July 3, 1973 H. E. DE WOLF 3,743,568

CORRUGATED PANEL STRUCTURE HAVING VERTICALLY ORIENTED COLUMNAR SHAPES

Filed March 31, 1971 2 Sheets-Sheet 1

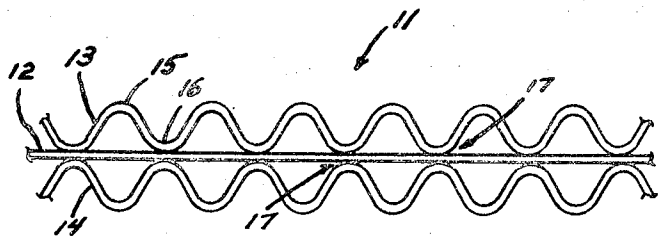

FIG. 1

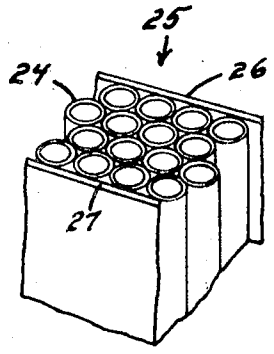

FIG. 9

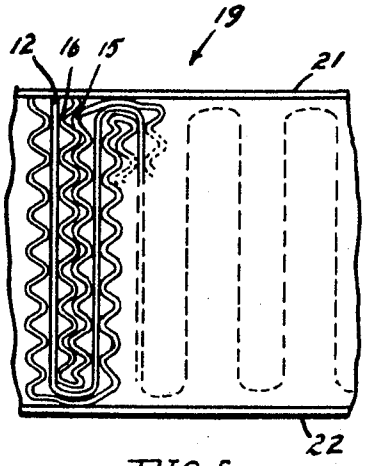

FIG. 5

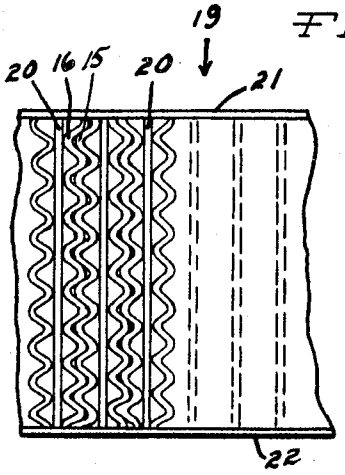

FIG. 6

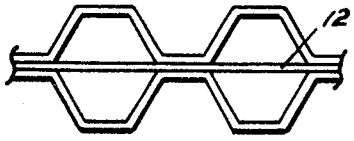

FIG. 2

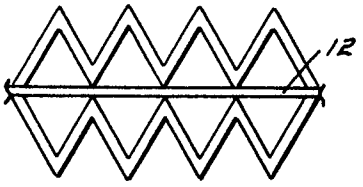

FIG. 3

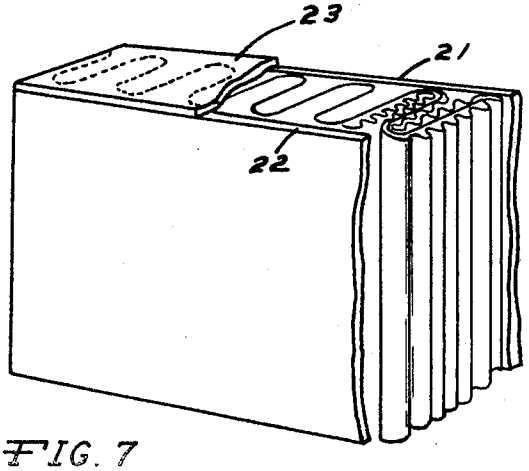

FIG. 7

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CORRUGATED PANEL STRUCTURE HAVING VERTICALLY ORIENTED COLUMNAR SHAPES

