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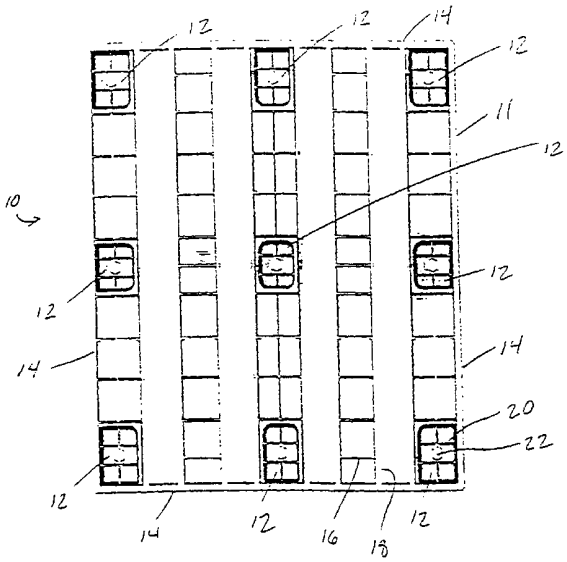
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(54) Title: LOAD-BEARING SYSTEMS



(57) Abstract: The disclosure is based on the discovery that load-bearing systems (10) and materials handling systems having excellent physical properties (e.g., high capacity/weight ratio, durability) can be manufactured from composite materials. In general, the disclosure features load-bearing systems (e.g., a pallet or a skid, or a unit that can be attached to similar units to form superstructures such as piers, docks, bridges, scaffolding, or marine flooring). The load-bearing systems include a body (11), having at least three (e.g., three, four, six, or more) intersecting walls (14) and a plurality of structural members (18) (e.g., beams, ribs, or other elements) extending between two of the walls, and support members (12) (e.g., legs, feet, vertical spacers) extending downwardly from the body. At least part of the load-bearing system can include a composite of thermoplastic resin and a fibrous organic material.

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LOAD-BEARING SYSTEMS

Background of the Invention

The invention relates to load-bearing systems.

Load-bearing systems such as pallets and skids are increasingly made of plastics, reflecting a demand for systems having high load capacity, longer useful life, and cleanability. Although plastic pallets represent an improvement over traditional wooden slat pallets in terms of each of these characteristics, there remains a demand for lightweight systems having still greater load capacity, versatility, and durability than the current state of the art provides.

Summary of the Invention

The present invention is based on the discovery that load-bearing systems and materials handling systems having excellent physical properties (e.g., high capacity/weight ratio, durability) can be manufactured from composite materials such as those described in U.S. Patent No. 5,952,105, USSN 08/961,863, USSN 09/337,580, and USSN 09/338,209, all of which are incorporated by reference.

In general, the invention features load-bearing systems (e.g., a pallet or a skid, or a unit that can be attached to similar units to form superstructures such as piers, docks, bridges, scaffolding, or marine flooring). The load-bearing systems include a body, having at least three (e.g., three, four, six, or more) intersecting walls and a plurality of structural members (e.g., beams, ribs, or other elements) extending between two of the walls, and support members (e.g., legs, feet, vertical spacers) extending downwardly from the body. At least part of the load-bearing system includes a composite of thermoplastic resin and a fibrous organic material (e.g., cellulosic or lignocellulosic fiber).

The body (including the walls, structural members, or both) and/or support members can be, for example,

rigid, meaning that they are able to resist deformation due to external load and/or have a relatively high stiffness/weight ratio. Each of the walls can be, for example, about 10" to 200" in length (e.g., 30" to 60"). Thus, the load bearing system may be rectangular (e.g., about 40" by 48", about 44" by 48", or about 20" by 24"). The load bearing system can alternatively be triangular (e.g., having walls of about 40", about 48", and about 62.5" length), square, trapezoidal, polygonal, or otherwise shaped. The walls can be, for example, about 1" to 20" in height (e.g., about 4" to 12"). The walls can be, for example, about 0.01" to 1" in thickness (e.g., about 0.1" to 0.25", or about 0.12" to 0.16"). The structural members can be substantially flat, or can include flanges that render them L-shaped, T-shaped, Z-shaped, I-shaped, or as variants of these shapes.

In some cases, the body and support members are integral (e.g., formed as one piece); in other cases, the support members are detachable from the body and/or repairable (e.g., by attaching an external cap). The support members can be cylindrical, square, rectangular, trapezoidal, polygonal, or otherwise shaped, and can include internal stiffening structures. The support members can be made of the same material as or a different material than the body. For example, the support members could be made of metal. In some cases, at least three (e.g., three, four, or more) of the support members are situated at intersections of at least two of the walls. In certain embodiments, each support member can comprise a cluster of smaller support members.

In certain cases, at least one (e.g., one, two or more, half or more) of the structural members include at least one (e.g., one, two or more) gas channel, as would be formed by a gas-assisted injection-molding (GAIN) process. The thickness of at least one of the structural members (e.g., a member that includes a gas channel), at its thickest point, is three to five times the average

thickness of the walls.

In the case of a load-bearing system that includes four walls (i.e., the walls comprising a first pair of opposing walls, a second pair of opposing walls, and four pairs of adjacent walls), the structural members can extend between one or both pairs of opposing walls (e.g., to form a rectilinear grid), and/or between any pair of adjacent walls (e.g., forming a diagonal pattern). In some cases, a single structural member runs the entire distance from one wall to another. In other cases, no single structural member spans the distance from one wall to another, but the walls may be connected via a network of two or more structural members. Structural members can also bisect or traverse the support members, resulting in cloven, or split, support members.

At least some of the structural members can have exposed upper and lower surfaces, meaning that the edges of the walls and tops of support members can form a contact surface (e.g., to increase surface area, rigidity, or both).

The load-bearing system can also include an upper plate attached to at least one (e.g., one, two or more, or all) of the walls. The upper plate can be solid or it can have openings (e.g., for weight reduction), and it can have a textured surface. Texturing can be accomplished, for example, by texturing the mold (e.g., using EDM or acid etching) or using grit, rubberizing material, grip tape, etc., in order to increase the coefficient of friction on the upper plate. The texturing can be, for example, 0.001-0.02" deep (e.g., 0.005-0.008" deep), and can take the form of zig-zags, V-shapes, concentric circles, parallel lines, S-shapes, or other designs. In some cases, the upper plate can be attached to the wall via a hinge, and can optionally be lockable for protecting merchandise or protecting from theft. In some embodiments, the upper plate can, for example, be removable, foldable, unitary, or made up of multiple

pieces.

A payload shifting restraint (e.g., drum rings, tiers, or wells) can also be included, as can a reservoir (e.g., for liquid containment). The reservoir can be, for example, at least partially mounted in one of the support members.

The load-bearing system can also include a lower plate attached to at least one (e.g., one, two or more, or all) of the support members. A lower plate can, for example, be useful for distributing load over the support members while the load-bearing system is suspended on racks. The lower plate can be solid or it can have openings (e.g., for weight reduction). The lower plate can, for example, be attached to at least one of the support members via a hinge. In some embodiments, the lower plate can, for example, be foldable, unitary, or made up of multiple pieces. The lower plate can also be removable, and can be attached to the support members via at least one fastener (e.g., a nail, a snap-lock, a screw, or a bolt). Such fastener can be made of a material having a tensile strength at least as great as the composite from which at least part of the body of the load-bearing system is made. The lower plate can also include ridges (e.g., nests) to accept at least one of the support members.

The composite can include, for example, 30-70% of the thermoplastic resin by weight and 30-70% of the fibrous organic material by weight. The fibrous organic material can be, for example, cellulosic or lignocellulosic fibrous material such as texturized cellulosic or lignocellulosic material (e.g., a sheared lignocellulosic or cellulosic material such as poly-coated paper, having internal fibers that are substantially exposed) or can be a material having substantially the same physical properties as a mass of paper that has been subjected to rotary cutting would have. The composite can also include an inorganic fibrous material and/or other

additives (e.g., plasticizers, lubricants, antioxidants, opacificers, heat stabilizers, colorants, impact modifiers, photostabilizers, flame retardants, biocides, antistatic agents, calcium carbonate, graphite, asbestos, wollastonite, mica, glass, fiber glass, chalk, silica, talc, ceramic, ground construction waste, tire rubber powder, carbon fibers, or metal (e.g., stainless steel) fibers. When such additives are included, they can be, for example, present in quantities ranging from about 0.5% up to about 20-30% by weight. For example, submicron calcium carbonate can be added to the composites of texturized fibrous material and resin to improve impact modification characteristics or to enhance composite strength.

