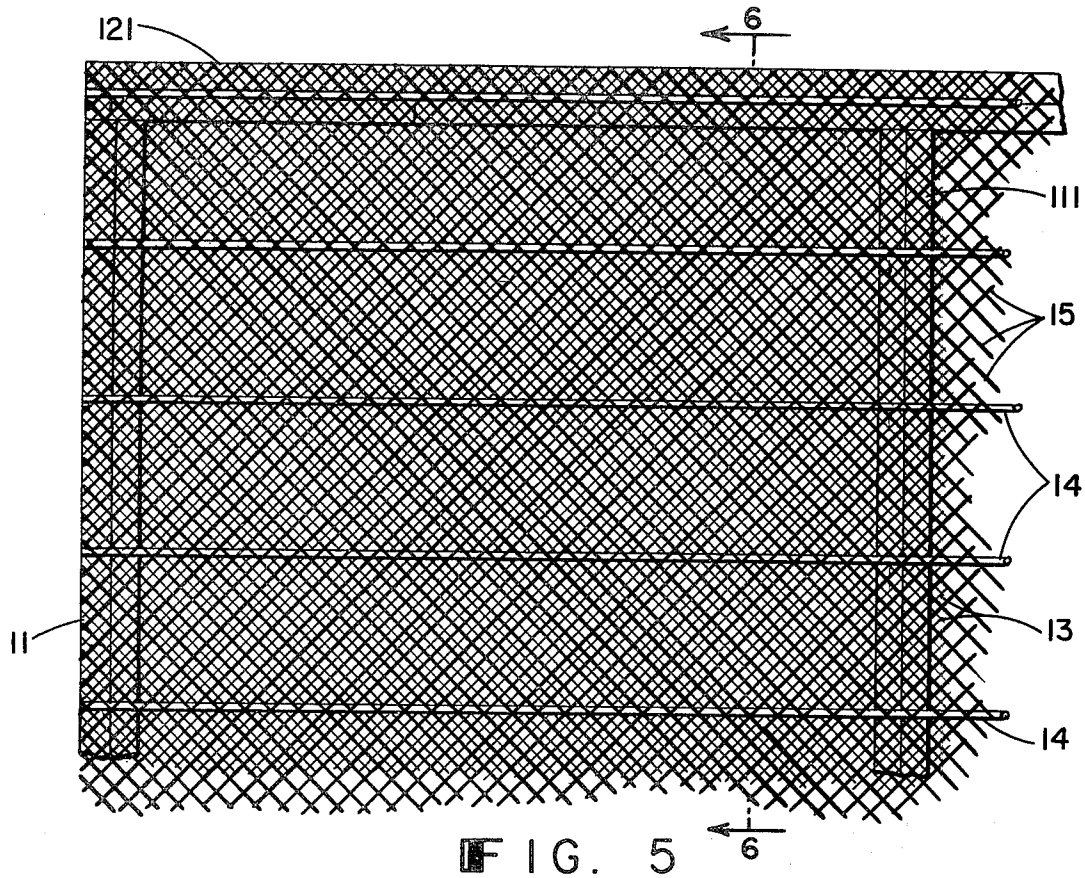


FIG. 5

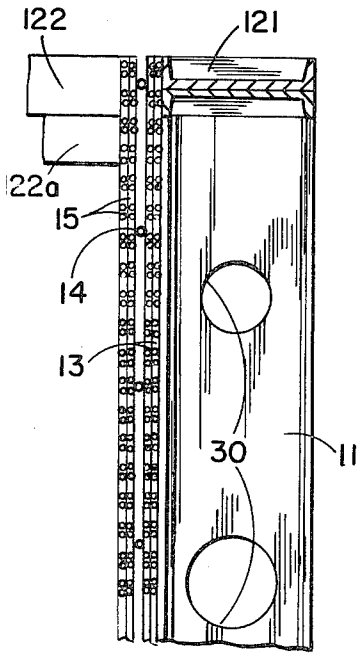


FIG. 6

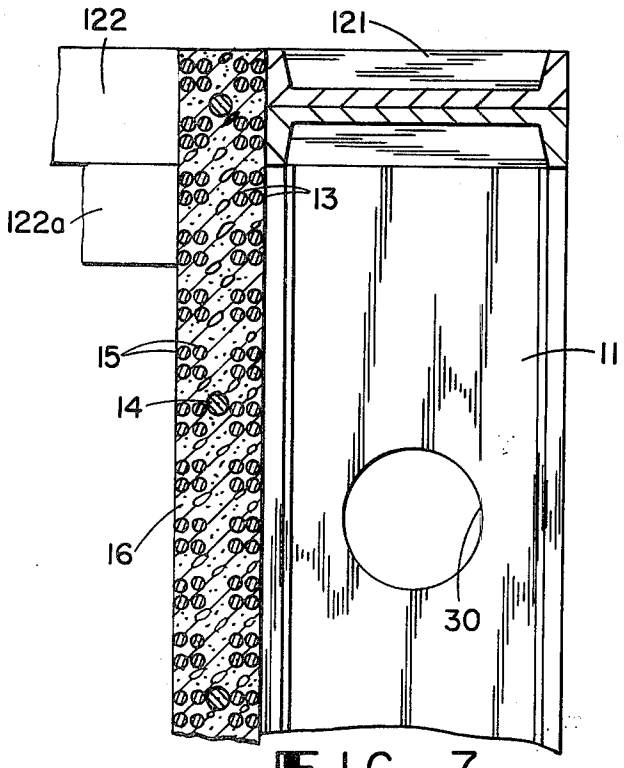


FIG. 7