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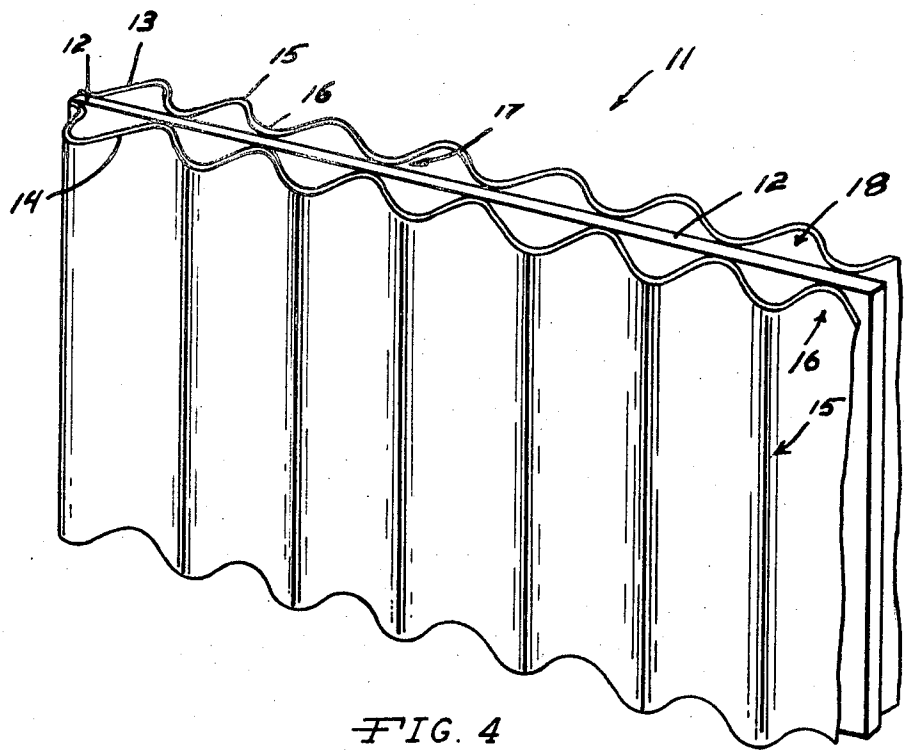

FIG. 4

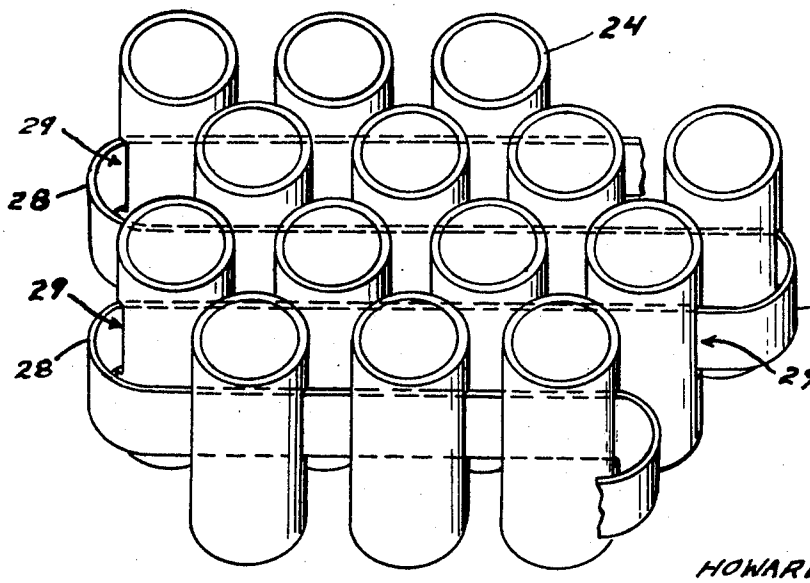

FIG. 8

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United States Patent Office 3,743,568 Patented July 3, 1973