The thermoplastic resin can include, for example, polyethylene, polypropylene, polystyrene, polycarbonate, polybutylene, thermoplastic polyesters, polyethers, thermoplastic polyurethane, polyvinylchloride, or a polyamide.

The load-bearing system can also include one or more rails extending upwardly from at least one (e.g., one, two, three, four or more, or all) of the walls and/or structural members. Each of the rails can be, for example, from about 1/4" to about 72" in height. The rails can be integral with the walls or can be removable.

The load-bearing system can include an embedded identification system or tracking device (e.g., an identification tag, a bar code, an electronic circuit, a GPS system, an RF transmitter, a radio tracking system, or a laser or photooptical tracking system).

The load-bearing system can include gussets extending downwardly from the walls (e.g., for sheathing, banding, locking, or preventing crushing), and/or lift holds (i.e., smooth gripping areas underneath the walls, or straps or strap-holding functionalities, for mechanical or manual lifting).

Pairs or groups of structural members define spaces

(i.e., in between the structural members) of a size and shape that enable the load-bearing system to be lifted (e.g., using a pallet jack or a forklift). The structural members can be, for example, about 1" to 20" in height (e.g., about 4" to 12", or about 6").

Another embodiment of the invention also features a load-bearing system including a body having at least three intersecting walls and a plurality (i.e., one, two, or more) of structural members extending between two of the walls and support members extending downwardly from the body. The ratio of stiffness to weight of the load bearing system, defined as the ratio of load/deflection to weight, is at least 700 in^{-1} (e.g., at least about 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, or 2000 in^{-1} or more).

The invention also features a materials handling system. The materials handling system includes a load-bearing system as described above, and at least one collapsible container mounted thereto. The materials handling system can also include a second load-bearing system. Either or both of the load-bearing systems can be collapsible. By "collapsible" is meant that the systems can be folded, flattened, or otherwise reduced in volume for storage; even though a load-bearing system is collapsible, it can still be rigid so as not to deform under load.

The terms "texturized poly-coated paper" and "texturized fibrous material", as used herein, mean that the poly-coated paper or other fibrous material (e.g., hemp, jute, kenaf, wood fiber, flax, cotton, rags) have internal fibers that are substantially exposed. In some examples, the paper has been sheared to the extent that its internal fibers are substantially exposed. At least about 50%, more preferably at least about 70%, of these fibers, as well as the external polymer fibers, have a length/diameter (L/D) ratio of at least 5, more preferably at least 25, or at least 50.

The term "materials handling system" refers to an apparatus that can be used to support goods (e.g., boxes, produce, liquid vessels, or other articles or commerce or manufacture) during storage, transport, or display thereof. The materials handling systems described herein include load-bearing systems such as pallet, meaning that they each include one or more load-bearing system of the invention, and, optionally, other components. In a preferred embodiment, a single materials handling system can be used to bring goods from a point of manufacture to a point of sale. An example of such use is provided in Example 1 (*infra*).

The load-bearing systems and materials handling systems can be thoroughly cleaned and disinfected between uses. The load-bearing systems can be assembled into superstructures having, for example, multiple pallets or other load-bearing systems attached to one another, detachable rails, flat top plates, wheels, lower racking plates, or internal walls. The load-bearing systems can be both aesthetically pleasing enough to be used for merchandise display and sufficiently durable to be used for transporting heavy payloads. As a result, the load-bearing systems do not require repeated unloading and reloading within the stream of commerce. The load-bearing systems are easily recycled, since they can be cleaned prior to recycling and generally do not have any nails that might need to be removed prior to recycling. The load-bearing systems are non-absorbent, and so do not become irreversibly contaminated with spilt oil, mold, insects, or other chemical or biological contaminants. In general, the load-bearing systems are smooth and can be handled manually without risk of splinters.

Other features and advantages of the invention will be apparent from the following detailed description, and from the claims.

Brief Description of the Drawing

Fig. 1 is a top view of a load-bearing system;

Fig. 2 is a top corner view of a load-bearing system;

Fig. 3 is a top corner view of a portion of a load-bearing system;

Fig. 4 is an exploded top corner view of a load-bearing system;

Fig. 5 is an exploded top corner view of a portion of a load-bearing system;

Fig. 6 is bottom corner view of a portion of a load-bearing system;

Fig. 7 is a cut-away view of a portion of a load-bearing system, including a cross-section of one of the system's support members;

Fig. 8 is a cut-away top view of a load-bearing system;

Fig. 9 is a cut-away view of a portion of a load-bearing system;

Fig. 10 is a cross-sectional view of a Z-shaped structural member;

Fig. 11 is a top view of a load-bearing system;

Fig. 12 is a top corner view of a load-bearing system;

Fig. 13 is a cut-away view of a portion of a load-bearing system; and

Fig. 14 is a top corner view of four load-bearing systems.

Detailed Description of the Invention

Referring to Figs. 1-8, load-bearing system 10 includes a rigid body 11 and nine support members 12. The body is made up of intersecting four walls 14 and a plurality of flat structural members 16 and T- or Z-shaped structural members 18. Each of the support members 12 also includes structural members 20 and a drainage hole 22.

As shown in Fig. 10, the Z-shaped structural members 18 have a larger top surface area than the flat structural members 16. Referring back to the earlier figures, an optional lower plate 24 is attached to the support members 12. The plate 24 is useful, for example, if the load-bearing system 10 is to be racked, since the plate 24 allows the load to be distributed to each of the support members 12 even when the load-bearing system 10 is supported, for example, at only two edges. At least one wall 14 of the pallet body 11 includes two recessed areas 26 where an identification system or tracking device can optionally be embedded.

Load-bearing system 10 is shown with identification systems or tracking devices 27 for embedding in recessed areas 26. Optional rails 30, which can be attached to the top surface of each wall 14, are also shown. The rails 30 can be useful, for example, to prevent payloads (e.g., liquid containers) from sliding off in transit. Lower plate 24 can be seen to include nests 32 for attachment of the plate 24 to the support members 12. Fasteners 28 and tabs 34 secure the support members 12 in the nests 32. Fasteners 28 can be, for example, snap locks, screws, or bolts.

Support member 12 includes a recess 36 for receiving fastener 28. Optional gussets 38 are useful, for example, for sheathing, banding, or locking load-bearing system 10 while empty or loaded. Load-bearing system 10 is also shown with optional an hand-hold surface 40, which provides a gripping area underneath the walls for use when load-bearing system 10 is carried by hand.

Load-bearing system 10 is suitable for manufacture by a gas-assisted injection (GAIN) molding process. In this process, manufacturing material is injected into a mold at various points, the injection points corresponding to the sprues 52 on the load-bearing system 10. Because the manufacturing process requires flowing a viscous material over long distances, gas is injected together

with the manufacturing material to force the material into every corner of the mold.

The gas generally flows through the centers of the thickest portions of the load-bearing system 10, resulting in those portions having hollow cores. The hollow cores are referred to as gas channels 50. The thickest portions of load-bearing system 10 are the tops of the Z-shaped structural members 18. Thus, at least some of the Z-shaped structural member 18 include a gas channel 50.

The mold also includes protrusions which formed bosses 42 in the top surface of load-bearing system 10. The bosses 42 act as gas-stopping points, blocking gas flowing from two opposing directions from forming a single channel.

Referring to Figs. 9 and 10, a cut-away view of a portion of load-bearing system 10 shows gas channels 50 and Z-shaped structural members 18. The Z-shaped structural members 18 have flattened top surfaces 44 and flattened bottom surfaces 49. The flattened top surfaces 44 can provide additional contact area between load-bearing system 10 and a load. The flattened bottom surfaces 49 can provide additional surface area for the tines of a pallet jack or forklift in the transportation of load-bearing system 10.

The thickness of the top portion 45 of each Z-shaped structural member 18 was optimized for the expected use of the load-bearing system.