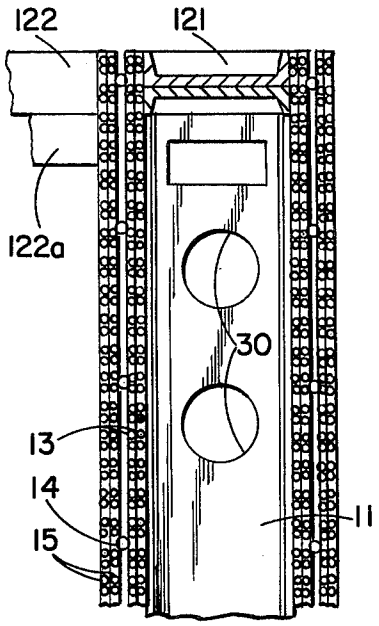


FIG. 8

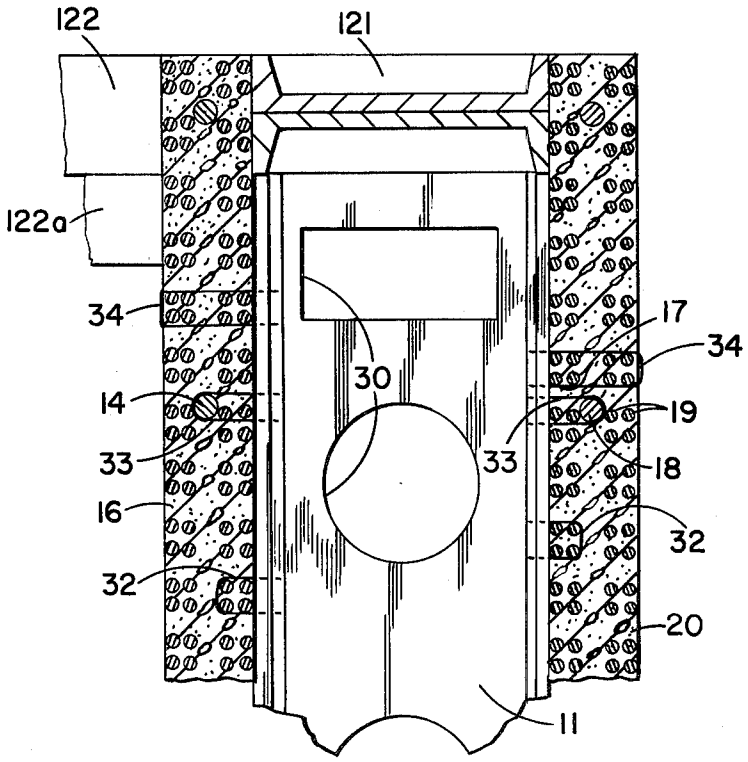


FIG. 9

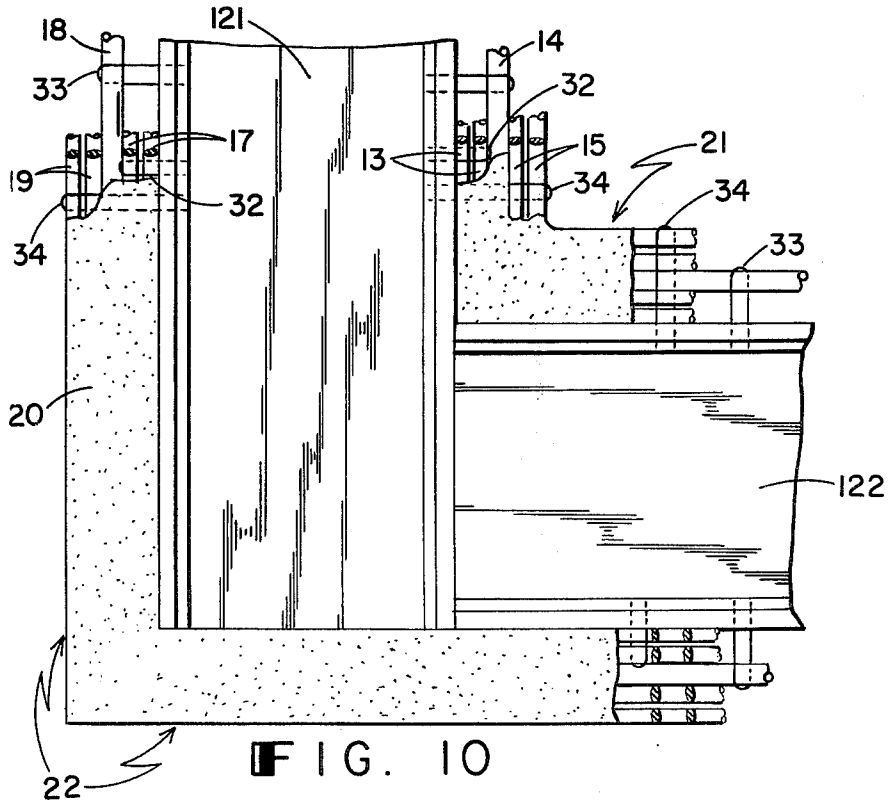


FIG. 10

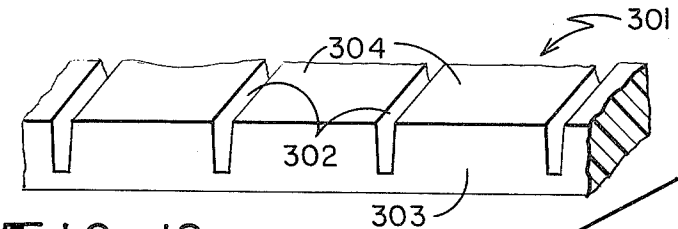