3,743,568

CORRUGATED PANEL STRUCTURE HAVING VERTICALLY ORIENTED COLUMNAR SHAPES

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Filed Mar. 31, 1971, Ser. No. 129,865
Int. Cl. B32b 3/12, 3/20
U.S. Cl. 161—68 6 Claims

ABSTRACT OF THE DISCLOSURE

A panel structure fabricated from a continuous structural sheet member consisting of a single flat sheet having a corrugated sheet affixed to each side thereof. The structural member is folded in an accordion-like pleated manner so that the corrugated portions of each pleat matingly and nestably interlock with the corrugated portions of the next adjacent pleat so as to form a panel structure having a plurality of vertically oriented columnar shapes provided therethrough.

SUMMARY OF THE INVENTION

This invention relates to a panel structure which is fabricated from inexpensive re-cycled waste paper products. This invention also constitutes an environmental improvement in that such waste products are productively utilized instead of polluting the environment. The panel structure is formed by use of a structural member consisting of a continuous flat sheet having a corrugated sheet affixed to each side thereof. The structural member is folded in an accordion-like pleated manner to form the panel structure. The structural member is folded in such a manner that the corrugated portions of the next adjacent pleats matingly and nestably interlock with each other so as to form a plurality of vertically oriented columns therethrough which impart a high strength-to-weight ratio to the resultant panel structure. Outer wall covering sheets or decorative facing panels may be added to each side of the folded structural member to complete the panel structure as desired.

PRIOR ART

The use of corrugated sheets in panels is well known in the prior art. Representative of such prior art are United States Pats. 1,925,453; 1,963,609; 2,417,435; 2,501,180; 3,224,205 and 3,461,013. Most of such patents teach the use of the corrugated sheets as insulation or filler material. Further, none of the prior art panel structures teach the use of matingly nesting corrugated surfaces which interlock to form vertically oriented columns which impart a high strength-to-weight ratio to the panel formed thereby.

Nowhere in the prior art is there shown a panel structure having a plurality of corrugated sheets which nestably interlock so that the crowns and valleys of one corrugated sheet portion matingly receive and fit closely against the crowns and valleys of the next adjacent corrugated sheet portion.

In addition, none of the prior art devices provide a structure, such as the structure of applicant, which has a high resistance to horizontal deflection and which has a high compressive strength due to the plurality of columns formed by the unique interlock of the matingly nested corrugated sheets.

None of the prior art structures teach a panel structure which is formed by use of a unique structural member having corrugated outer surfaces and which is folded in an accordion-like pleated manner so that the corrugated surfaces of each pleat matingly nest with the corrugated surfaces of the next adjacent pleat so as to form a panel structure comprised of an internal network of vertically oriented columnar shapes.

As will be described hereinafter, the present invention enables the fabrication of a panel structure having a high strength-to-weight ratio and which has a unique internal configuration which permits the use of low cost waste paper pulp products that have been treated with waterproofing, fireproofing and compatible hardener-stiffener additives to achieve the desired characteristics and to meet all applicable building code and fire regulations.

OBJECTS

It is therefore an object of this invention to provide a panel structure having a high strength-to-weight ratio form while being fabricated of paper pulp derived from the use of reclaimed low-cost paper and/or cardboard waste products.

Another object of this invention is to provide a panel structure having (1) high compressive strength, (2) exhibiting high resistance strength and (3) exhibiting high resistance to horizontal deflection.

Yet another object of this invention is to provide a panel structure which is formed by use of unique structural member consisting of a continuous flat sheet having a continuous corrugated sheet affixed to each side thereof.

Yet another object of this invention is to provide a panel structure fabricated by use of structural members having corrugated surfaces which matingly and nestably interlock to form an internal network of vertically oriented elongate columns.

A still further object of this invention is to provide a panel structure fabricated by use of a plurality of nestably interlocked structural members which form internal network of hollow vertically-oriented columns which extend the entire length of the panel structure.

Yet another object of this invention is to provide a unique process for producing a high strength construction unit from waste paper pulp products and other additives thereto necessary to achieve certain desired characteristics.