Referring to Figs. 11-13, load-bearing system 60 includes a body 62 and support members 70. Body 62 includes L-shaped walls 68 and Z-shaped structural members 66. Certain of the structural members 72 extend between opposite walls, while other structural members 74 extend between adjacent walls. Support members 70 can be cloven by structural members 76, as shown in Figs 11-13, or can be cylindrical or otherwise shaped.

Referring to Fig. 14, four additional load-bearing systems 80, 82, 84, and 86 are shown, each having a solid

upper plate (not shown). Load-bearing systems 80, 82, 84, and 86, respectively, include bodies 100, 102, 104, and 106, and support members 90, 92, 94, and 96. Additionally, load-bearing systems 84 and 86, respectively, include lower plates 110 and 112. Support members 96 of load-bearing system 86 are cylindrical.

The following examples illustrate certain embodiments and aspects of the present invention and are not to be construed as limiting the scope thereof.

Example 1

Four 20" x 24" interlocking load-bearing systems are obtained by agricultural workers. Each load-bearing system has four walls and four support members situated at the corners of the load-bearing system (i.e., defined by the intersection of the walls). Each support member is 4" x 4", and extends 6" below the walls of the load-bearing system. The four load-bearing systems are locked together to form a 40" x 48" superstructure. This is the size of a standard Grocery Manufacturers Association (GMA) pallet. Rails 24" high are attached to the tops of the walls of each load-bearing system to form a box-like structure having an open top and four compartments arranged in a 2 x 2 matrix, with the load-bearing system's top acting as a floor.

The workers place a layer of oranges on the floor of each compartment, then cover the layer with a 20" x 24" slip. Another layer of oranges is placed on top of the slip, and another slip is placed on top. This process is continued until no additional layers of oranges could by placed on top without going above the tops of the rails. A lid is then placed on top and locked onto each of the rails.

The superstructure box has 9 support members altogether. This is so because, although each of the interlocking load-bearing systems has four support members, the support members of adjacent load-bearing systems are conjoined in the superstructure. Thus, for

example, the central support member of the superstructure is actually made up of four support members (i.e., one from each of the interlocking load-bearing systems), and has a footprint of 8" x 8". The support members in the middle of each side of the superstructure are made up of two support members, and hence measure 4" x 8". On the short sides of the superstructure, there is a 12" space between the support members; on the log side, there is a 16" space. The spaces allow the tines of a forklift or pallet jack to reach under the superstructure box.

The box is lifted onto the bed of a pickup truck using a forklift. When the bed of the truck is full of such boxes, the truck is driven to a distribution center, where the boxes are unloaded from the pickup using a pallet jack, and stacked four high and two across in a 44' container. When the container is full of such boxes, the container is hoisted by crane onto a cargo ship. At the cargo ship's destination, the containers are unloaded and hauled by truck to a grocery store, possibly via a distribution center. The boxes are removed from the containers at the store or distribution center. A lower plate is attached to the underside of each box for racking, then a forklift is used to place the boxes on racks.

The boxes are taken down from the racks as necessary, and delivered to the sales floor of the grocery store. On the sales floor, the lid is removed and the four load-bearing systems are detached from one another. Each load-bearing system is placed on a shelf, where consumers can choose from among the oranges in each layer. When the oranges are depleted from the load-bearing system, the rails are removed and the components (i.e., load-bearing systems, rails, lower plate, and lid) can be sent out for cleaning and reuse.

According to this example, there is no need for unpacking and repacking of the oranges between the field where they are grown and the shelf in the grocery store.

Through the use of a single, reusable materials handling system for transportation, storage, and display, labor costs can be reduced significantly.

Other embodiments are within the claims.

What is claimed is:

Claims

1. A load-bearing system comprising:

a body comprising at least three intersecting walls and a plurality of structural members extending between two of the walls; and

support members extending downwardly from the body,

wherein the load-bearing system comprises a composite of thermoplastic resin and a fibrous organic material.

2. The load-bearing system of claim 1, wherein the body is rigid.

3. The load-bearing system of claim 1, wherein the body comprises four intersecting walls.

4. The load-bearing system of claim 1, wherein the body and support members are integral.

5. The load-bearing system of claim 1, wherein at least one of the structural members includes at least one gas channel.

6. The load-bearing system of claim 1, wherein the thickness of at least one of the structural members, at its thickest point, is three to five times the average thickness of the walls.

7. The load-bearing system of claim 3, wherein the four walls comprise a first pair of opposing walls, a second pair of opposing walls, and four pairs of adjacent walls; and the structural members extend between the first pair of opposing walls.

8. The load-bearing system of claim 7, wherein the structural members are rigid.

9. The load-bearing system of claim 7, further comprising structural members extending between the second

pair of opposing walls, thereby forming a rectilinear grid of structural members.

10. The load-bearing system of claim 9, further comprising structural members extending between at least one pair of adjacent walls.

11. The load-bearing system of claim 9, wherein the structural members are rigid.

12. The load-bearing system of claim 1, wherein at least some of the structural members have upper and lower exposed surfaces.

13. The load-bearing system of claim 1, further comprising a solid upper plate attached to at least one of the walls.

14. The load-bearing system of claim 1, further comprising a lower plate attached to at least one of the support members.

15. The load-bearing system of claim 14, wherein the lower plate is attached to the support members via at least one fastener.

16. The load-bearing system of claim 15, wherein the fastener comprises a material having a tensile strength at least as great as the material comprised by the body of the load-bearing system.

17. The load-bearing system of claim 14, wherein the lower plate includes ridges to accept at least one of the support members.

18. The load-bearing system of claim 1, wherein said composite comprises 30-70% of said thermoplastic resin by weight and 30-70% of said fibrous organic material by weight.

19. The load-bearing system of claim 1, wherein at

least three of the support members are situated at intersections of at least two of the walls.

20. The load-bearing system of claim 1, further comprising a rail extending upwardly from at least one of the walls.

21. The load-bearing system of claim 1, further comprising a rail extending upwardly from at least one of the structural members.

22. The load-bearing system of claim 1, wherein the fibrous organic material is a cellulosic or lignocellulosic material.

23. The load-bearing system of claim 1, wherein the fibrous organic material is a texturized cellulosic or lignocellulosic material.

24. The load-bearing system of claim 1, wherein the composite further comprises an inorganic fibrous material.

25. The load-bearing system of claim 1, wherein the composite further comprises an additive selected from the group consisting of plasticizers, lubricants, antioxidants, opacificers, heat stabilizers, colorants, impact modifiers, photostabilizers, flame retardants, biocides, and antistatic agents.

26. The load-bearing system of claim 1, wherein the composite further comprises an inorganic additive selected from the group consisting of calcium carbonate, graphite, asbestos, wollastonite, mica, glass, fiber glass, chalk, silica, talc, ceramic, ground construction waste, tire rubber powder, carbon fibers, and metal fibers.

27. The load-bearing system of claim 22, wherein the thermoplastic resin is selected from the group

consisting of polyethylene, polypropylene, polystyrene, polycarbonate, polybutylene, thermoplastic polyesters, polyethers, thermoplastic polyurethane, polyvinylchloride, and polyamides.

28. The load-bearing system of claim 22, wherein the texturized fibrous material is a sheared lignocellulosic or cellulosic material having internal fibers that are substantially exposed.

29. The load-bearing system of claim 22, wherein the texturized fibrous material is poly-coated paper having internal fibers that are substantially exposed.

30. The load-bearing system of claim 1, further comprising an embedded identification system or tracking device, said identification system or tracking device being selected from the group consisting of an identification tag, a bar code, an electronic circuit, a GPS system, an RF transmitter, a radio tracking system, and a laser or photooptical tracking system.

31. The load-bearing system of claim 1, wherein each of the walls is between 10 and 200 inches in length.

32. The load-bearing system of claim 1, wherein each of the walls is between 30 and 60 inches in length.

33. The load-bearing system of claim 3, wherein two of the walls are about 40" in length and two of the walls are about 48" in length.

34. The load-bearing system of claim 3, wherein two of the walls are about 44" in length and two of the walls are about 48" in length.

35. The load-bearing system of claim 3, wherein two of the walls are about 40" in length and two of the walls are about 24" in length.

