# United States Patent [19]

**Weismann**

[11] **3,879,908**

[45] **Apr. 29, 1975**

[54] **MODULAR BUILDING PANEL**

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[21] Appl. No.: **365,538**

**Related U.S. Application Data**

[63] Continuation of Ser. No. 202,879, Nov. 29, 1971, abandoned.

[52] **U.S. Cl.** ..................... **52/309;** 52/410; 52/577; 52/600

[51] **Int. Cl.** ............................................ **E04c 2/26**

[58] **Field of Search** ............ 52/650, 309, 409, 410, 52/382, 576, 577, 582, 405

[56] **References Cited**

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[57] **ABSTRACT**

An improved prefabricated modular building panel includes a three-dimensional lattice fabricated of a plurality of rod-like slender elongated metal elements. The lattice elements are arranged to define a pair of substantially parallel spaced major lattice surfaces, and side and end lattice edge surfaces. A plurality of strut members traverse the interior of the lattice and interconnect the major surfaces to define a plurality of passages within the lattice. The passages are open at at least one end thereof to one of the lattice edge surfaces. Thermal insulating filler material is disposed within the lattice and extends from side to side and from end to end of the lattice. The filler material includes a plurality of insulative elements positioned in the passages through the passage open ends to be disposed wholly within the lattice. A bonding agent is used to secure the insulative elements in position within the lattice, and the bonding preferably is a layer of foam material applied over the insulative elements within the lattice to foam at least partially in situ and to bond to the insulative elements and to the metal elements of the lattice, particularly the lattice strut members.