Another object of this invention is to provide a structure and process whereby paper product waste materials are utilized in a constructive manner thereby improving the ecological environment.

Other objects and advantages found in the construction of the invention will be apparent from a consideration of the following specification in connection with the appended claims and the accompanying drawings.

In the drawings

FIG. 1 is a top view of the preferred embodiment of the structural member utilized in this invention which comprises a central flat sheet having a corrugated sheet affixed to each side thereof.

FIG. 2 is a top view of another embodiment of the structural member comprising a central flat sheet having a corrugated sheet with a different geometric cross-sectional configuration affixed to each side thereof.

FIG. 3 is a top view of yet another embodiment of the structural member.

FIG. 4 is a perspective view of the structural member showing the central sheet member with a corrugated sheet affixed to each side thereof and further illustrating the vertically oriented corrugations.

FIG. 5 is a schematic top view of the panel structure showing the structural sheet member folded upon itself in an accordion-like pleated manner between two outer wall facing sheet members.

FIG. 6 is a schematic top view of another embodiment of the panel structure showing separate linear segments of the structural sheet member in a nestable, mating, interlocked relationship between two outer wall facing sheet members.

FIG. 7 is a schematic perspective view of the panel structure showing the vertically oriented folded structural sheet member whose nested mating corrugations form

columnar shapes which vertically extend the height of the panel structure.

FIG. 8 is a schematic perspective view of another embodiment of the invention showing a plurality of vertically-oriented tubular members held in a nesting position by a continuous flexible band passed therethrough.

FIG. 9 is a perspective view of a panel structure formed by a plurality of nested vertically oriented tubular members between two outer wall facing sheets.

GENERAL DESCRIPTION

In general, a panel structure is fabricated by use of a structural sheet member consisting of a continuous flat sheet having a corrugated sheet provided on each surface thereof. The folds of the corrugated sheets are vertically oriented and extend the entire height of the continuous flat sheet.

The panel structure is formed by folding the structural sheet member in an accordion-like manner wherein the folded pleats are the width of the desired panel structure. The pleats are folded tightly against each other so the folds of the corrugated sheets matingly and nestably interlock with each other so as to form a network of closely packed hollow columns which extend the entire height of the panel structure formed thereby. Thus positioned, the crowns and valleys of the corrugated sheet on each pleat surface matingly nested against the corresponding crowns and valleys of the corrugated sheet on the next adjacent pleat surface.

It is within the scope of the invention to form the panel structure by cutting the continuous structural sheet member into a plurality of elongate strips, each of which are the width of the proposed panel structure. The strips are cut parallel to the vertically oriented folds of the corrugated sheets so that each strip has vertically-oriented folds of corrugated material extending the entire length and on each side thereof. The panel structure is then formed by matingly and nestably interlockably packing the individual strips against each other in a side-to-side relationship. The width of the strips determines the width of the resultant panel. The length of the panel is determined by the number of strips that are packed together.

The nestably interlocking corrugated portions of the accordion-like structure insures that the panel structure holds its general shape and structural integrity without the need of a structural outer wall covering or skin. An outer covering or facing sheet of minimum strength can be provided on each side of the panel structure as desired for decorative purposes.

Yet another embodiment of this invention is to utilize a plurality of vertically oriented straw-like tubular members which are held in a sheaf arrangement so as to matingly interlock with each other to form a panel structure between two outer wall facing sheets.

As will be more specifically described hereinafter, the flat sheet and corrugated sheets utilized in forming the structural member are made from a combination of waste paper pulp products, an admixture of new pulp, and flame-retardant or flame-proofing additives, waterproofing additives and stiffener-hardener agents as required.

A conversion plant is provided to produce the panel structures in a continuous automatic operation. The waste paper is collected and brought to the plant for conversion back into pulp through the use of soaking vats and high-speed beaters. During this repulping process, new pulp is added as required for specified strengths. The corrugated and flat sheets are then formed by use of machinery well known in the art.