FIG. 12

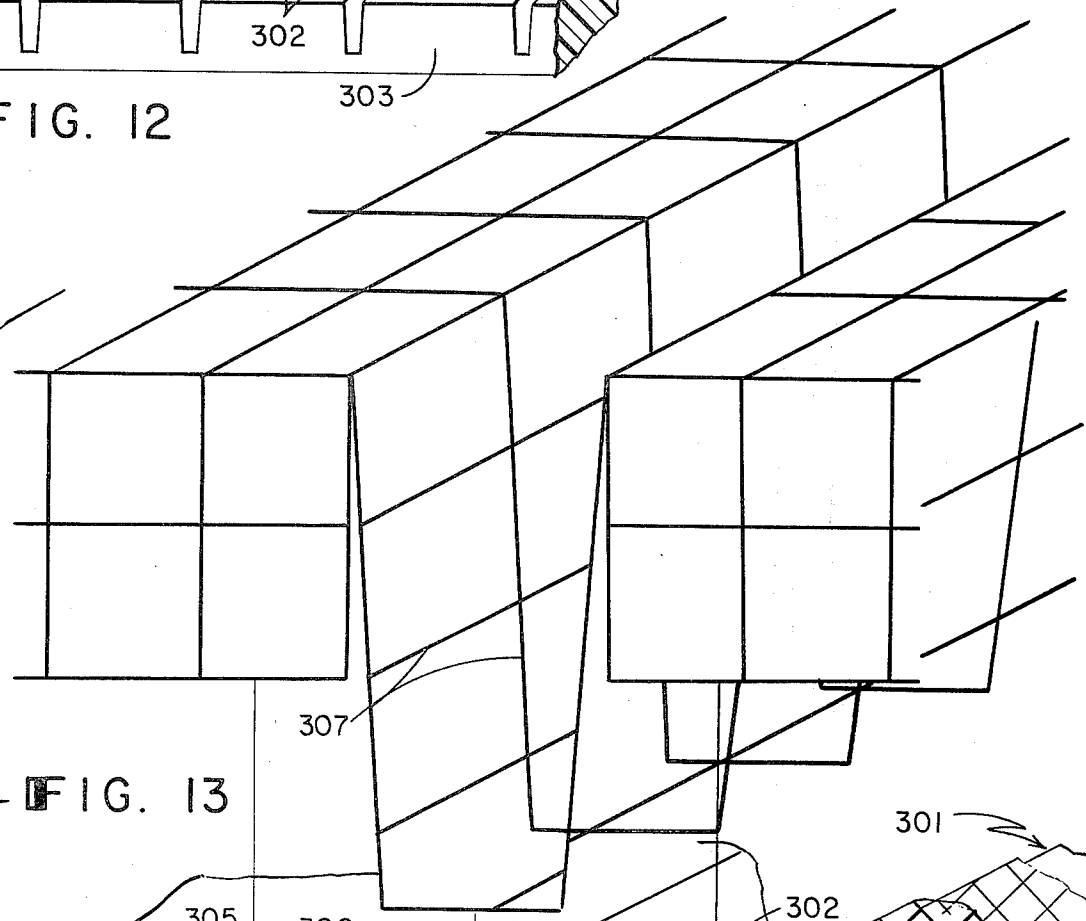


FIG. 13

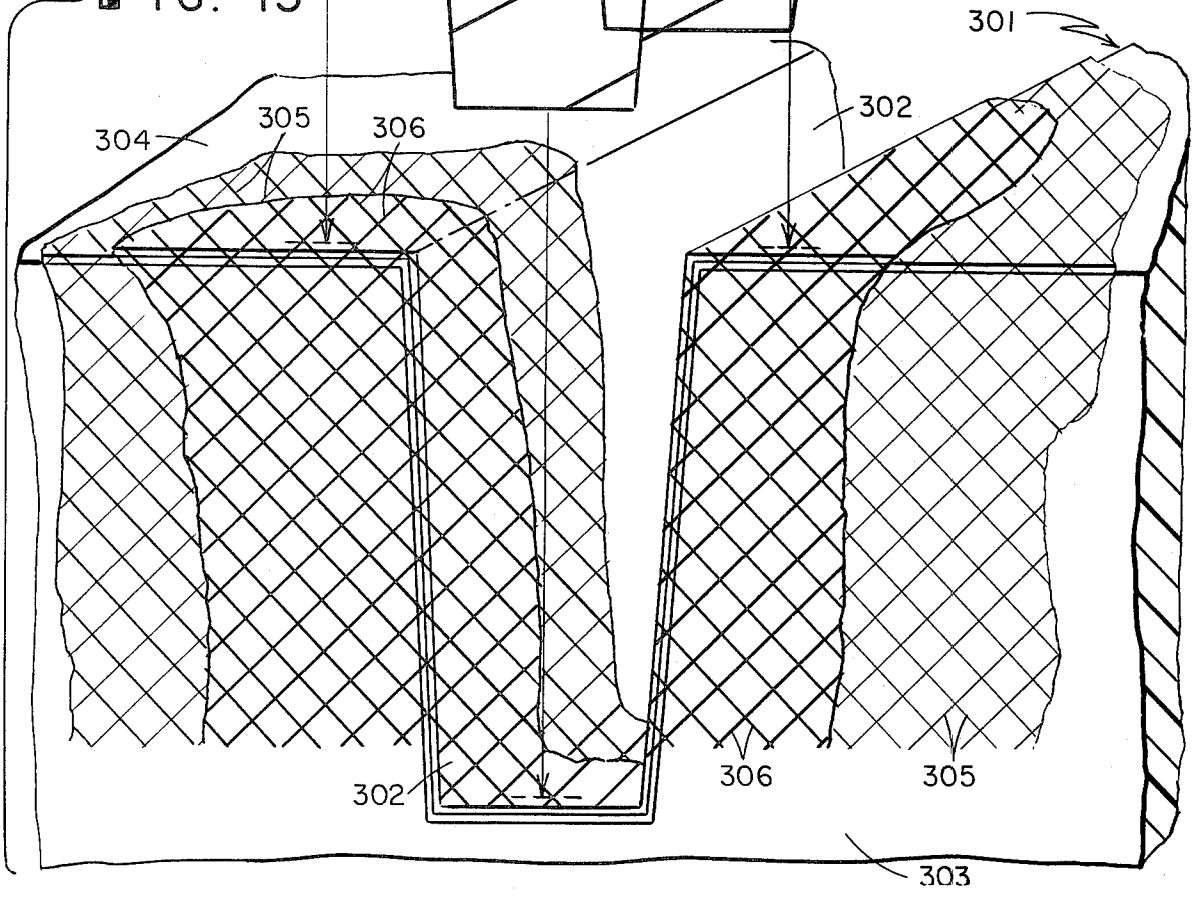
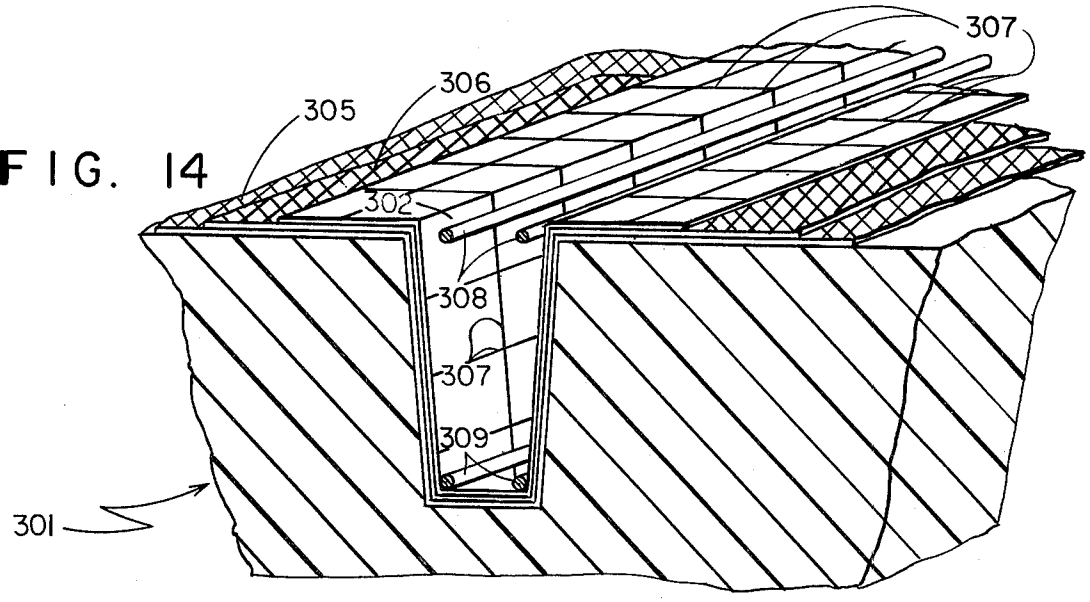