**6 Claims, 6 Drawing Figures**

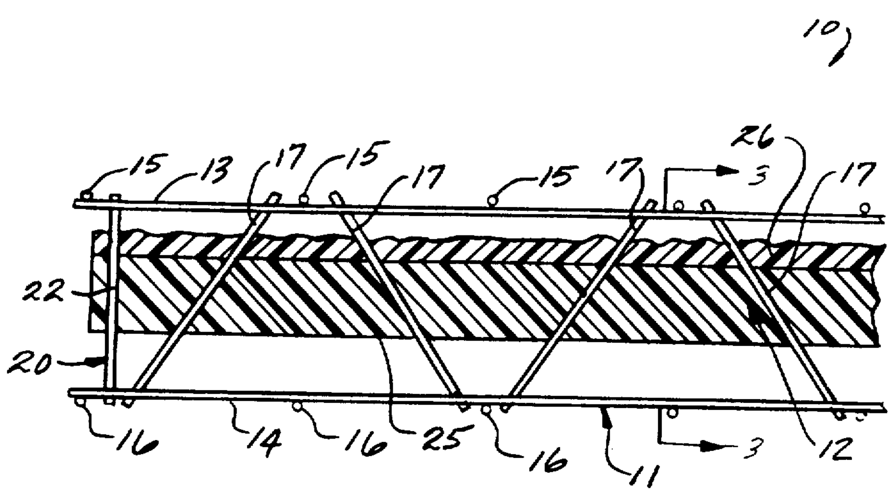


FIG. 1

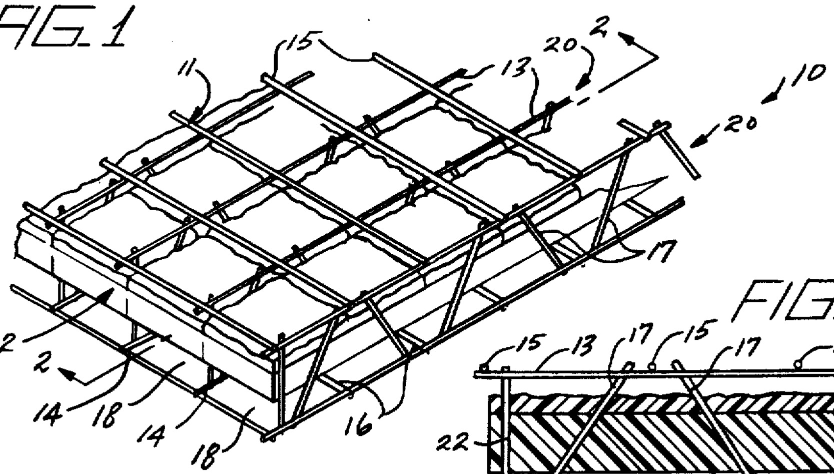



FIG. 2

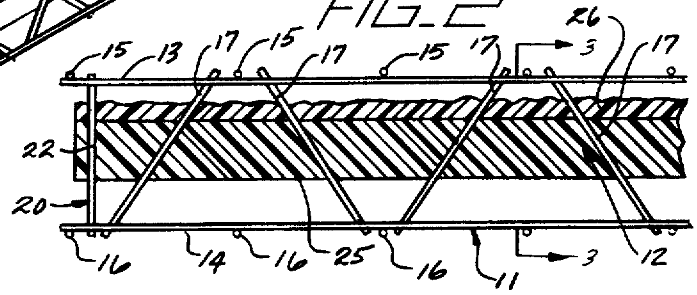



FIG. 3

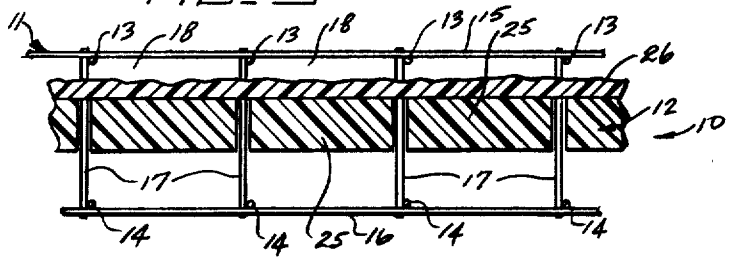



FIG. 4

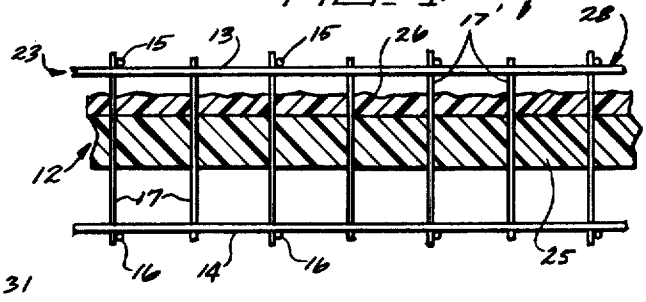



FIG. 6

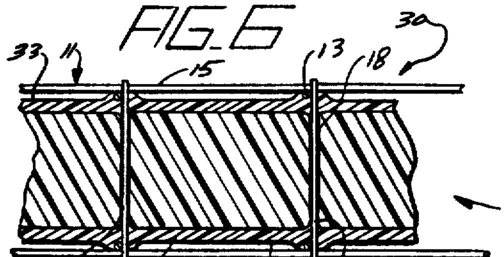
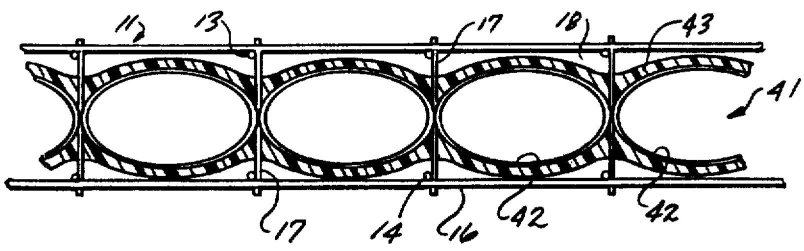



FIG. 5



## MODULAR BUILDING PANEL

This is a continuation of application Ser. No. 202,879, filed Nov. 29, 1971, now abandoned.

### FIELD OF THE INVENTION

The invention pertains to improvements in modular building panels. More particularly, it pertains to building panels having a three-dimensional wire lattice within which is disposed a composite insulative core comprised of insulative elements inserted into the interior of the lattice and a bonding agent securing the inserted elements in fixed position within the lattice.