The structural sheet member is then formed in a continuous process by gluing the corrugated sheets to each side of the central flat sheet member. The corrugated sheets are glued or otherwise affixed to the flat sheet member along the points where the crown portions of the corrugated sheets contact the flat sheet member.

Thereafter, a folding machine folds the structure member into an accordion-like pleated configuration with the corrugated portions being moved into a mating and nestable interlocked configuration with each other to form the panel structure. Thereafter, the facing or covering sheets are added as desired.

At this stage, the continuous panel structure is cut to the desired size and protective top and bottom cover members are secured thereto to provide a unitary panel structure. Other protective and/or decorative materials can then be applied to the panel structures as desired.

In addition to the use of reclaimed water paper pulp products, the structural member can be formed from any paper product, light guage metal sheeting product, or plastic and plastic type sheeting material. Further, a lightly impregnated cloth of natural or man-made fibers can be used to fabricate the hereinafter described configured sheets.

The foregoing manufacturing processes would create a four inch thick (for exterior walls) or two inch thick (for interior walls) panel having an eight foot height and a length of twelve feet. These dimensions can of course be varied as desired to meet any specific building application.

SPECIFIC DESCRIPTION

As shown in FIG. 1, a structural sheet panel **11** is provided which comprises a central flat sheet member **12** having corrugated sheets **13** and **14**, respectively, affixed to opposite surfaces thereof. Each corrugated sheet **13** and **14** comprises a plurality of vertically oriented crown **15** and valley **16** portions. The central flat sheet member **12** and the corrugated sheets **13** and **14** can be fabricated from low cost waste products, particularly reclaimed paper pulp products. Suitable fireproofing agents and compatible hardener-stiffener agents can be added separately or in combinations in the initial pulping process or at any point during the fabrication of the panel structure.

In addition to the use of reclaimed water paper pulp products, the structural member can be formed from any paper product, light guage metal sheeting product, or plastic and plastic type sheeting material. Further, a lightly impregnated cloth of natural or man-made fibers can be used to fabricate the hereinafter described configured sheets.

The corrugated sheets **13** and **14** are affixed to the surface of the central flat sheet member **12** by use of suitable adhesive materials such as glue or adhesive plastic materials well known in the art along the contact points **17** thereof. In the case of plastic sheets, heat can be used to bond the sheets together at the contact points thereof. In the case of metal sheeting which is thin but tempered, a slotted and interlocking punched configuration can be utilized to bond the three principal sheets at the points of contact.

As shown in FIG. 1, the corrugated sheets **13** and **14** have a standard serpentine cross-sectional configuration. However, this cross-sectional configuration can be varied to any desired geometric shape as desired as long as the convolutions thus formed can matingly nest with each other. Examples of other shapes of corrugated or convoluted sheets are shown in FIGS. 2 and 3.

As shown in FIG. 4, the structural sheet member **11** thus formed constitutes a structure wherein the folds or convolutions of the corrugated sheets **13** and **14** are vertically oriented so as to form a plurality of elongated vertically oriented columnar cell sections **18**.

The structural sheet member **11**, as shown in FIG. 4, is formed in a continuous length as desired. It can be of a standard eight foot height or can be varied in height as desired to accommodate any particular application or use environment. Thus, the columnar cell sections **18** would be eight feet in height in the standard embodiment of this invention. Further the crown **15** and valley

16 portions are vertically oriented so as to extend the entire height of the resultant panel structure.

As shown in FIGS. 5 and 7, a panel structure **17** is formed by folding the structural sheet member **11** in an accordion-like pleated manner so that convoluted portions of the corrugated sheets **13** and **14** on the side of each pleat matingly, nestably and interlockably fit the convoluted portions of the corrugated sheets on the next adjacent pleat surface. This folding sequence and nestable mating of next adjacent corrugated sheets are clearly illustrated by the top view of FIG. 5.