36. The load-bearing system of claim 3, wherein two of the walls are about 20" in length and two of the walls are about 24" in length.

37. The load-bearing system of claim 1, wherein one of the walls is about 40" in length, one of the walls is about 48" in length, and one of the walls is about 62.5" in length.

38. The load-bearing system of claim 1, wherein each of the walls is between 1 and 20 inches in height.

39. The load-bearing system of claim 1, wherein each of the support members is between 4 and 12 inches in height.

40. The load-bearing system of claim 1, wherein the average thickness of the walls is in the range of 0.01-1".

41. The load-bearing system of claim 40, wherein the average thickness of the walls is in the range of 0.1-0.25".

42. The load-bearing system of claim 41, wherein the average thickness of the walls is in the range of 0.12-0.16".

43. A materials handling system comprising a first load-bearing system according to claim 1 and at least one collapsible container mounted thereto.

44. The system of claim 43, where collapsible container comprises a second load-bearing system.

45. The system of claim 43, wherein said load-bearing system is collapsible.

46. The load-bearing system of claim 1, wherein at least some of the structural members are "Z"-shaped in cross section.

47. The load-bearing system of claim 1, wherein at least some of the structural members are "T"-shaped in cross section.

48. The load-bearing system of claim 1, wherein at least one of the support members is cloven by at least one of the structural members.

49. A load-bearing system comprising:

a body comprising at least three intersecting walls and a plurality of structural members extending between two of the walls; and support members extending downwardly from the body, wherein the ratio of stiffness to weight is at least 1000 in^{-1}.