### BACKGROUND OF THE INVENTION

#### Review of the Prior Art

My prior U.S. Pat. Nos. 3,305,991 and 3,555,131 describe a reinforced modular foam building panel and methods for fabricating such a panel, respectively. The panel is a composite of a welded three-dimensional wire lattice and of an insulative core defined by a quantity of cellular foamed material foamed and hard-set in the lattice to bond to the strut members which traverse the interior of the lattice. The strut members interconnect and reinforce the wire elements defining the two spaced major surfaces of the lattice. Panels in accord with the disclosures of these patents have been approved for use by the International Conference of Building Officials, Pasadena, Calif. Report No. 2440, as structural or non-structural roof and wall panels for commercial and residential construction. These panels are characterized by their light weight, good thermal, moisture and acoustic insulative properties, their adaptability to efficient erection procedures, their compatibility with conventional construction techniques, and their strength. The strength of these prior panels is obtained in part from the intimate bonding relation between the foamed-in-situ core of the panels to the strut members of the wire lattice.

For many applications, however, it has been found that panels fabricated according to U.S. Pat. No. 3,305,991, for example, so far exceed the requirements of the application that they may not be a practical alternative to other more conventional construction materials. For example, in warm or tropical areas where a structure need not be designed to withstand snow loads or the like, these prior panels are stronger and more insulative than is necessary. Also, in some instances, notably in the case of foreign markets and special usages, suitable insulation materials and elements may exist which are equally well or better suited to the particular application than the foam materials contemplated by my prior patents and which may be more attractive economically. In view of these factors, a need exists for modular building panels which have the general advantages of my prior panels, such advantages deriving in large part from the wire lattice, but which incorporate insulative cores different from those encountered in panels fabricated pursuant to my prior patents. Satisfaction of this need will enhance the utility and usage of my prior panels and will make possible the use of improved construction techniques in many geographic and functional areas where the prior panels cannot or are not being used to best advantage.

### SUMMARY OF THE INVENTION

This invention fills the need described above by pro-



viding improvements in reinforced welded-wire lattice modular building panels. The present panels possess all of the advantages found in my prior panels due to the presence of the lattice therein. The present panels, however, incorporate insulative core elements and materials which may differ from those of my prior panels to adapt the present panels to particular applications or to take advantage of particular economic and supply situations. The present panels are light, strong, simple to use in construction, efficient and economical.

Generally speaking, this invention provides a prefabricated modular building panel which includes, as a principal component, a three-dimensional lattice fabricated of a plurality of slender elongated metal elements. These elements are arranged to define a pair of substantially parallel spaced major lattice surfaces, and side and end lattice edge surfaces. The metal elements include a plurality of strut members which traverse the interior of the lattice and interconnect the lattice major surfaces. The strut members and the other elements of the lattice are arranged to define a plurality of passages within the lattice which open at at least one end thereof to the lattice edge surfaces. Thermal insulation filler material is disposed within the lattice and extends substantially from side to side and from end to end of the lattice. The filler material includes a plurality of insulative elements which are positioned in the lattice passages through the open ends of the passages to be disposed wholly within the lattice. A bonding agent interconnects the insulative elements to the adjacent lattice elements, notably the strut members, to secure the insulative elements in position in the lattice.

### DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features of this invention are more fully set forth in the following description of certain presently preferred embodiments of the invention, which description is presented with reference to the accompanying drawings, wherein:

FIG. **1** is a perspective view of a portion of a panel according to this invention;

FIG. **2** is a cross-section view taken along line **2—2** in FIG. **1**;

FIG. **3** is a cross-section view taken along line **3—3** in FIG. **2**;

FIG. **4** is a view similar to that of FIG. **2** but of another panel;

FIG. **5** is a transverse cross-section view of another panel; and

FIG. **6** is a transverse cross-section view of another panel.

### DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

As shown in FIG. **1**, the principal components of a building panel **10** are a lattice **11** and a core **12** of insulative filler material disposed within the lattice. The lattice is defined by a plurality of elongate, slender rod-like metal elements. Conveniently, the lattice may be made of elements defined by wire having a size of from 8 to 16 gage, inclusive, and preferably the elements of the lattice are defined by 14 gage wire. Preferably, the same size wire is used throughout lattice **11**, but it is within the scope of this invention that the wires used to define one group of elements of the lattice may be of a different size, within the preferred range mentioned above, from the elements defining the remainder or different groups of elements within the lattice.