The width of the pleats in essence determines the thickness of the resultant panel structure. The preferred embodiments of this invention generally provide a panel structure thickness of 2" for use as interior walls and 4" for use as exterior walls. The panel structures are generally formed into units which are 8 feet in height and are 8, 10 or 12 feet in length.

The folding sequence is calculated so that each crown portion **15** of the corrugated sheet is brought into a matingly nesting position within each valley portion **16** of the corrugated sheet as positioned on the next adjacent folded pleat portion. Although FIG. 5 shows a slight space between the nested corrugated sheets, such spacing is merely provided for purposes of clarity in the drawing. In the actual panel structure **19**, the next adjacent corrugated sheets fit closely against each other in an abutting interlocked manner.

Thus, a plurality of columnar shapes are provided in an interlocking close proximity to each other. This interlocking of columnar shapes of the configured or corrugated structural sheet member **11** provides a frictional resistance to lateral deflection (bending) and permits a transference of vertically applied loading to as many of the columnar shapes as required to resist a load.

As shown in FIG. 6, it is within the scope of the invention to cut the structural sheet member **11** into vertical strips **20**, each of which have a length which is the width or thickness of the desired composite panel structure **17**. The individual elongate strips **20** are nestably placed against each other so as to form a panel structure **19** having substantially the same unique strength-to-weight ratio as the panel structure shown in FIG. 5 which was formed by the folding sequence previously described.

In each of the foregoing embodiments of the invention, it is also considered to be within the scope of the invention to have a bonding material applied to the outer faces of corrugated material so that, upon the nestable mating thereof, a more positive interlock is obtained which enhances the resistance factors applying to the bending moment (lateral deflection) if and/or when such additional strength is required.

Although the panel structure holds its general shape and structural integrity without the need for a structural outer covering or skin, outer covering sheets **21** and **22**, respectively, can be provided on each side of the panel structure for decorative purposes. The outer covering sheets can also be fabricated by use of low cost pulp paper products or more expensive washable and decorative plastic sheets can be utilized. Further, wood or plastic decorative panel boards can be applied directly to the panel structure as desired.

As shown in FIG. 7, head and sill plate elements **23** are applied to the top and bottom of the panel structure **19** for purposes of protection prior to final erection and to effect full distribution of loading throughout the entire panel structure. Such plate elements are affixed to the panel structure by use of a suitable adhesive bonding material.

Another embodiment of the invention is shown in FIGS. 8 and 9. A plurality of stiff straw-like tubular elements **24** are provided in a closely packed vertically oriented sheaf arrangement to form the panel structure **25** as shown in the partial schematic perspective view of FIG. 9. The thickness of the sheaf arrangement can be varied depending on the desired thickness of the completed panel structure.

The tubular elements **24** can be retained in the closely packed sheaf arrangement by use of a suitable adhesive material applied to the external surfaces thereof. Thus the tubular elements would adhere to each other as they were packed into the desired closely packed sheaf arrangement. The tubular elements **24** are fabricated from re-cycled low cost paper pulp waste products or any desired thin wall plastic or metal sheet material. The tubular elements **24** are formed continuously and then cut to any desired length corresponding to the desired height of the completed panel structure. Decorative outer facing panels **26** and **27** are provided to complete the panel structure. Here again suitable head and sill panels are utilized to completely enclose the panel structure.

As shown in the schematic view of FIG. 8, a more positive spacing, positioning and interlocking arrangement of the column-like tubular elements **24** may be achieved by use of a continuous flexible strip or band **28** passed through vertically-oriented diametrically opposed elongate slots **29** provided through the walls of each tubular element **24**. The continuous strip or band method of interlockably positioning the tubular elements **24** in a sheaf arrangement can be used in addition to as well as in place of the adhesive method of holding the tubes together. In FIG. 8, the tubes **24** are shown in spaced apart positions for purposes of illustration only. In use, they are in fact closely packed together as shown in FIG. 9.