FIG. 14


307
306
305
302
308
307
309
301

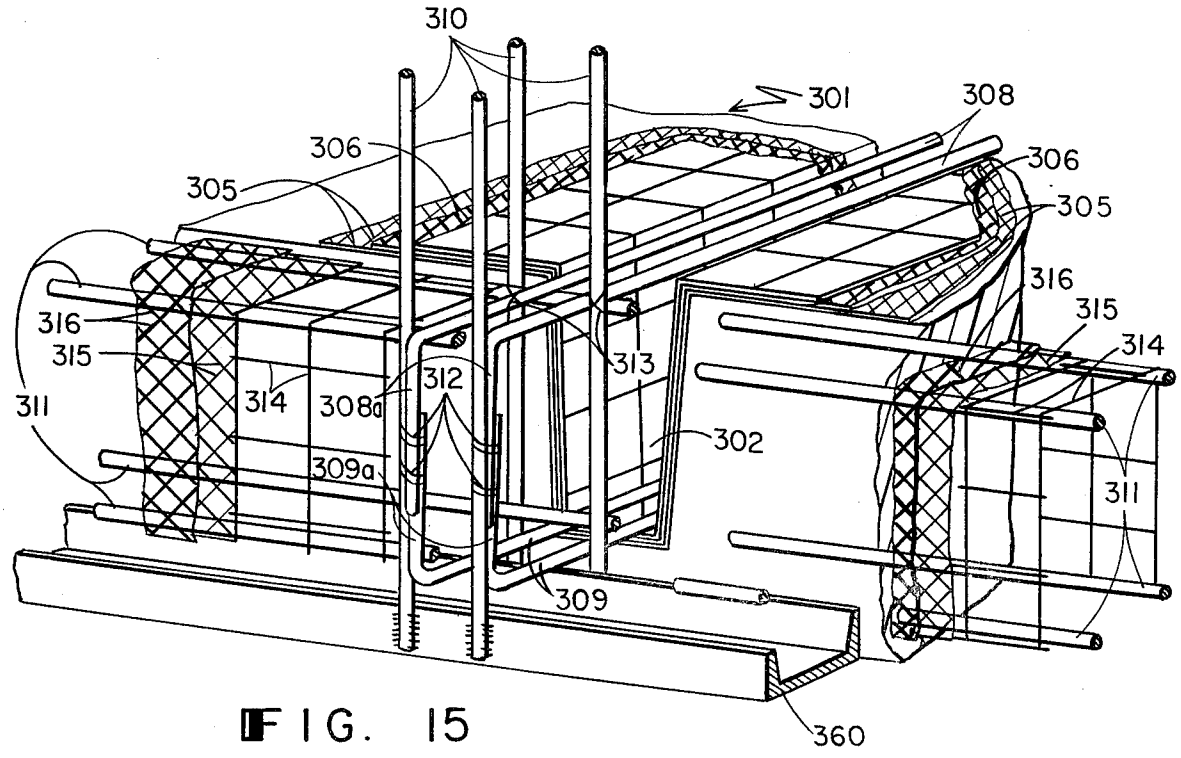

310
301
308
306
306
305
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316
315
316
314
315
313
311
314
308a
312
302
309a
311
309
360