The lattice includes a plurality of spaced parallel upper longitudinal elements **13** which are conveniently referred to as upper truss runners. A corresponding plurality of spaced parallel lower longitudinal elements **14** define lower truss runners. The upper truss runners **13** are interconnected by a plurality of spaced parallel transverse members **15**, and the lower truss runners **14** are interconnected by a corresponding plurality of transverse members **16**. The upper truss runners and their corresponding transverse members define an upper major surface of panel **10**. Similarly, the lower truss runners and their transverse members define a lower major surface of the lattice. These major surfaces are spaced apart in substantially parallel relationship to each other by a plurality of strut members **17** which traverse the interior of the lattice and interconnect the lattice major surfaces.

As shown most clearly in FIG. **1**, it is preferred that the upper and lower truss runners be disposed in pairs in which one upper truss runner **13** and one lower truss runner **14** are disposed in parallel spaced alignment with each other. Strut members **17** preferably are interconnected between the upper and lower truss runners in each aligned pair thereof rather than being interconnected between transverse members **15** and **16**. Accordingly, a plurality of parallel passages **18** are defined within the interior of lattice **11** between the lattice major surfaces and between adjacent pairs of truss runners as interconnected by the strut members. Each passage **18** is open at at least one end to one of the lattice edge surfaces. Preferably the passages extend along the length of the lattice and open at their opposite ends to the end surfaces of the lattice.

In a presently preferred lattice, truss elements **13, 14, 15** and **16** are spaced apart from each other on 2 inch centers within their respective groups. Also, it is preferred that the aligned upper and lower truss runners be spaced apart on 2 inch centers. Accordingly, lattice **11** is organized on a 2 inch cubicle module and conveniently is fabricated in 4 foot widths and in lengths of from 8 to 14 feet, the length varying within this range in 2 inch increments. It will be appreciated, however, that different spacing of the elements of lattice **11** may be used as desired and that the lattice may be fabricated with different nominal width or length, all without departing from the scope of this invention.

Each upper truss runner **13**, its corresponding lower truss runner **14**, and the strut members **17** which interconnect them define a truss section **20** within lattice **11**. Because of the above-mentioned 2 inch spacing between adjacent ones of truss runners **13** and **14**, respectively, it is apparent that the truss sections are spaced apart from each other in parallel relationship on 2 inch centers across the width of lattice **11**. Each passage **18** longitudinally through lattice **11** is defined between an adjacent pair of truss sections **20**.

FIGS. **2** and **4** illustrate, respectively, two different styles of truss sections which may be used to advantage in the lattice for a panel according to this invention. Truss section **20**, shown in FIG. **2**, is characterized in that strut members **17**, located within the ends of the truss section, are disposed in alternate converging and diverging relationship to each other along the length of the truss section. That is, one strut member may slope at about a 45° angle from left to right proceeding upwardly from lower truss runner **14** to upper truss runner **13**, and the next strut member to the right may slope from left to right proceeding downwardly from upper truss runner **13** to lower truss runner **14**, and so on throughout the length of the truss section. At each end of truss section, however, an end strut member **22** is provided and is disposed perpendicular to the adjacent truss runners. In lattice **11**, or in any other lattice according to this invention, it is preferred that the various elements defining the lattice be interconnected via resistance welding, although other interconnection techniques may be used if desired. Where the truss sections in the lattice have the configuration shown in FIG. **2**, in which strut members **17** are alternately inclined to each other, it is preferred that the converging ends of strut members **17** be interconnected to the truss runners on opposite sides of and spaced from alternate ones of the transverse members associated with that truss runner. That is, if an adjacent pair of strut members **17** converge toward each other at the upper truss runner **13**, then the upper ends of these strut members are interconnected to the upper truss member in somewhat spaced relationship from and on opposite sides of one of upper transverse members **15**; it is preferred that a lower transverse member **16** be disposed directly below this upper transverse member. Proceeding along the length of the truss section, however, the next upper transverse member **15** lies between the diverging ends of a pair of strut members which have their lower ends interconnected to lower truss runner **14** close to and on opposite sides of the next lower transverse member **16**.