In use, the completed panel structure is cut to any desired height or length. Openings are cut into selected of the panel structures so that, upon assembly with other panels, windows and doors are provided in the completed building. Thus, the panel structure comprises a new construction component product for use as interior and exterior walls and, under certain circumstances, for floor framing and roof structures.

The additional components which are also fabricated from low cost paper and plastic wastes are (1) one-piece plastic door framing (2) doors of wall material where the cut-out opening is made, bound in a one-piece converted plastic waste casement and (3) windows in a one-piece frame. End butt jointing is accomplished by use of an unobstrusive spline-batten element. Other means of fastening and/or anchoring the panels together in their use positions may be utilized as desired.

It is thus seen that this invention is designed to improve the environment by utilizing waste materials which would otherwise cause pollution of our natural resources. The process begins by collection of waste materials and hauling them to a central in-city transfer plant. At this point the paper, plastics, steel, aluminum and glass wastes are separated. Further treatment of waste paper at this plant includes soaking in water and use of high-speed beaters to convert paper back into pulp. The partially dried pulp is shipped to a conversion plant to make single face back-to-back corrugated paper board using conventional single facer type corrugation machines. The corrugated product can be processed during the re-pulping process with fireproofing and waterproofing additives or such protective inorganics can be added later in the processing cycle.

The structural element is formed by affixing a corrugated sheet to each side of a central sheet member as previously described. The structural element is then folded in an accordion-like pleated manner as previously described to complete the panel structure. It is thus seen that the structural member having back-to-back corrugations is folded in a pleated accordion-like manner so that corrugation faces nestably interlock thereby providing the opportunity to develop a high resistance to horizontal

deflection. Each flute of the corrugated sheets, coupling with that opposite it across the central flat backing sheet, in effect forms a narrow column with considerable compressive strength.

The fabrication of the entire panel structure including accordion folding, gluing, addition of outer facing sheets can be automated to produce the panel structure in a continuous length of any desired height. The panel structure can subsequently be cut into panel sections of any desired length.

Various other modifications of the invention may be made without departing from the principle thereof. Each of the modifications is to be considered as included in the hereinafter appended claims, unless these claims by their language expressly provide otherwise.

Having thus set forth the nature of my invention, I claim the following:

1. In a panel structure, the combination comprising:
a continuous structural sheet member, said structural sheet member having a central flat sheet member provided with a corrugated sheet on each side thereof, said structural sheet member folded upon itself in an accordion-like pleated manner so that said corrugated sheet of each pleat nestably interlocks with the corrugated sheet of the next adjacent pleat to form a panel structure which has a plurality of vertically oriented columnar shapes therein.

2. In the panel structure of claim 1 wherein said accordion-like folded structural sheet member is contained within a pair of parallel spaced-apart outer wall members to form a panel structure.

3. In a panel structure, the combination comprising:
a plurality of structural sheet strip members, each of said structural sheet members having a central flat sheet member provided with a corrugated sheet on each side thereof, said structural sheet strip members positioned in an abutting relationship to each other so that the next adjacent corrugated sheets nestably interlock to form a panel structure which has plurality of vertically oriented columns therein.

4. In the panel structure of claim 3 wherein said nestably interlocked structural sheet strip members are contained between a pair of parallel spaced-apart outer wall members to form a panel structure.

5. In a panel structure, the combination comprising:
a plurality of elongate vertically oriented tubular members nestably provided in sheaf arrangement to form a panel structure, the longitudinal axis of each of said tubular members being parallel to the planes of the outer side surfaces of said panel structure, each of said tubular members having slots provided therethrough; and
a continuous flexible band member mounted through said slots provided in said tubular members.

6. In the panel structure of claim 5 wherein said tubular members are contained between a pair of parallel spaced-apart outer wall members to form a panel structure.

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PHILIP DIER, Primary Examiner

U.S. Cl. X.R.

161—127, 137, 159, 139