FIG. 15

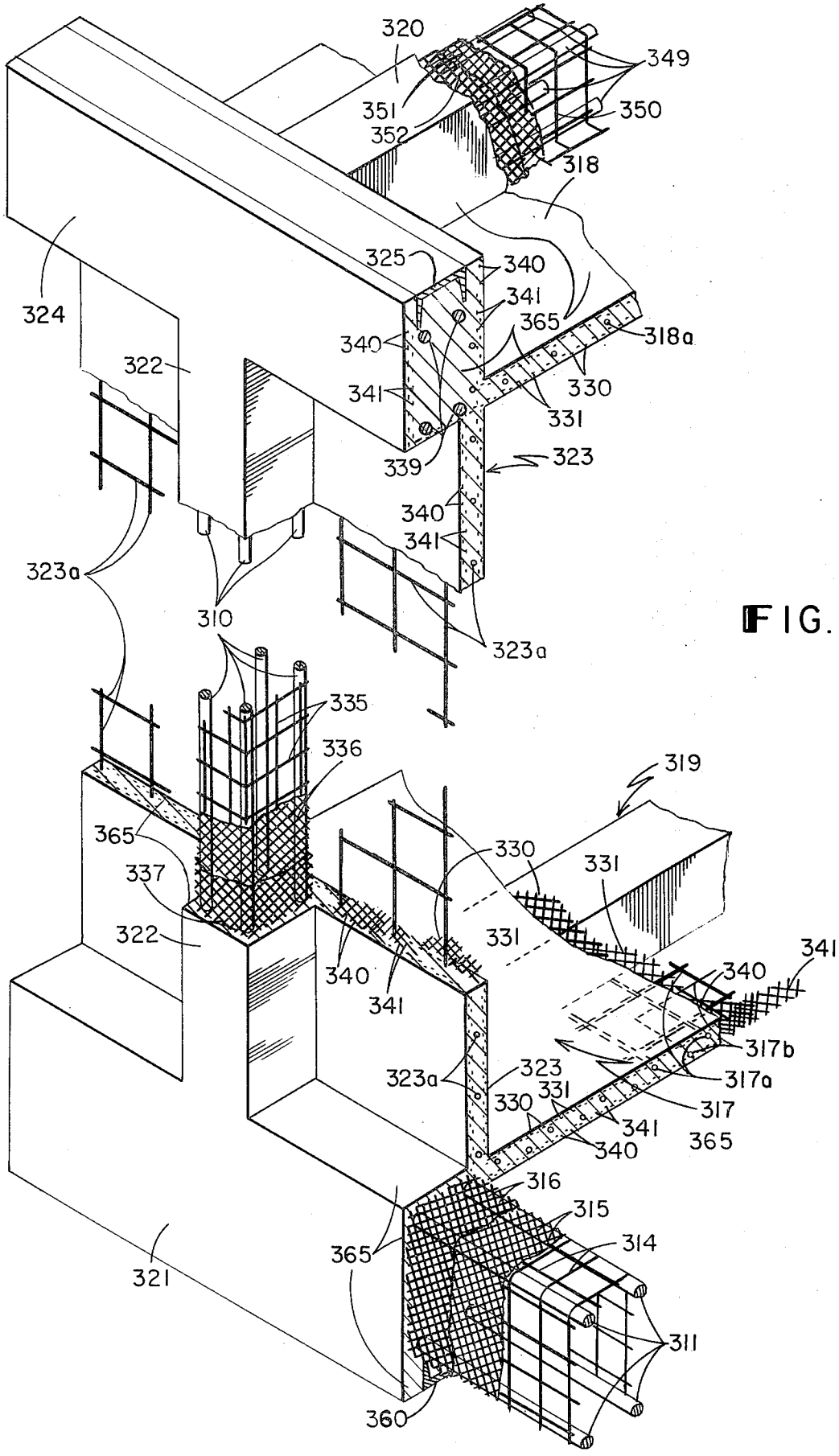

320
349
351
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318
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341
365
318a
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322
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323a
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322
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340
340
341
317b
323a
323
317a
331
330
317
341
340
365
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315
365
314
321
311
360

FIG. 16

MODULAR BUILDING UNITS

CROSS-REFERENCE TO PATENT APPLICATION

This is a continuation of our co-pending patent application of the same title, Ser. No. 115,276 filed Feb. 16, 1971, now abandoned, which in turn was a continuation-in-part of our then co-pending but now abandoned patent application of the same title, Ser. No. 33,675 filed May 1, 1970.

BACKGROUND OF THE INVENTION

This invention relates to building structures. In particular it relates to prefabricated or modular building units made of cementitious material.

Many attempts have been made in the past to reduce the cost of building structures by prefabricating the buildings or portions thereof or designing modular units. Cementitious building structures as have been previously described have suffered from one or more disadvantages. One particular disadvantage has been the inability to transport a modular unit to its site because of its excessive weight. Another disadvantage is that in handling or transportation, severe cracking often takes place which cannot be repaired.

One object of the present invention is to provide a novel building structure and method for its construction which provides modular cementitious building units of substantially less weight than previously described prefabricated or modular units.

Another object of the present invention is to provide such a building unit which would be economically transportable.

A further object of this invention is to provide such a building unit which has greatly improved resistance to cracking.

Another object of this invention is to provide a building unit which can be completely or partially constructed in a factory.

Yet another object of this invention is to provide such a building unit which can be used with other similar units to provide larger building units or multiple apartments.

Other objects and advantages of this invention will appear in the description and claims which follow taken together with the appended drawings.

Summary of Invention

The invention comprises broadly an enclosed building unit. The unit has an intergral frame having floor, ceiling and exterior wall framing elements with provisions for open portions such as windows, doors, stairs, chimneys, conduit spaces and the like. Extending over substantially the entire interior surface of the frame, except for said open portions, is an integral cover member which forms the floor, ceiling and walls. The cover member comprises an apertured core generally rigid but with some flexibility as, for example, spaced rods and wire mesh. The core is anchored to the frame on all sides and is embedded in cementitious material. The layer of core embedded in cementitious material can be quite thin, as for example, from about one-quarter to one-half inches in thickness. In one example, the floor has a thickness of about 1½ inches and wall and ceiling thickness of about ¾ inches.

In one form of the invention, the frame of the building unit is preferably made from peripheral and intermediate horizontal studs for the floor and ceiling and vertical studs attached to and extending between the peripheral studs. The core of the integral cover member preferably comprises layers of wire mesh and spaced rods connected to the studs on their interior surfaces.

In a second form of the invention, the frame elements comprise spaced rods wrapped with wire mesh and embedded in a cementitious material. The peripheral horizontal elements also preferably include steel channel beams. The core of the integral cover member preferably comprises layers of wire mesh.