FIG. **4** illustrates another truss section **23** for use in a lattice for a panel according to this invention. As to truss section **23**, however, the strut members are identifed as **17'** to distinguish them from the alternately converging and diverging strut members of truss section **20**. Strut members **17'** are all disposed parallel to each other perpendicular to upper and lower truss runners **13** and **14** in each truss section **23**. It is preferred that, if lattice elements **13, 14, 15** and **16**, respectively, are spaced apart upon 2 inch centers within their corresponding groups, then strut members **17'** are spaced apart on 1 inch centers along the length of each truss section **23**. As a practical matter, the configuration of truss section **20** is preferred over the configuration of truss section **23** since truss section **20** requires the use of a smaller amount of lattice wire stock than does truss section **23** to define a lattice of comparable strength. That is, to define lattices of equivalent structural properties, about 40 percent more lattice wire stock must be used to define strut members **17'** of truss section **23** than is required to define strut members **17** of lattice section **20**.

Regardless of whether truss sections **20, 23,** or some other truss section configuration is used in the definition of a lattice for a panel according to this invention, it is preferred that the truss sections be defined as subassemblies of the lattice, which subassemblies are then interconnected by transverse members **15** and **16**, for example, to define the completed lattice.

In the manufacture of panel **10**, for example, it is preferred that insulative core **12** be installed within the lattice after the lattice has been fabricated. The core of a panel according to this invention is composed of a plurality of discrete insulative elements which are inserted into the lattice one to each passage **18** through the open ends of the passages. A suitable bonding agent is then applied to the inserted insulative elements to connect the inserted insulative elements to the lattice structure, thereby to secure the insulative elements in the desired relationship to one another within the lattice.

In panel **10**, core **12** is defined by a plurality of strips of polystyrene foam **25**, which are shown best in FIG. **3**. Polystyrene is prefoamed to define strips of the appropriate length, width and thickness, or the strips **25** are cut from a board of polystyrene foam to the desired size prior to insertion of the strips into passages **18** of lattice **11**. In panel **10**, each strip **25** has a width which approximates the spacing between the adjacent surfaces of the strut members of the truss sections which bound opposite sides of passages **18**. Strips **25** have a thickness which is substantially less than the spacing between the upper and lower major faces of lattice **11**. For example, strips **25** may have a width just slightly less than 2 inches so that they may be inserted into passages **18**, and have a thickness on the order of about three-fourths inch. In panel **10**, the strips are inserted into passages **18** to be disposed within the passages parallel to and substantially midway between the major faces of the lattice. The inserted polystyrene foam strips are maintained in this position while a suitable bonding agent **26** is disposed, preferably by spraying, over at least one side of the array of strips **25**. The bonding agent hardens to secure the strips in their predetermined positions within lattice **11**. In panel **10**, the bonding agent preferably is a polyurethane foam which is deposited over the upper surfaces of the array of inserted strips **25** to foam in situ and to cure to a hardened state, thereby to bond the inserted insulative elements to the adjacent portions of lattice **11**. It is preferred that foam layer **26** be formed to a thickness which is less than the spacing between the substantially coplanar upper surfaces of insulative elements **25** and the upper major surface of lattice **11**.

FIG. **4** illustrates that the precise nature of the insulative core for a panel according to this invention is not dependent upon the use of a particular type of truss section in the lattice of the panel. Accordingly, FIG. **4** illustrates a panel **27** in which the lattice **28** thereof includes truss sections **23**, but in which core **12** is identical to the core of panel **10**, illustrated in FIGS. **1, 2** and **3**.

FIG. **6** is a fragmentary transverse cross-sectional elevation view of another panel **30** according to this invention. Panel **30** includes a lattice **11**, which may include truss sections **20** or **23**, as desired. Panel **30** has an insulative core **31** which is defined by elongate pieces of rigid foam material **32**, one of which is inserted into each passage **18** provided within the lattice. Each inserted insulative element **32** for panel **30** has a cross-sectional configuration which corresponds closely to the cross-sectional configuration of each passage **18** so as to substantially fill passage **18**. In the case of panel **30**, a layer **33** of bonding agent is deposited over the surfaces of elements **32** which are exposed to the opposite major faces of the lattice. Bonding agent **33** may be provided in the form of liquid latex or latex-base material applied to the inserted insulative elements to cure and thereby produce the desired bond of the insulative elements to the lattice elements, notably the strut members of the lattice. Preferably, the core, comprised of the inserted insulative elements and the bonding agent, is disposed essentially wholly within the lattice of the completed panel and does not significantly embed the lattice elements defining the major and edge surfaces of the lattice.