50. The load-bearing system of claim 49, wherein the ratio of stiffness to weight is at least 1200 in^{-1}.

51. The load-bearing system of claim 49, wherein the ratio of stiffness to weight is at least 1400 in^{-1}.

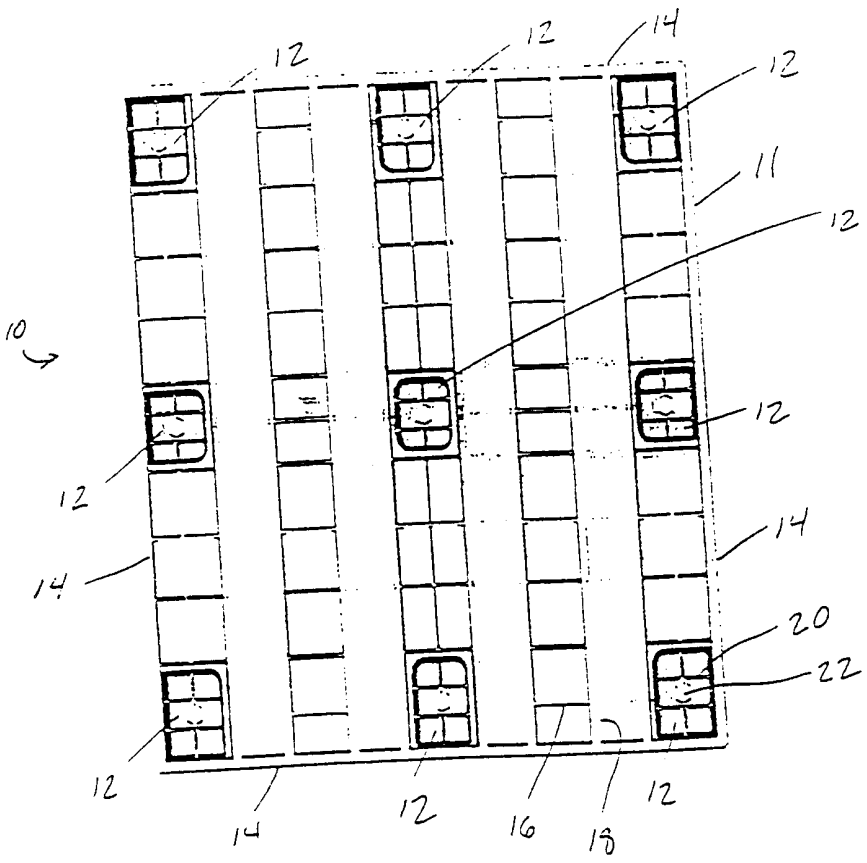


FIG. 1

FIG. 2

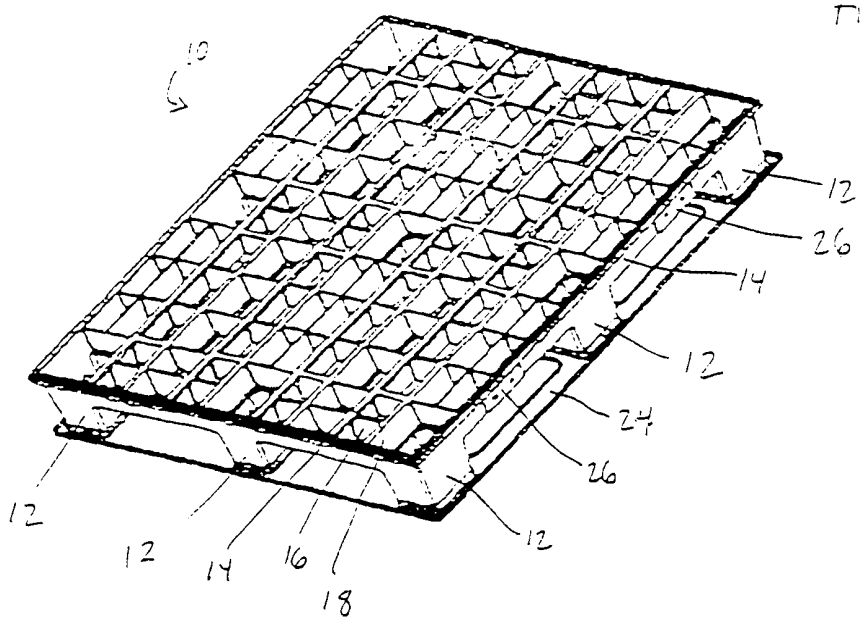


FIG. 3