In a preferred construction for the first embodiment, a first steel wire mesh layer e.g. **22** wire gage having about ½ inch openings, is positioned on the interior surfaces of the steel studs on all sides and attached to the studs. A rod layer comprising spaced steel rods e.g. **12** gage, is laid over the mesh and attached to the studs by ties, staples or the like. A second wire mesh layer is then positioned on and attached to the rod layer. A high viscosity cementitious material e.g. cement or concrete, is then applied to fill in and surround the rod and mesh layers e.g. to a thickness of about ½ inch to 1½ inch. After the cementitious material has cured, the combined layers provide a continuous cover structure. The space between adjacent studs is then filled with insulating material such as fiberglass, foam, plastic, asbestos, rock wool, or similar low density insulating material, as may be desired.

If the particular wall, ceiling, or floor is to be exposed to the atmosphere, cementitious material may be applied to the exterior surfaces of the studs in question.

In a preferred construction for the second embodiment, a transversely grooved wire mesh core is used for the floor and ceiling, a floor or ceiling framing element is formed from rods spaced within a groove and wrapped with mesh, a vertical forming element is formed from rods spaced adjacent the ends of the grooves and wrapped with mesh, and a horizontal peripheral framing element is formed from a beam e.g. steel beam, in conjunction with spaced rods wrapped in wire mesh.

Other finishing material may be applied to the exterior as may be dictated by various designs. These include wood, clapboard and metal. At the factory, interior portions, kitchen cabinetry, pre-assembled doors, and pre-assembled windows are fitted and installed. Other interior finishing such as painting, electrical services, and leads may also be accomplished at the factory. Accordingly, except for the foundations, the building unit is ready for installation when it arrives at the site.

Because of its construction, the building units of this invention may be stacked or arranged in various combinations with suitable interior designs so as to provide single or multiple dwellings or office buildings or industrial buildings of a wide variety of size and scope.

Because of their construction, the building units of this invention require much less material than previously described prefabricated buildings. Accordingly, building units made in accordance with this invention are sufficiently light in weight to enable them to be handled by conventional transportation, cranes and similar lifting devices. Thus, the building unit illustrated in FIGS. **1–11** in the drawings, has approximate dimensions of 42 feet by 14 feet by 8½ feet and weighs only 24,000 pounds. Concrete structures of the same volume typically weigh at least double. A 12 foot width is

used in many instances because it is the maximum usable on roads and railroads in the United States.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is an end view of the frame of a building unit made in accordance with this invention.

FIG. **2** is an isometric diagrammatic view of the frame of FIG. **1.**

FIG. **3** is a partial enlarged interior view of the end wall showing the first wire mesh layer attached to horizontal and vertical framing elements.

FIG. **4** is a partial enlarged interior view as in FIG. **3** showing the rod layer extending over the wire mesh layer.

FIG. **5** is a more enlarged partial interior view as in FIGS. **3** and **4,** showing the second wire mesh layer extending over the rod layer.

FIG. **6** is a section along line **6—6** of FIG. **5.**

FIG. **7** is a slightly enlarged similar view as in FIG. **6** but in this case including the cementitious layer interspersed in and surrounding the mesh and rod layers.

FIG. **8** is a similar view as in FIG. **6** with the addition of an exterior assembly of a first wire mesh layer, a rod layer and a second mesh layer.

FIG. **9** is a slightly enlarged partial view of FIG. **8** showing a cementitious layer interspersed in and surrounding the exterior mesh-rod layer as well as the interior mesh-rod layer.

FIG. **10** is a plan view of a corner of the end showing interior and exterior cementitious-rod-mesh wall layers and their attachments to framing elements.

FIG. **11** is a diagrammatic view of an assembly of three enclosed building units made in accordance with this invention.

FIG. **12** is a partial end view with partial cutaway showing the mold used for forming the wire core of the floor in accordance with a second embodiment of this invention.

FIG. **13** is a partial perspective end view with cutaway showing two wire layers substantially coextensive with the floor and positioned in the mold of FIG. **12** with a third layer (shown prior to insertion) substantially coextensive only with the groove portions.

FIG. **14** is a partial sectional view with cutaway showing the wire layers positioned in the mold of FIG. **12,** together with spaced rods in the grooves.

FIG. **15** is a partial end view with partial cutaway showing the joining of the floor in the mold with a base of the wall.

FIG. **16** is a partial end view with partial breakaway showing a floor, wall and ceiling, wherein the mold has now been removed and the wire mesh and rods embedded in cement.

SPECIFIC EXAMPLES OF INVENTION

FIGS. **1–11** relate to an enclosed building unit made in accordance with this invention which is of a size and shape particularly useful for standardized factory production, ease of handling with conventional equipment, and suitable for transportation over the highway. Thus, the illustrated unit has approximate dimensions of 42 feet by 14 feet by 8½ feet and with such a unit the interiors can be arranged and laid out in a wide variety of designs.

Referring now to FIGS. **1** and **2,** the frame for the building unit consists of peripheral, horizontal steel studs **12,** and intermediate, horizontal steel studs **12***a* as the floor framing elements; peripheral, horizontal steel studs **121** and intermediate horizontal steel studs **121***a* as the ceiling forming elements; and vertical steel studs **11, 111, 116, 117** and **118** on the end wall **10** and corresponding vertical steel studs on the other end wall and the two side walls as the vertical wall framing elements attached to and extending between the floor and ceiling elements. By means of intermediate framing elements such as **113, 114, 115, 113***a*, **114***a* and **115***a*, open portions are provided in the frame for windows **102, 103, 104, 105, 106, 107, 108** and doors **109** and **110.** By similar intermediate framing open portions for stairs, chimneys, conduit spaces and the like can be provided.

The framing elements illustrated in FIGS. **1** and **2** may be assembled in a variety of ways, thus, for example, they may be pre-assembled as walls or cross frames. In all cases, the completed frame resembles a six-sided cage wherein the steel studs are firmly attached to one another by welding, bolting or the like. In the illustrated example, the studs are uniformly spaced about 21 inches apart on their centers. The particular studs illustrated in the drawings are I-beams about two inches wide and 4 inches deep. Each beam thus provides an interior surface of about 2 inches, an exterior surface of about 2 inches and a space between these surfaces of about 4 inches.