Another panel **40** according to this invention is shown in FIG. **5** and includes a lattice **11**. Panel **40** has an insulative core **41** which is composed of a plurality of hollow paper tubes **42**, preferably treated on their interior surfaces to be water impermeable, and a quantity of polyurethane foam **43**, for example, disposed over those exterior surfaces of tubes **42** which lie adjacent the major surfaces of the lattice. Preferably tubes **42** are of an elliptical shape and are configured so that in the normal state of the tubes the major diameter of the ellipse is slightly greater than the width of lattice passages **18**, and in which the minor diameter of the ellipse is less than the distance between the spaced major surfaces of the lattice. Tubes **42** may be held in position in their respective lattice passages following insertion of the tubes into the lattice by interferring mechanical engagement between the tubes and the strut members of the lattice prior to application of the liquid polyurethane foam material. The foam material is deposited over the exterior surfaces of the tubes in such a condition that the foam material foams in situ within the lattice and cures to a hardened or semi-hardened state to embed the strut members and secure tubes **42** in position within the lattice.

The accompanying drawings illustrate that the cores for the panels of this invention may be disposed wholly within the confines of the lattice of the corresponding panel; this disposition of the insulative core wholly within the panel lattice is the preferred relationship of the core to the lattice. It is within the scope of this invention, however, that the insulative core may, if desired, extend outside the lattice and embed the lattice elements defining one or both of the lattice major surfaces, but preferably not any of the lattice edge surfaces. The manufacture of a panel in which one or both of the lattice major surfaces is embedded by the insulative core of the panel is particularly possible where the bonding agent is a foam material which is susceptible of being foamed and hardened in situ, i.e., within the panel lattice rather than in a separate foaming chamber. For example, the manufacture of a polystyrene foam requires that the constituents of the foam material be foamed in a closed mold. Polyurethane foam, on the other hand, may be foamed and set in an open mold at ambient temperature and pressure conditions. Accordingly, where a foam material is used as the bonding agent to secure the inserted insulative elements of the core in position within the panel lattice, the foam bonding agent must be of the type which may be foamed in an open container.

In the preceding description, reference has been made to specific materials for use as inserted insulative elements of the panel core and also to specific materials which may be used as the bonding agent in the core. As is apparent from the foregoing description, the bonding agent itself may contribute to the insulative properties of the core, as in the case where the bonding agent is foamed in situ urethane foam, for example. Other foams which can be used either solely or in combination with other foam materials to define the inserted insulative elements of the core are phenolic foam, expanded vinyl foam, cross-linked polyvinyl chloride foam, low density polyethylene foam, cross-linked polyethylene foam, and ureaformaldehyde foam. All of these foams are of the type which require formation in a closed, or at least partially closed mold, and therefore may be used to advantage in a panel according to this invention only to define the inserted insulative elements. Materials other than foams, such as balsa wood, may be used to define the inserted insulative elements of the panel. Other bonding agents which may be used to advantage in the fabrication of a panel according to this invention include foamed plaster, asphalt or asphalt-based materials, or suitable adhesives such as epoxy system adhesives.

Urethane foams are preferred as the bonding agent to secure the inserted insulative elements within the lattice of a panel fabricated according to this invention. Also, rigid urethane foams may be used to define the inserted insulative elements. Urethane foams possess several important properties, notably good insulating efficiency, light weight, strength, and adhesion in the in situ situation. When a urethane foam is used as the bonding agent, it is particularly desirable because it structurally bonds itself securely to the inserted insulative elements and to the adjacent members of the panel lattice. Polystyrene foams, on the other hand, cannot be used to advantage as a bonding agent in a panel according to this invention since polystyrene foams cannot be foamed in an open container. Polystyrene foams are somewhat less expensive than urethane foams and have thermal and acoustical insulating properties which closely approach those of polyurethane foam.

If desired, a panel according to this invention may be formed with an opening to conveniently receive a window or door assembly.

