

PATENT SPECIFICATION

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(54) BUILDING PANEL

(71) I, VICTOR PAUL WEISMANN, a citizen of the United States of America, of 430 Prospect Circle, South Pasadena, California, United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention pertains to improvements in building panels. My prior United States Patents 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 material foamed and hard-set in the lattice to bond to 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, California, Report No. 2440, as structural or non-structural roof and wall panels for commercial and residential construction. These panels are characterised 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 Patent 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.

The present invention provides a prefabricated building panel comprising a three-dimensional lattice fabricated of a plurality of elongated metal elements arranged to define a pair of substantially parallel spaced major lattice 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 an edge surface of the lattice; thermal insulation being disposed within the lattice, and the insulation comprising elongated insulative elements positioned in respective ones of said passage wholly within the lattice and sized relative to the passages to make contact with portions of the lattice defining the respective passages whereby the insulative elements are located in predetermined positions within the lattice by the lattice itself; and a bonding agent being disposed between the insulative elements and the adjacent portions of the lattice for retaining the insulative elements in the said predetermined positions.

The embodiments of the present invention hereafter described by way of example possess all of the advantages found in my prior panels due to the presence of the lattice

therein. The panels according to the present invention, however, incorporate insulative core elements and materials which may differ from those of my prior panels to adopt the present panels to particular applications or to take advantage of particular economic and supply situations. The panels according to the present invention are light, strong, simple to use in construction, efficient and economical.

Specific embodiments of the present invention will now be described by way of example 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, according to the present invention;

Fig. 5 is a transverse cross-section view of another panel, according to the present invention; and

Fig. 6 is a transverse cross-section view of another panel, according to the present invention.

Referring to the accompanying drawings, 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 American Wire Gauge (AWG), inclusive, and preferably the elements of the lattice are defined by 14 AWG wire. Preferably, the same size wire is used throughout lattice 11, but 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 elements 15, and the lower truss runners 14 are interconnected by a corresponding plurality of transverse elements 16. The upper truss runners and their corresponding transverse elements define an upper major surface of the lattice. Similarly, the lower truss runners and their transverse elements define a lower major surface of the lattice. These major surfaces are spaced apart in substan-

tially 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 vertically one above the other 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 elements 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, the 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 runners be spaced apart on 2 inch centers. Accordingly, lattice 11 is organized on a 2 inch cubic 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.

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. 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 45 degree 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 incorporated in a panel being described, 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 element 15; it is preferred that a lower transverse element 16 be disposed directly below this upper transverse member. Proceeding along the length of the truss section, however, the next upper transverse element 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 element 16.

Fig. 4 illustrates another truss section 23. As to truss section 23, however, the strut members are identified 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 the 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% 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, it is preferred that the truss sections be defined as subassemblies of the lattice, which subassemblies are then interconnected by transverse elements 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 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 poly-styrene 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 to the spacing between the adjacent surfaces of the strut member of the truss sections which bound opposite sides of passage 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 pushed into passages 18, and yet retained therein by contact with adjacent portions of the lattice, and have a thickness on the order of about $\frac{1}{4}$ 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 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. 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 both the upper and lower 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 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 interfering 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 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. The insulative core may, if desired, extend also 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 mould. Polyurethane foam, on the other hand, may be foamed and set in an open mould 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 formed *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 mould, 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 as described are characterized by their light weight. Preferably the panels weight no more than about two pounds per cubic foot of panel. The exact weight per unit volume of the panel would be dependent upon the gauge of wire used in the fabrication of the panel and the precise nature of the materials used to define the panel core.

WHAT WE CLAIM IS:—

1. A prefabricated building panel comprising a three-dimensional lattice fabricated of a plurality of elongated metal elements arranged to define a pair of substantially parallel spaced major lattice 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 an edge surface of the lattice; thermal insulation being disposed within the lattice, and the insulation comprising elongated insulative elements positioned in respective ones of said passages wholly within the lattice and sized relative to the passages to make contact with portions of the lattice defining the respective passages whereby the insulative elements are located in predetermined positions within the lattice by the lattice itself; and a bonding agent being disposed between the insulative elements and the adjacent portions of the lattice for retaining the insulative elements in the said predetermined positions.

2. A panel as set forth in claim 1 wherein the bonding agent itself has insulative properties.

3. A panel as set forth in claim 1 or 2 wherein the insulative elements include hollow paper tubes.

4. A panel as set forth in any one of the preceding claims wherein the bonding agent comprises a layer of cellular foam material foamed at least in part within the lattice.

5. A panel as set forth in any one of claims 1 to 3 wherein the insulative elements are defined by a rigid cellular foam material.

6. A panel as set forth in claim 5 wherein the rigid cellular foam material is polystyrene foam.

7. A panel as set forth in any one of the preceding claims wherein the insulative elements and the bonding agent are disposed within the lattice in spaced relation to at least one of two opposite major surfaces of the lattice.

8. A panel as set forth in any one of the preceding claims wherein the bonding agent is comprised of a latex-base material.

9. A prefabricated modular building panel substantially as any one of the embodiments hereinbefore described with reference to, or with reference to and as shown in, the accompanying drawings.

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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.

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1. A prefabricated building panel comprising a three-dimensional lattice fabricated of a plurality of elongated metal elements arranged to define a pair of substantially parallel spaced major lattice 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 an edge surface of the lattice; thermal insulation being disposed within the lattice, and the insulation comprising elongated insulative elements positioned in respective ones of said passages wholly within the lattice and sized relative to the passages to make contact with portions of the lattice defining the respective passages whereby the insulative elements are located in predetermined positions within the lattice by the lattice itself; and a bonding agent being disposed between the insulative elements and the adjacent portions of the lattice for retaining the insulative elements in the said predetermined positions.

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