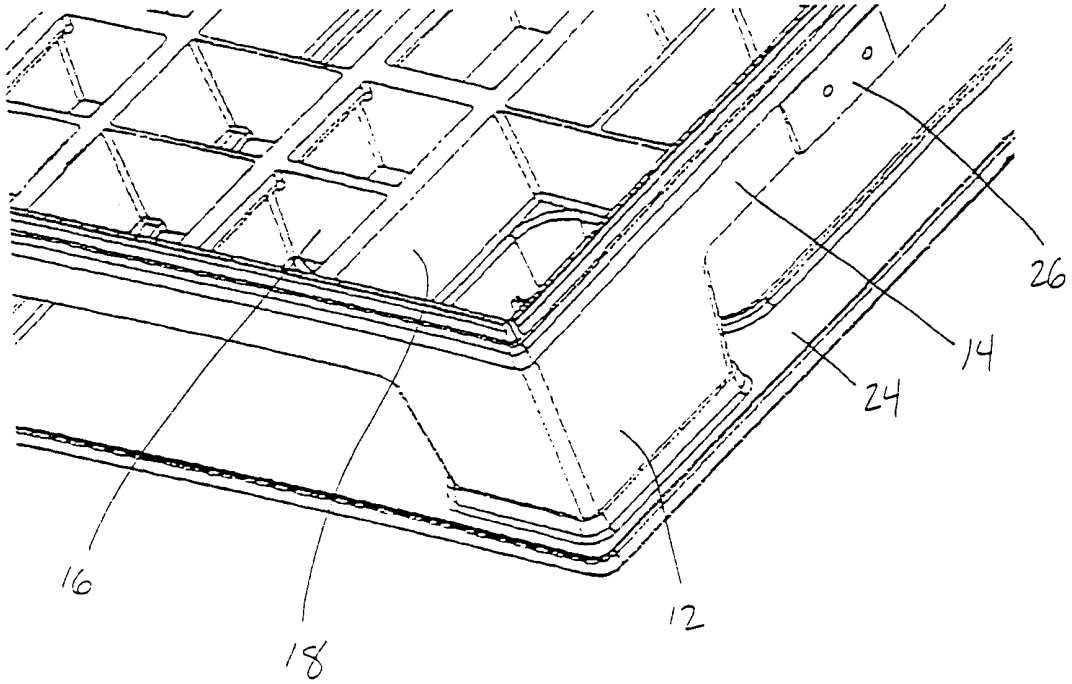


FIG. 4

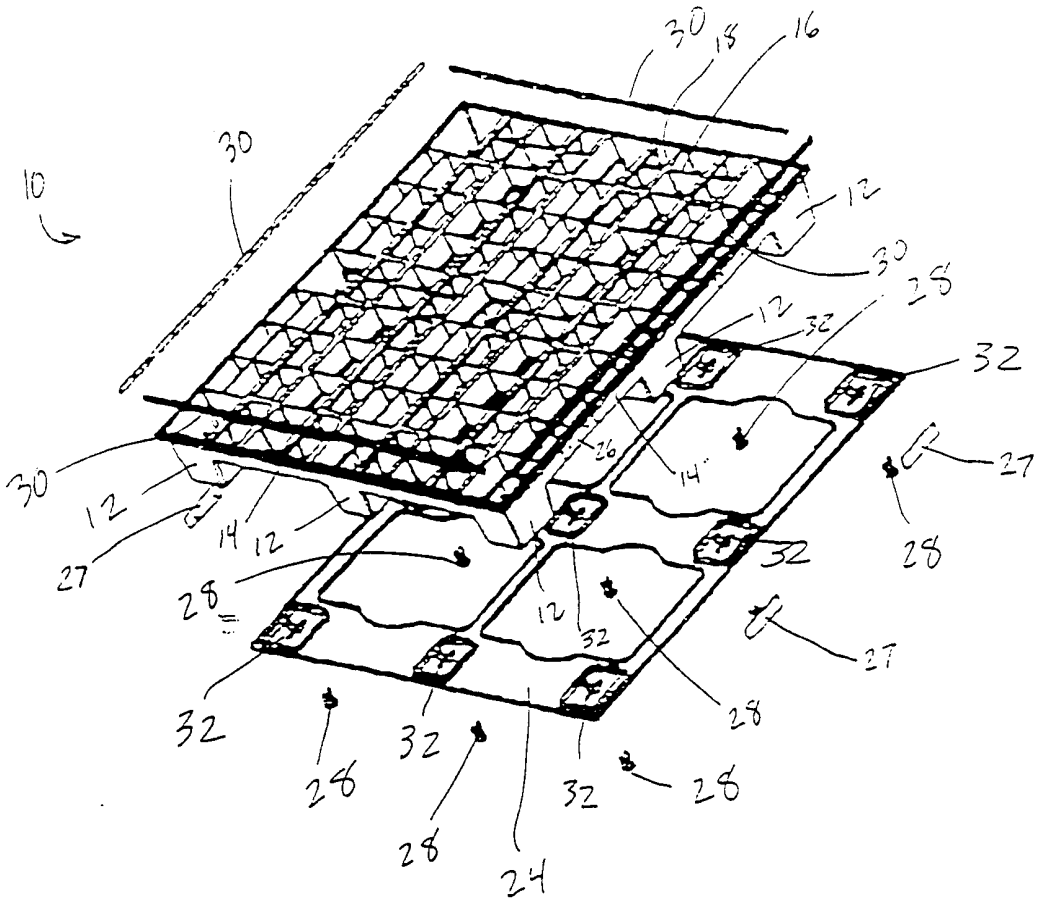


Fig. 5

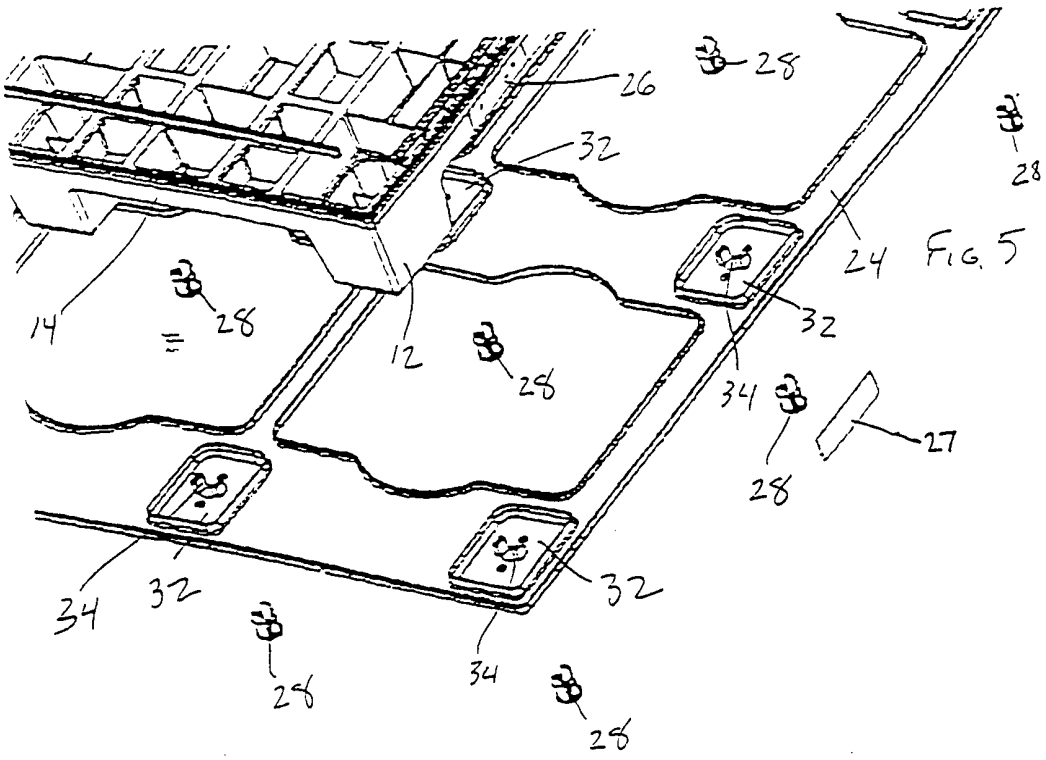


Fig. 5

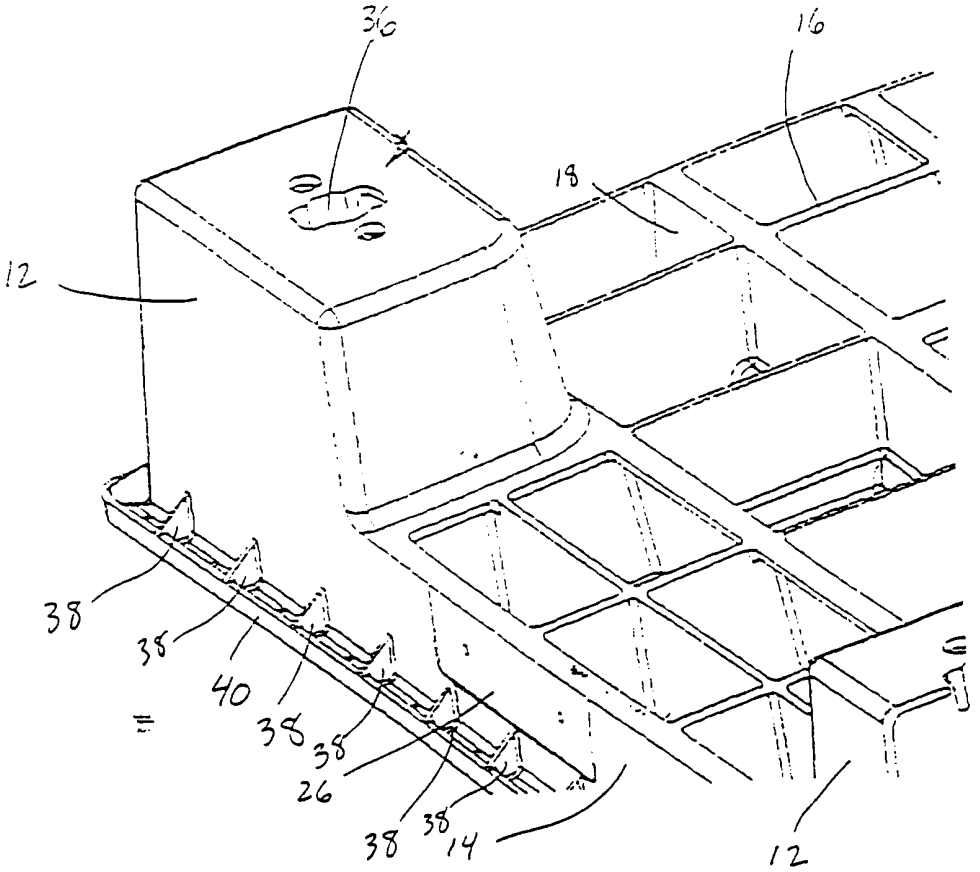


FIG. 6

FIG. 7

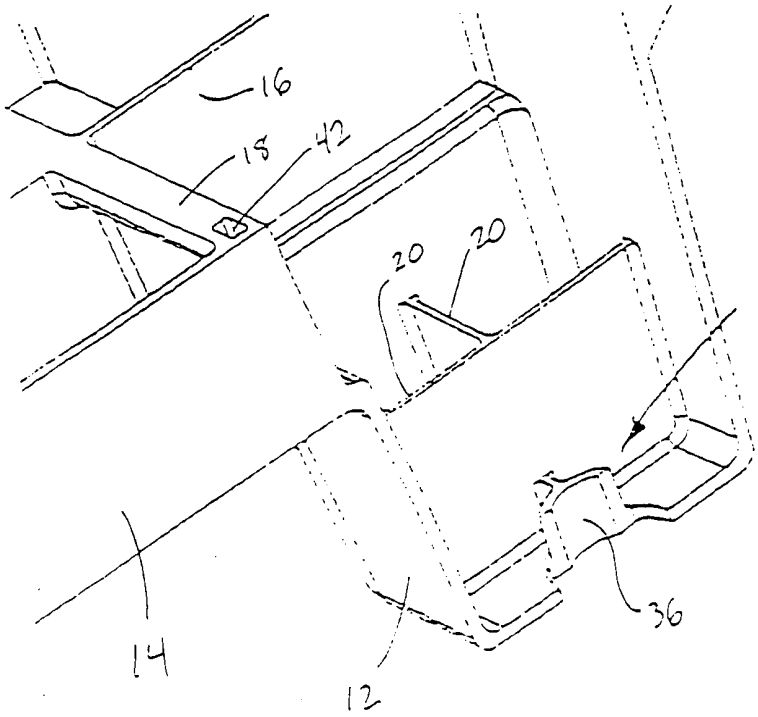


FIG. 3

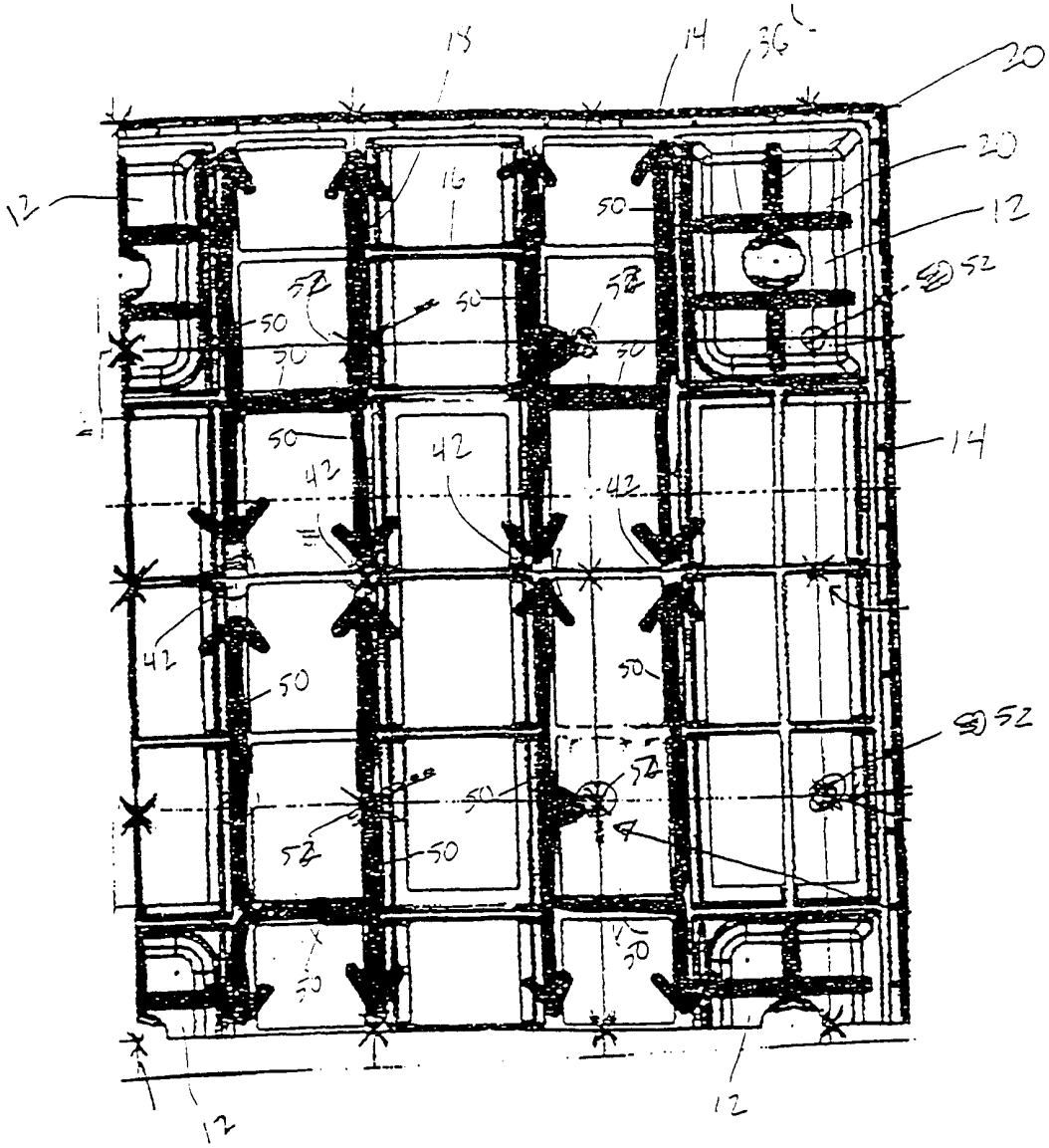
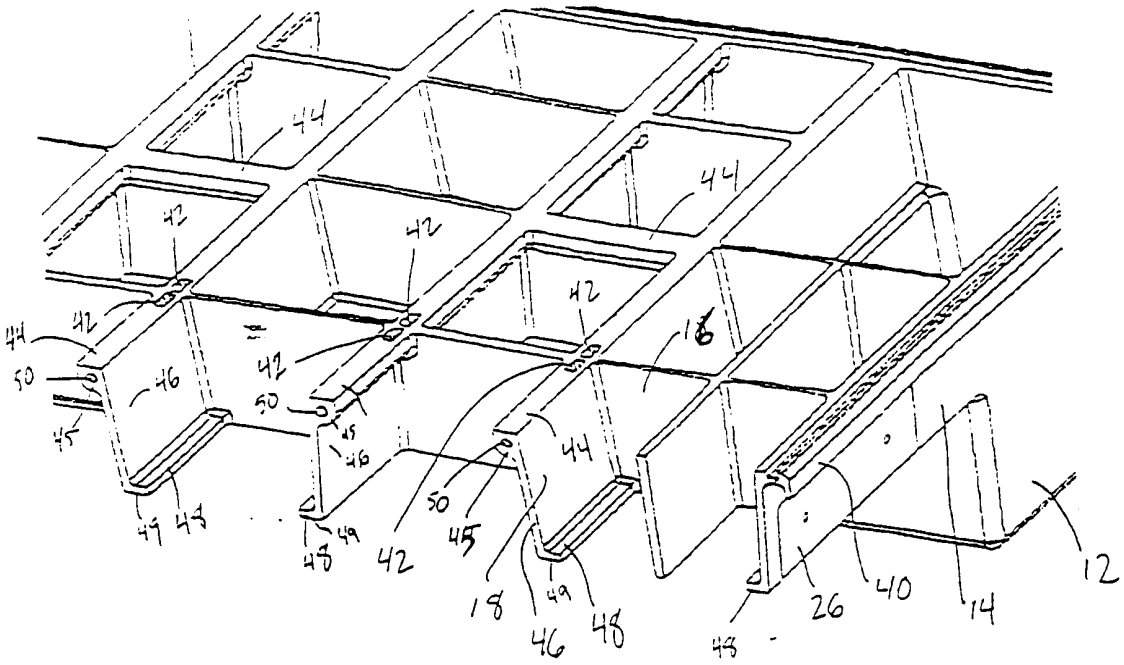