In erecting a structure, such as a dwelling, from panels provided by this invention, extremely simple techniques may be used. The panels are first aligned with each other with the edges abutting. Since the lattice members of the panels are exposed at the edges of the panels, or are just barely covered by the bonding agent used in the fabrication of the panel, adjacent panels may be wired or welded together by very simple and economical techniques. In such a manner, the entire external and internal wall system of a building, as well as the roof of the building, may be erected by one or two men in an extremely short time.

The panels of this invention are characterized by their light weight. Preferably the panels weigh no more than about 2 pounds per cubic foot of panel. The exact weight per unit volume of the panel would be dependent upon the gage of wire used in the fabrication of the panel and the precise nature of the materials used to define the panel core.

While this invention has been described above in conjunction with specific panels and materials constituting the same, it is to be understood that this has been by way of describing certain presently preferred embodiments of the invention and is not intended as a limitation of the scope of this invention.

What is claimed is:

**1.** A prefabricated modular building panel as an article of manufacture comprising a three-dimensional lattice fabricated of a plurality of slender elongated metal elements arranged to define a pair of substantially parallel spaced major lattice surfaces, side and end lattice edge surfaces, and a plurality of strut members traversing the interior of the lattice and interconnecting the major surfaces thereof to define a plurality of passages within the lattice open at at least one end thereof to one of the edge surfaces, and thermal insulating filler material disposed within the lattice to extend from side to side and from end to end of the lattice, the filler material being held in position within the lattice by the elements defining the lattice, the filler material being comprised of a plurality of insulative elements positioned in the passages through the open ends of the passages to be disposed wholly within the lattice and sized relative to the passages to make substantial positioning contact with the lattice elements defining the respective passages whereby the insulative elements are held in predetermined positions within the lattice by the lattice itself, and a bonding agent disposed between the insulative elements and the adjacent lattice elements for immovably fixing the insulative elements in said predetermined positions within the lattice, wherein the bonding agent is comprised of a layer of cellular foamed material foamed at least in part and at least partially hard set within the lattice.

**2.** A panel according to claim **1** wherein the bonding agent comprises polyurethane foam material.

**3.** A prefabricated modular building panel as an article of manufacture comprising a three-dimensional lattice fabricated of a plurality of slender elongated metal elements arranged to define a pair of substantially parallel spaced major lattice surfaces, side and end lattice edge surfaces, and a plurality of strut members traversing the interior of the lattice and interconnecting the major surfaces thereof to define a plurality of passages within the lattice open at at least one end thereof to one of the edge surfaces, and thermal insulating filler material disposed within the lattice to extend from side to side and from end to end of the lattice, the filler material being held in position within the lattice by the elements defining the lattice, the filler material being comprised of a plurality of insulative elements defined by a rigid cellular foam material positioned in the passages through the open ends of the passages to be disposed wholly within the lattice, and a bonding agent disposed between the insulative elements and the adjacent lattice elements for fixing the insulative elements in position within the lattice.

**4.** A panel according to claim **3** wherein the foam material is a synthetic non-cementitious foam material.

**5.** A panel according to claim **4** wherein the foam material is polystyrene foam.

**6.** A prefabricated modular building panel as an article of manufacture comprising a three-dimensional lattice fabricated of a plurality of slender elongated metal elements arranged to define a pair of substantially parallel spaced major lattice surfaces, side and end lattice edge surfaces, and a plurality of strut members traversing the interior of the lattice and interconnecting the major surfaces thereof to define a plurality of passages within the lattice open at at least one end thereof to one of the edge surfaces, and thermal insulating filler material disposed within the lattice to extend from side to side and from end to end of the lattice, the filler material being held in position within the lattice by the elements defining the lattice, the filler material being comprised of a plurality of insulative elements positioned in the passages through the open ends of the passages to be disposed wholly within the lattice and sized relative to the passages to make substantial positioning contact with the lattice elements defining the respective passages whereby the insulative elements are held in predetermined positions within the lattice by the lattice itself, and a bonding agent disposed between the insulative elements and the adjacent lattice elements for immovably fixing the insulative elements in said predetermined positions within the lattice, the bonding agent being comprised of a latex base material.

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