As explained in detail below, the basic integral cover member of this invention is formed and abuts on the inner interior surface of the studs. Supplemental cover portions are applied to the exterior surfaces of the studs where such surfaces are to be exposed to the atmosphere. The sheets of insulating material are inserted so as to be positioned between the interior and exterior cover members and are generally fitted between adjacent steel studs.

After the frame has been formed, the first wire mesh layer is applied to substantially all the interior surfaces of the studs, except for the open portions, including the walls, floor and ceiling. This first wire mesh layer which can itself consist of one or more thicknesses of wire mesh, is attached to the steel studs by ties, staples or the like. A suitable wire mesh, for example, would consist of 22 gage steel having ½ inch openings.

As illustrated in FIG. **3** the end wall interior is covered by wire mesh **13** which extends over and is attached to vertical I-beams **111** and **112** and horizontal I-beams **12** and **121.** After the first wire mesh layer, which as indicated previously can be single or multiple construction, is applied over substantially all of the interior steel stud surfaces including the walls, floor and ceiling, a rod layer comprising horizontal steel rods **14** spaced 6 inches on center is applied over all the wire mesh. The rods, e.g. 12 gage steel, are tied to the steel studs on 4 inch centers by ties, staples, or the like.

A further wire mesh layer **15** which can also be either singular or multiple, is then applied over all of the rod layer **14,** as illustrated in FIGS. **5** and **6** and is tied to the rods.

The final step in the construction of the integral cover member is to apply a heavy viscosity, cementitious material **16** such as a mortar mix of Portland cement and sand, which can be applied with a trowel. This cementitious material **16** is interspersed in and surrounds the mesh and rod layers, thus providing as the integral cover member anchored to the frame, a continuous interior wall of about ½ inch thickness.

Where there are exterior cover portions of mesh and rod layers, as for example, FIG. **8**, a similar cementitious layer **20** is applied thereto.

It should be noted that the ties and staples referred to above, although present in all the rod constructions as described are illustrated only in FIG. **9** so as not to obscure the pattern of the various mesh and rod layers.

Further, although there has been no specific illustration showing an insulating layer or panel in position between adjacent studs and between the exterior and interior surfaces of the studs, it can be readily apparent from the drawings where such insulating panels or blocks would be positioned. Thus, having reference to FIGS. **7** and **9**, an insulating block would be perpendicular to the surface of the drawing and cover the stud portion **11**. Thus, a wall, ceiling or floor which is intended to be exposed to the atmosphere constructed in accordance with FIG. **9** would in affect have a sandwich of exterior and interior cementitious wire-rod layers enclosing insulating blocks or material.

In the second embodiment of the invention, as illustrated in FIGS. **12** to **16**, the elements of the integral frame are formed of spaced bars and wire mesh rather than the studs exemplified in the first embodiment, except for flat steel beams at the base and top of each wall.

Having reference now to FIGS. **12** and **16** and treating FIG. **2** as schematic, the floor and ceiling elements of the integral frame are formed by shaping wire mesh as, for example, steel mesh in a mold (e.g. wood or plastic), the mold having transverse grooves in which steel rods are spaced adjacent the edges of such floor and ceiling mold assemblies. Wall frame elements are assembled comprising horizontal spaced rods with steel channels on top and bottom with vertical rods spaced at the end of each groove and tied in to the transverse rods. After this tie in, wire mesh is wrapped around both the vertical rods and the horizontal rods so as to provide a caged structure similar to the schematic view in FIG. **2**. While assembling the frame elements, floor, ceiling and wall cores are formed with layers of wire mesh.

After the frame elements and the mesh layers have been assembled, their surfaces are covered on both sides with a high viscosity cement having a high compressive strength. Such a cement in parts by weight is 100 parts Portland Cement, 100 parts of sand and 44 parts of water, which has a compressive strength in excess of 7000 p.s.i. Generally, the compressive strength of cement used in this invention should be at least 5000 p.s.i. and preferably at least 7000 p.s.i.

The mold **301** is coextensive with the dimensions of the floor or ceiling to be formed but can be made in sections for ease of handling. The mold **301** has transverse grooves **302** spaced at regular intervals as, for example, on 4 foot centers and has a front face **303** and a top face **304**.

In assembling this embodiment, the floor mold **301** is placed in position on a working surface and covered with successive ½ inch wire mesh layers **305** and **306** which extend into the grooves and over the entire top face **304** as well as the front face **303**. The wire mesh in effect contributes to both the floor framing elements, which are to be constructed in the grooves, and the floor itself, which extends the area of the top surface **304**. For reinforcement, a third somewhat larger wire mesh layer **307** as, for example, 4 inch mesh, is placed in each groove with only a small overhang on the top surface **304**. Wire mesh layers **305** and **306** are formed by pressing into the grooves. It is understood that these layers can be applied with adjacent sections which are tied to one another. Mesh layer **307** is preferably preformed and then inserted into the groove as illustrated in FIG. **13**.

The floor framing element is constructed in each groove by means of upper rods **308** and lower rods **309**. These rods preferably have bent over ends **308***a* and **309***a* so that they may be attached to vertical wall frame element rods **310** by means of ties **312** and **313**. Rods **310** are welded to a horizontal longitudinal channel **360** which forms the base of the wall frame. Attached to the base **360** and tied into rods **310, 308** and **309** are longitudinal horizontal rods **311**.

In a similar fashion, wall framing elements comprising base channels and vertical rods are spaced around the entire periphery of the floor, being tied in when adjacent to the floor groove to the transverse floor frame element rods. At the top of each wall frame element assembly is a channel (e.g. **325**) which is attached to the vertical rods (e.g. **310**) and tied in with the transverse ceiling framing element rods (e.g. **349**) and has similar horizontal rods **339** attached to it.

After The rods and channel members have been assembled so as to form the enclosure with the appropriate openings, mesh layers are then applied around the spaced rods of the various framing elements and also to form the apertured core portion of the walls, ceiling and floor.