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FIG. 9


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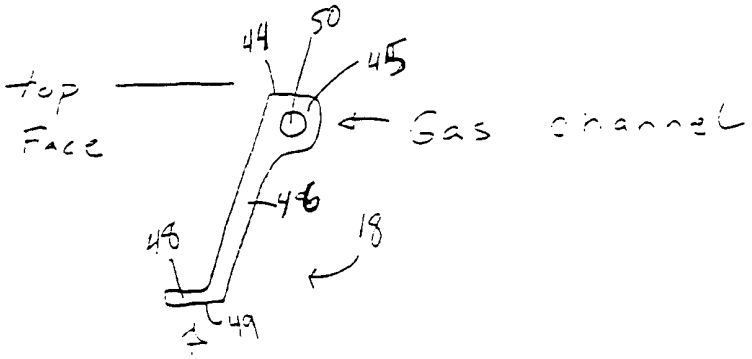

Top Face
Gas channel
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Fig. 10

FIG. 11

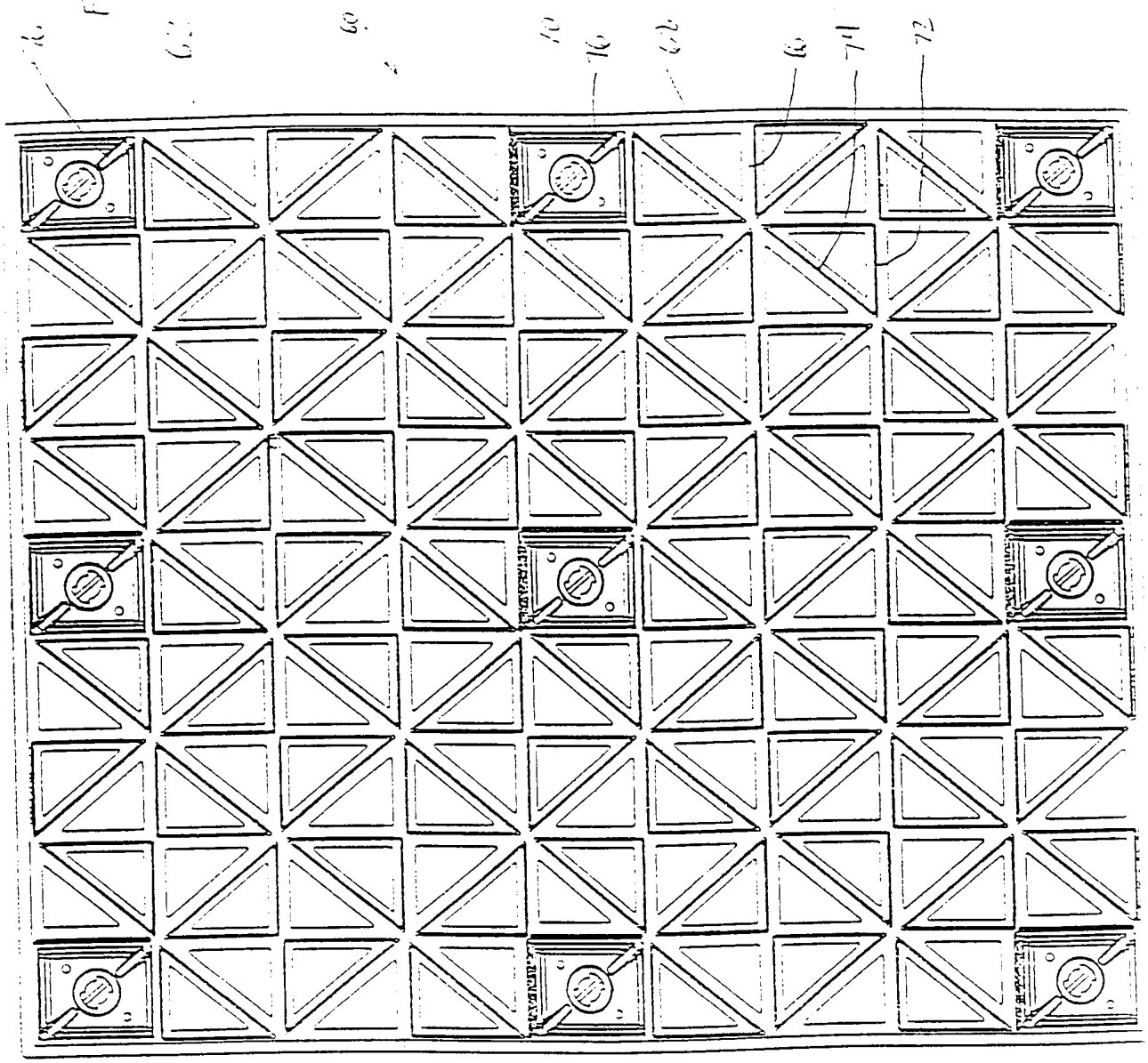


Fig. 12

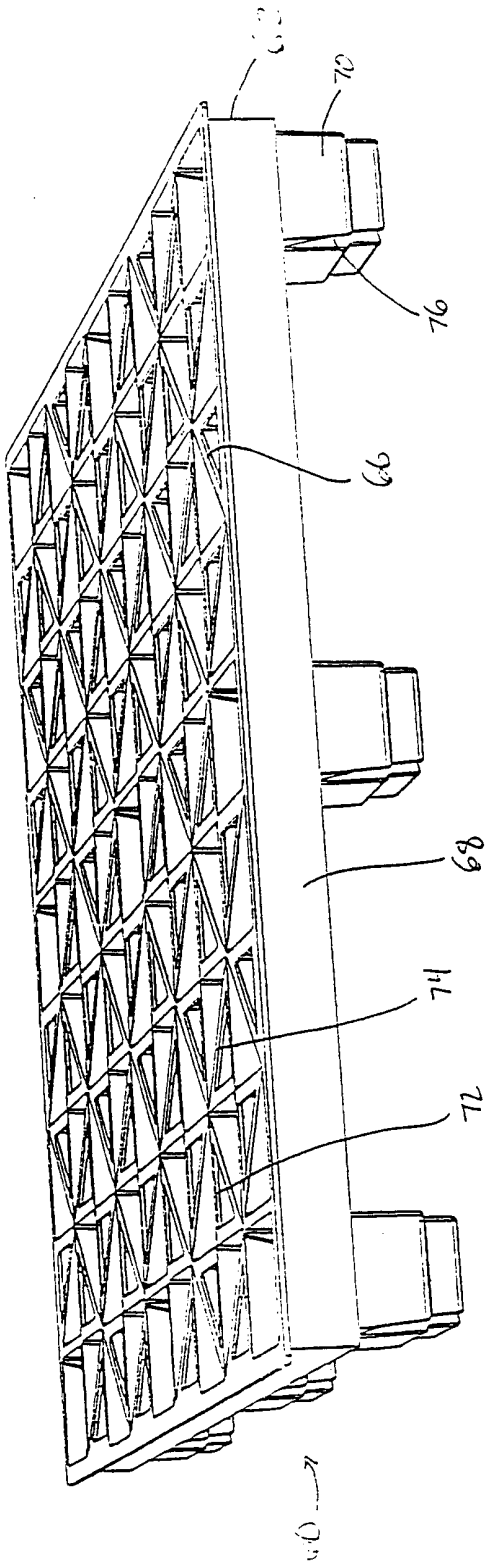


FIG. 10

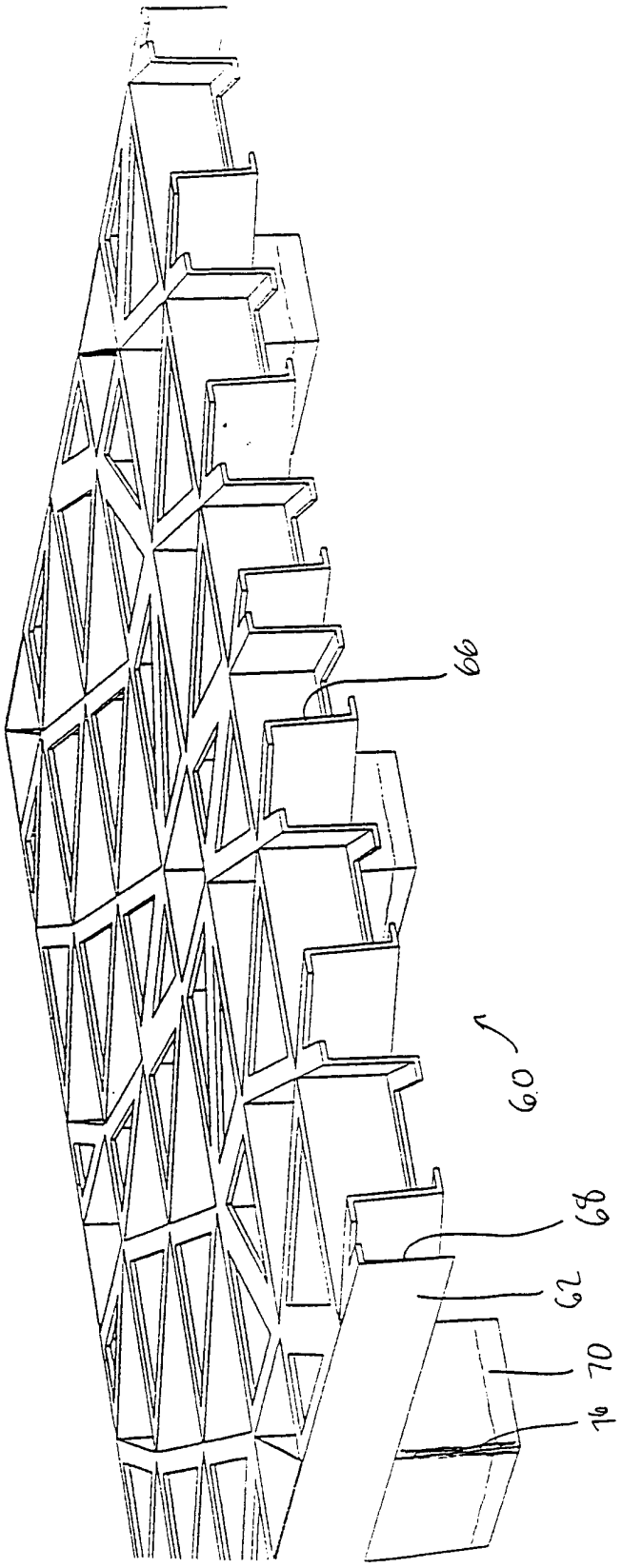
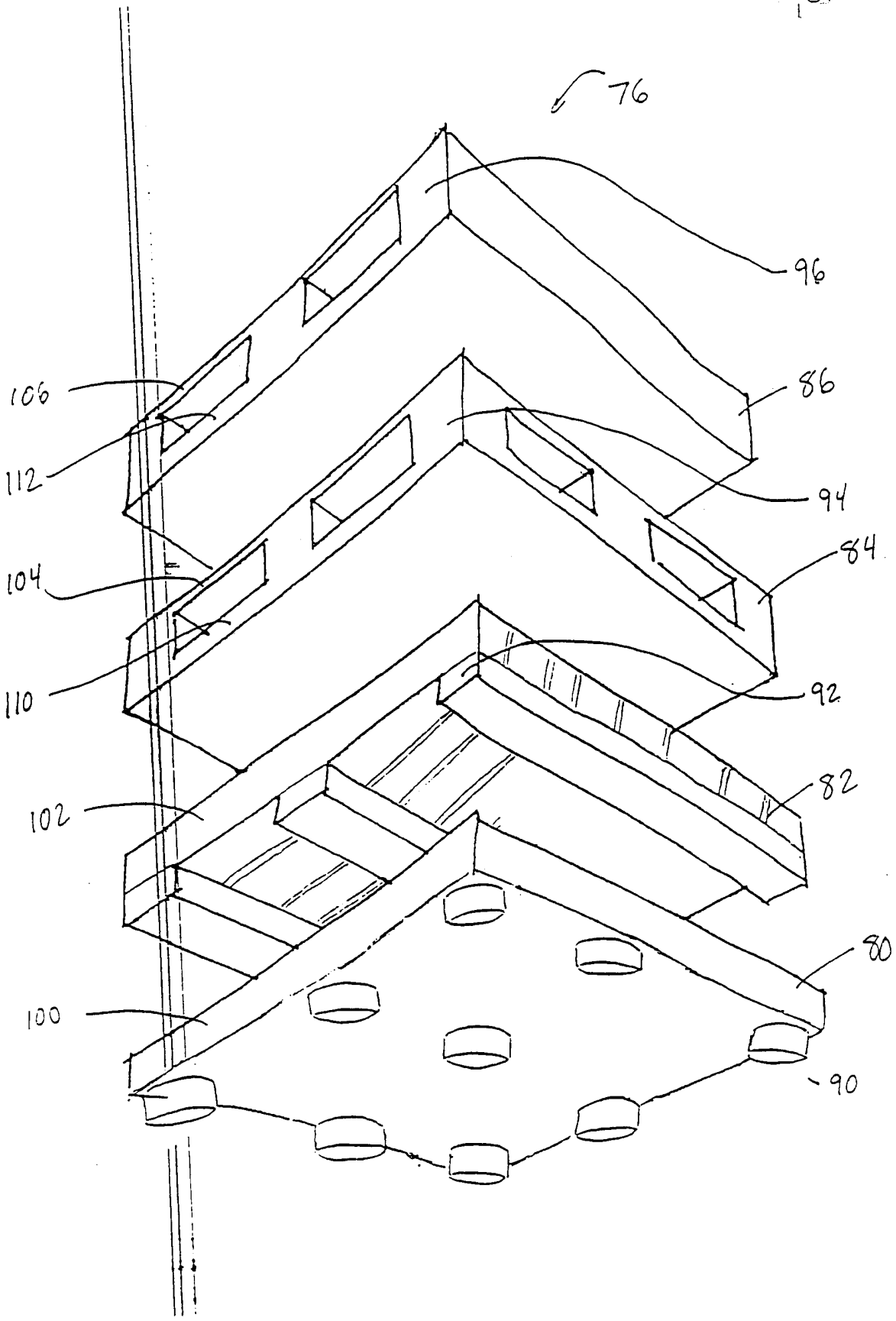


FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/28629

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :E04C 1/00; B65D 19/38
US CL :52/309.1
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 52/309.1; 108/57.25, 57.28, 901, 902, 51.11

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3,580,190 A (FOWLER) 25 May 1971 (25/05/71), see entire document.	13-17
A	US 4,013,021 A (STEINLEIN ET AL) 22 March 1977 (22/03/77), see entire document	1-51
Y	US 4,103,857 A (LEVENHAGEN) 01 August 1978 (01/08/78), see entire document.	1-12, 18-47
A	US 5,483,899 A (CHRISTIE) 16 January 1996 (16/01/96), see entire document.	1-51
A	US 5,527,585 A (NEEDHAM ET AL) 18 June 1996 (18/06/96), see entire document.	1-51
A	US 5,555,820 A (SHUERT) 17 September 1996 (17/09/96), see entire document.	1-51

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
28 JANUARY 2001	[illegible]
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer JOSÉ V. CHEN Diane Smith for Telephone No. (703) 308-2168

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/28629

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,687,652 A (RUMA) 18 November 1997 (18/11/97), see entire document.	1-51
X --- Y	US 5,791,262 A (KNIGHT ET AL) 11 August 1998 (11/08/98), see entire document.	48-51 -------- 1-47
A	US 5,845,588 A (GRONNEVIK) 08 December 1998 (08/12/98), see entire document.	1-51
Y, P	US 5,967,057 A (NAKAYAMA ET AL) 19 October 1999 (19/10/99), see entire document.	5