Thus, horizontal rods **311** are covered in sequence with coarse (e.g. 2 inch) wire mesh layer **314** and then by successive fine wire mesh layers **315** and **316**. Vertical rods **310** are likewise covered in sequence with a coarse wire mesh layer **335** and then with successive fine wire mesh layers **336** and **337**. Top horizontal rods **339** are similarly wrapped in mesh layers **340** and **341** and ceiling frame element rods **349** are likewise wrapped in successive mesh layers **350, 351** and **352**.

The wall core is formed by connecting a central wire mesh **323***a* covered on each side by a fine wire mesh **340** and **341**. Similarly the ceiling core is formed from central coarse mesh **318***a* and fine mesh layers **330** and **331**. As indicated previously, the floor core is formed from mesh layers **305, 306** and **307**. It is generally preferred that the outer mesh layers (e.g. **340**) be so arranged that they are close to the surface after cementing (See FIG. **16**).

In one method of assembly, the entire rod, channel and wire skeleton is assembled and tied together, and appropriate forms then applied to permit embedding of the wire-wrapped rods and channel in cementitious material to form the framing elements. Cementitious material is also applied to embed the core portions of the walls, ceiling and floor also with the aid of appropriate forms to form the integral cover member.

The assembly of the skeleton frame can also be done in sections, as for example, welding the vertical rods to the upper and lower channels for each wall separately. As is readily apparent, the door and window areas can be cut out and formed either during or after the time when the walls, ceiling and floor cores are being connected.

After the concrete has been placed on all the desired sections, it is preferably vibrated to ensure penetration. After the concrete has set, the forms are removed with

the floor being poured last. To assist in curing, the entire building can be enclosed by a flexible material, as for example, a plastic tent, and steam applied.

In one modification of the method of assembly, the framing elements are assembled but cementitious material is poured and cured on the floor portion first. This permits support of forms on the floor to complete the pouring of cementitious material, particularly for the ceiling.

The unit is then finished by inserting desired interior partitions, electrical wiring and fixtures, plumbing and fixtures, outside panels for insulation and weather between the vertical framing elements, a functional or decorative roof, windows, doors, etc.

The modular building unit thus comprises a floor **317**, a ceiling **318**, spaced floor frame elements **319**, spaced ceiling frame element **320**, horizontal lower wall frame elements **321**, vertical wall frame elements **322**, vertical wall portion of covering member **323** and upper horizontal wall frame elements **324**.

In certain situations, as for example, in erecting multiple-dwelling buildings, the modular building unit can comprise framing elements and cover portions for the floor, two opposite walls, and the ceiling, the end walls being open.

What is claimed is:

1. A cementitious building unit having at least a floor, two opposing walls and a ceiling, a continuous interior surface and a ribbed exterior, comprising:

a. framing elements for the floor, ceiling and exterior walls, said framing elements consisting of upper peripheral horizontal framing elements, lower peripheral horizontal framing elements, vertical framing elements extending between said upper and lower elements and intermediate horizontal framing elements extending between said peripheral horizontal elements:

b. at least one layer of wire mesh attached to said framing elements and extending over the interior surfaces of said framing elements so as to form the core for the floor, ceiling and exterior walls; provision being made in said framing elements and wire mesh layers for open portions, such as windows, doors, chimneys, conduit spaces and the like; and

c. a mass of cementitious material interspersed in and surrounding said wire mesh layers so as to form the floor, ceiling and exterior walls as a continuous interior surface, with the forming elements forming exterior ribs; the portions of said floor, ceiling and walls which extend between said framing elements being thin.

2. The building unit of claim **1** wherein the portions of said floor, ceiling and walls which extend between said framing elements have their outer wire mesh layers close to the surface after cementing.

3. The building unit of claim **1** wherein the thickness of the portions of said floor, ceiling and walls which extend between said framing elements is approximately ½ to 1½ inches.

4. The building unit of claim **1** wherein spaced rods are used in conjunction with said wire mesh and are embedded in said cementitious material.

5. The building unit of claim **1** wherein a said framing element is a metallic member.

6. The building unit of claim **1** wherein a said framing element comprises metallic elements embedded in cementitious material.

7. The building unit of claim **1** where said cementitious material consists essentially of Portland cement and sand.

8. The building unit of claim **1** wherein a said framing element comprises spaced rods wrapped with wire mesh and embedded in cementitious material.

9. The building unit of claim **8** made by first assembling and tying together all rods and wire mesh to form a skeleton and then embedding the skeleton in cementitious material consisting essentially of Portland cement and sand.

10. The building unit of claim **1** wherein there are exterior finishing elements fitted in between adjacent framing elements so as to cover selected portions of the exterior surface of the cementitious wire mesh layer.

11. The building unit of claim **10** wherein said finishing elements include sheets of insulating material fitted in between adjacent framing elements.

12. The building unit of claim **1** positioned on another building unit made in accordance with claim **1**.

13. The building unit of claim **1** wherein there are a floor, ceiling and two opposite walls, with the end walls being open.

14. The building unit of claim **1** wherein said cementitious material consists essentially of Portland cement and sand, the thickness of the portions of said floor, ceiling and walls which extend between said framing elements is approximately ½ to 1½ inches, and a said framing element comprises metallic elements embedded in cementitious material.

15. A cementitious building unit having at least a floor, two opposing walls and a ceiling, a continuous interior surface and a ribbed exterior, comprising:

a. framing elements for the floor, ceiling and exterior walls, said framing elements including peripheral horizontal framing elements each of which contains a channel member anchored to rods wrapped with wire mesh and embedded in cementitious material;

b. at least one layer of wire mesh attached to said framing elements and extending over the interior surfaces of said framing elements so as to form the core for the floor, ceiling and exterior walls; provision being made in said framing elements and wire mesh layers for open portions, such as windows, doors, chimneys, conduit spaces and the like; and

c. a mass of cementitious material interspersed in the surrounding said wire mesh layers so as to form the floor, ceiling and exterior walls as a continuous interior surface, with the framing elements forming exterior ribs; the portions of said floor, ceiling and walls which extend between said framing elements being thin.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,874,134

DATED : April 1, 1975

INVENTOR(S) : Albert Feldman and Robert Feldman

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the title page [63] change "53,675" to "33,675".

Signed and Sealed this

twenty-fifth Day of *November 1975*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks