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Pottinger et al.

[11] **3,832,955**

[45] **Sept. 3, 1974**

[54] **REINFORCED PLASTIC PANEL**

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[73] Assignee: **Jered Products, Inc.,** Troy, Mich.

[22] Filed: **Sept. 1, 1972**

[21] Appl. No.: **285,807**

[52] **U.S. Cl.** **108/51**

[51] **Int. Cl.** **B65d 19/18**

[58] **Field of Search** 108/51–58; 52/573

[56] **References Cited**

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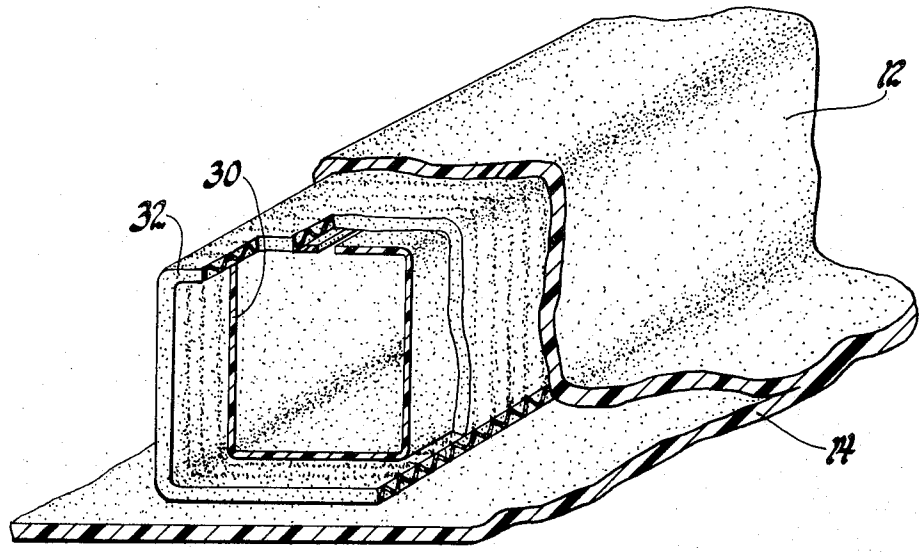
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Assistant Examiner—G. O. Finch
Attorney, Agent, or Firm—Robert G. Mentag

[57] **ABSTRACT**

A plastic panel adapted to be formed by a vacuum forming or other molding processes including a pair of plastic sheets fused together with high strength inserts encapsulated therebetween, the inserts defining reinforing ribs of substantial bending modulus, or a pattern for forming a stiffening configuration or reinforcement in the fused sheets, and means for establishing compliance between the reinforcements and the plastic sheet material during cooling following the forming operation.

8 Claims, 15 Drawing Figures



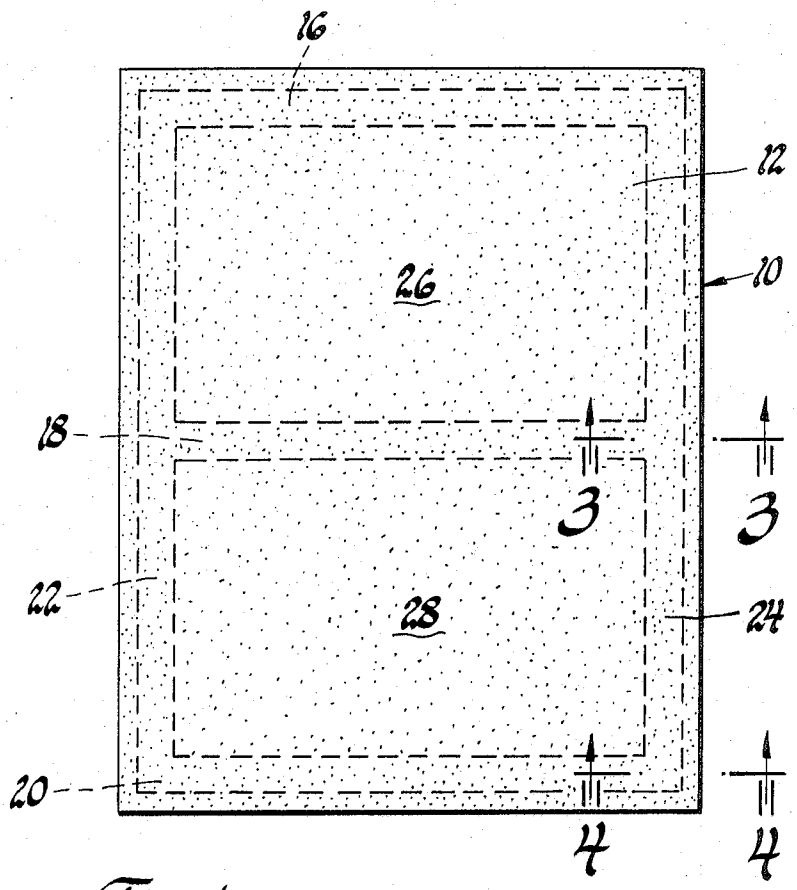


Fig. 1

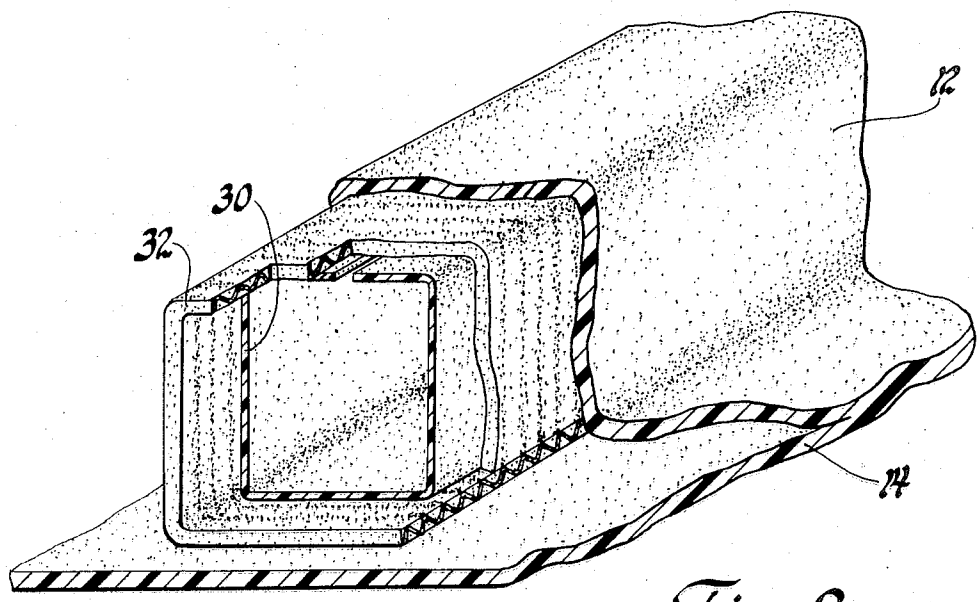


Fig. 2

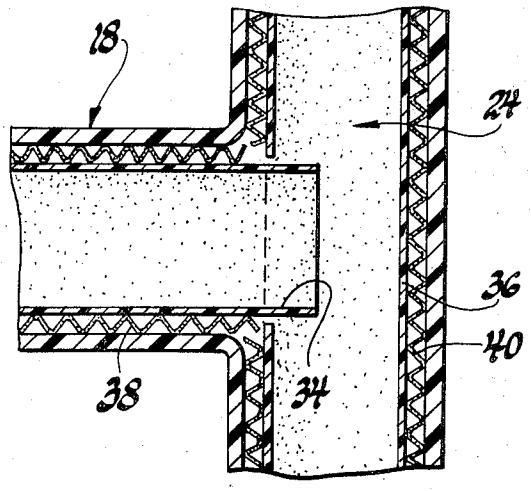


Fig. 3

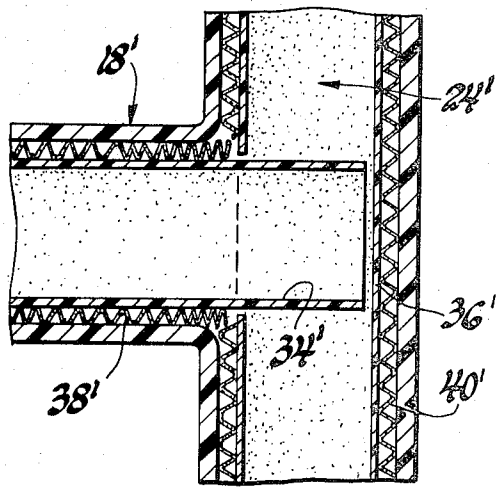


Fig. 3A

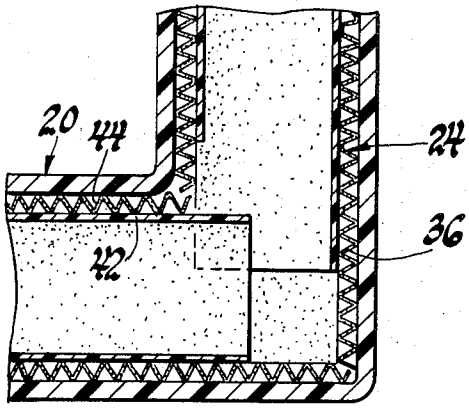


Fig. 4

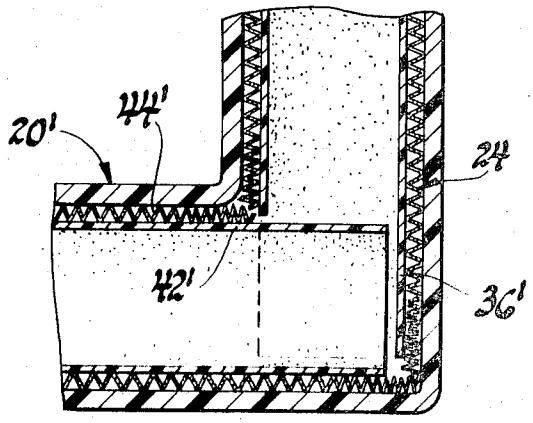


Fig. 4A

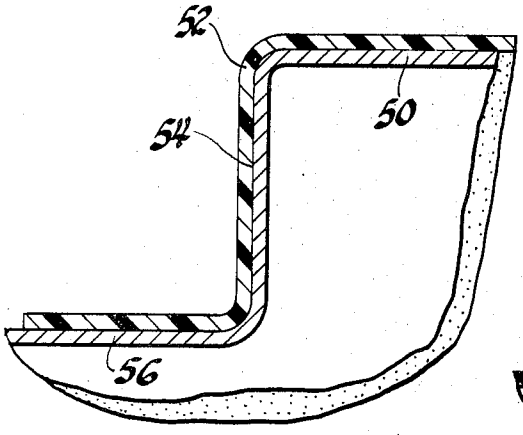


Fig. 5

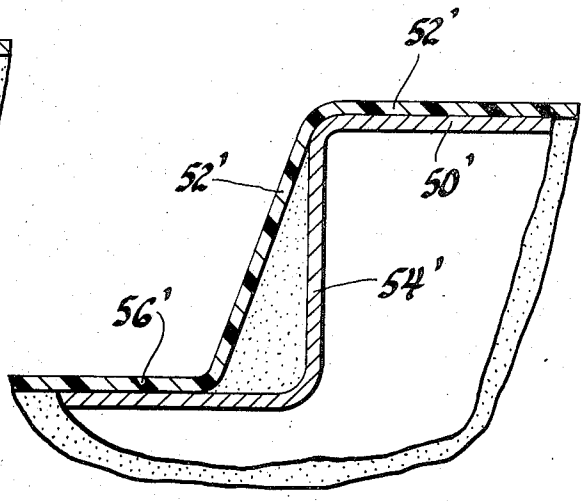


Fig. 5A

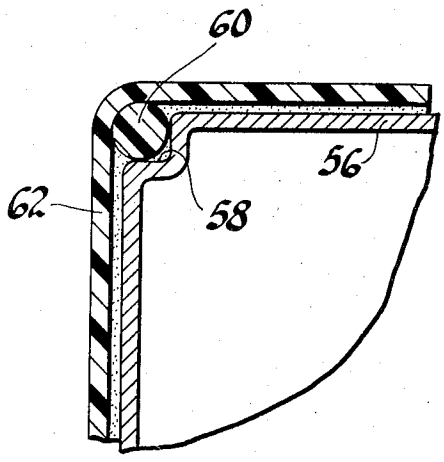


Fig. 6

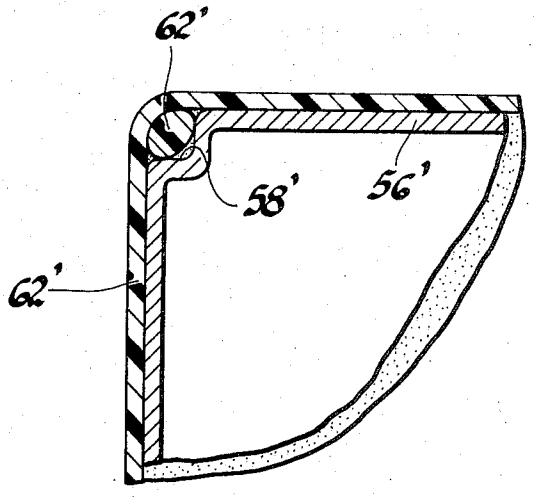


Fig. 6A

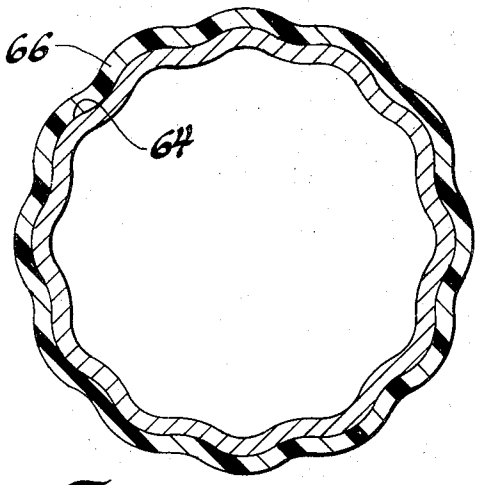


Fig. 7

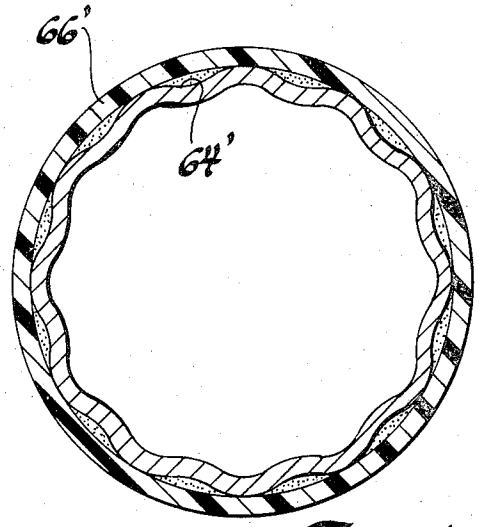


Fig. 7A

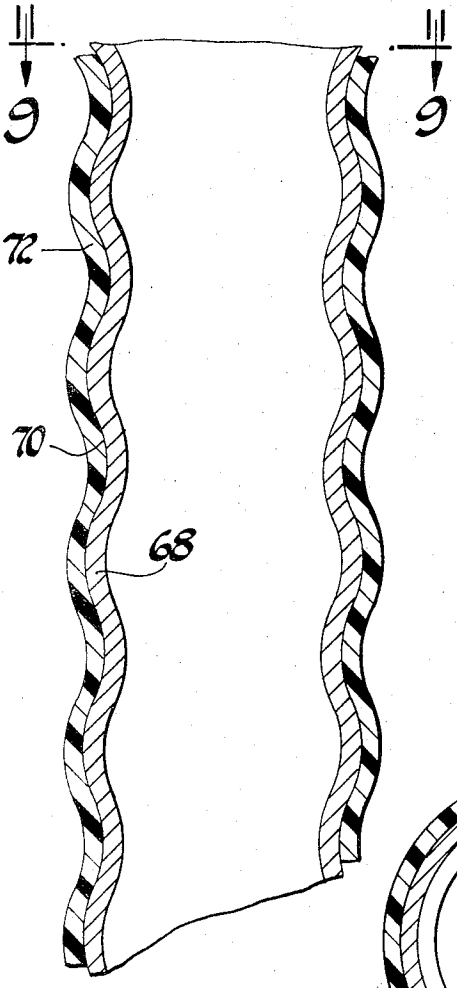


Fig. 8

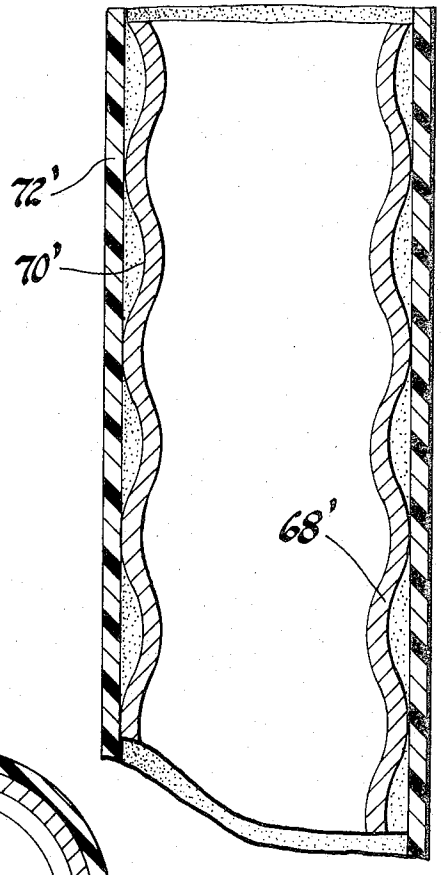


Fig. 8A

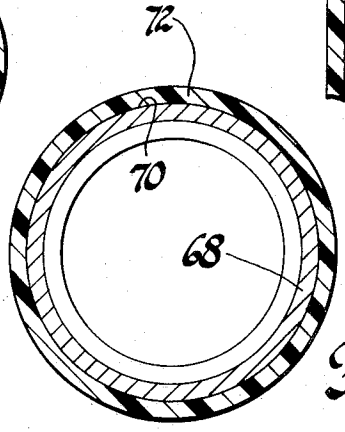


Fig. 9

REINFORCED PLASTIC PANEL

GENERAL DESCRIPTION OF THE INVENTION

This application is related to our co-pending application Ser. No. 285,900. The improvements of our invention are adapted especially to be used in the manufacture of plastic pallets for supporting loads such as warehouse containers, manufacturing materials or the like. We contemplate, however, that our invention may be used in other types of panels. For purposes of describing a preferred embodiment, we will describe in this specification a pallet. Our improved design is capable of being manufactured by vacuum forming two plastic sheets which define spaced outer skins that are connected together by spacers and reinforcing ribs, but other thermal forming processes also might be used.

We are aware of prior art plastic pallets having formed plastic sheets that are joined together with suitable spacers and strengthening ribs into an integrated plastic panel structure. Examples are described in U.S. Pat. Nos. 3,563,184, 3,467,032 and 3,404,642. Our improvements are related to these disclosures insofar as the choice of material and the thermoplastic forming steps are concerned. Our improved design, however, is capable of overcoming shortcomings found in prior art plastic panels or pallets where the panel or pallet is intended for relatively high loading.

The structural load supporting characteristics and the bending modulus of our improved design is substantially increased, thereby eliminating large deflections caused by bending or creep of the plastic material due to loading over a long period of time or due to excessive loads. If the panel or pallet is intended to be stored on a rack when it is loaded, it has been unacceptable heretofore to use thermoplastic forming materials in manufacturing the panel or pallet because of the inability of thermoplastic materials to tolerate the bending loads, especially sustained bending loads.

There have been some attempts to reinforce plastic panels so that they might be adapted for the higher bending loads. This heretofore has involved the introduction of suitable strengthening ribs into an encapsulating plastic shell which defines the upper and lower surfaces of the panel. The ribs of such panels are intended to provide suitable strength characteristics for the composite structure while the outer thermoplastic sheets could be designed to resist abrasion, impact and corrosive effects of certain solvents and contaminants that might exist in the storage area in which the panels or pallets would be used. These rib inserts usually are formed of wood products or metal which are relatively unaffected dimensionally by changes in temperature during the manufacturing process. The thermoplastic sheets that encapsulate these inserts, in contrast, are subjected to substantial shrinkage during the cooling process following the thermoplastic forming of the sheets. The shrinkage of the plastic skin for the panel or pallet during cooling then creates local stresses in the regions of the reinforcing ribs. Even in those instances when the high load concentrations resulting from the residual stresses of the plastic during cooling do not cause rupture, failure of the plastic skin may occur within a short period of time after the panel or pallet is loaded.

The improved construction of our invention makes it possible to use reinforcing beams or ribs within the encapsulating plastic skin while permitting a high degree of compliance between the material of the beam or rib and the plastic skin. Residual stresses are reduced to an acceptable stress level due to the differential expansion characteristics of the material for the inserts or reinforcements and the plastic material of the skin.

The reinforcements of the disclosed construction are formed with a box beam configuration, but other designs also may be used. In one embodiment, the beam is surrounded by a corrugated paperboard sheath which assumes the shape of the beam. The sheath engages the plastic as the plastic encapsulates the reinforcements. During cooling the sheaths permit compliance between the skin and the beam construction. Provision is made also for the individual beam elements to shift, one with respect to the other, as required by a differential contraction that results during the cooling step in the forming of the thermoplastic material.

There are at least three basic categories of compliance that may be relied upon to offset the tendency for differential contractions to produce localized stresses. For present purposes these may be called "integrated compliance", "interstitial compliance" and "localized compliance".

Integrated compliance is achieved by making provision for changes in overall dimension of the pallet with respect to any one or all of the principal coordinate axes of reference that may be used to define the geometry of the finished pallet.

Interstitial compliance takes place as the thermoplastic material assumes a reorientation with respect to the rigid reinforcing member situated directly adjacent to it. The reorientation may be transverse with respect to the reinforcing member whereby the clearance between the reinforcing member and the thermoplastic material is changed as the temperature of the thermoplastic material changes, or it may be in a direction generally parallel to the principal plane of the adjacent surface of the reinforcing member. It also may involve a combination of these two compliance modes.

Localized compliance takes place as the thermoplastic material, at a particular character or reference location, such as a corner, is allowed to shift locally relative to an adjacent reinforcing member. For example, if the finished pallet or plastic panel is characterized by an inside corner extending throughout a predetermined distance, the thermoplastic material may assume the general configuration of the inside corner when the material is at the molding temperature. Upon cooling, however, shrinkage occurs in the thermoplastic material in the region of the inside corner as well as in the adjacent regions. Localized compliance in the region of the corner is achieved by allowing the plastic material to separate from the reinforcing member thereby compensating for the total shrinkage. Localized compliance on an outside corner forming a principal character or reference line for the finished pallet or panel can be achieved by providing a deformable insert between the thermoplastic material and the reinforcing panel only at the region of the outside corner but not at adjacent regions. As the thermoplastic material changes in dimension upon a change in temperature, the resultant contraction in regions of the thermoplastic material adjacent the outside corner will cause the yieldable material to be crushed or deformed and the thermoplastic material tends to conform to the contour of the reinforcing member.

The embodiment described in FIGS. 1 through 4A of this disclosure may be described as a combination of integrated compliance and interstitial compliance. It is conceivable, however, that other embodiments could include other combinations of the three types of compliance.

GENERAL DESCRIPTION OF THE FIGURES OF THE DRAWINGS

FIG. 1 shows a plan view of a pallet incorporating the improvements of our invention.

FIG. 2 shows a typical beam construction used for reinforcing the pallet of FIG. 1.

FIG. 3 is a cross sectional detailed view of the region of intersection of two reinforcing beam structures used in the pallet of FIG. 1.

FIG. 3A shows the structure of FIG. 3 after the pallet has been cooled following the vacuum forming steps.

FIG. 4 shows a corner intersection of two peripheral reinforcing beam structures used in the pallet of FIG. 1.

FIG. 4A shows the same structure as FIG. 4 after the pallet has been cooled following the vacuum forming steps.

FIG. 5 shows a portion of a reinforcing panel section with a surrounding sheet of thermoplastic material as it would appear in a heated state.

FIG. 5A shows the same structure shown in FIG. 5 after it has been cooled.

FIG. 6 shows an outside corner for a reinforcing member as the plastic sheet and the reinforcing member would appear in a heated state.

FIG. 6A is an illustration of the structure shown in FIG. 6 after the temperature is lowered.

FIG. 7 is a sketch showing a reinforcing member with depressions or convolutions extending axially with respect to the principal axis of the member and a surrounding sheet of thermoplastic material as it would appear in a heated condition.

FIG. 7A shows the same structure as FIG. 7 after the thermoplastic material has cooled.

FIG. 8 shows a reinforcing member which may be generally round in cross section and having peripheral recesses or undulations with the thermoplastic sheet conforming to the surface of the reinforcing member, when the material is at the forming temperature.

FIG. 8A is a sketch showing the relative positions of the thermoplastic material and the reinforcing member of FIG. 8 after the temperature is reduced.

FIG. 9 is a view of the member of FIG. 8 as seen from the plane of section line 9—9 of FIG. 8.

PARTICULAR DESCRIPTION OF THE INVENTION

In FIG. 1, reference character 10 designates generally the improved panel or pallet of our invention. It includes an upper thermoplastic sheet 14 which forms a rectangular load supporting surface. The sheet 14 is situated in juxtaposed registering relationship with respect to a bottom sheet or skin 12, as indicated in FIG. 2.

Three horizontal reinforcing box beams are shown in FIG. 1. These are identified by reference characters 16, 18 and 20. These intersect two vertical side beams 22 and 24. The beams 22, 16, 24 and 20 are arranged about the periphery of the plastic sheets, and beam 18 forms an intercostal beam member joining the intermediate regions of the side beams 22 and 24. If desired, the intermediate regions indicated generally by reference characters 26 and 28 may be formed with reinforcing ribs and spacers in the manner described in our co-pending application, Ser. No. 285,900, or in the manner described in the previously mentioned prior art patent disclosures.

The intermediate region of any one of these beams illustrated in FIG. 1 is best seen by referring to FIG. 2. In FIG. 2 a box beam of rolled configuration is shown at 30. The beam 30 may be made of metal but other materials may be chosen depending upon the design requirements. It is surrounded by a sheath 32 which may be corrugated paperboard or the like. The sheath 32 and the beam 30 are encapsulated by the plastic sheets 12 and 14 during a thermoplastic forming operation. Reference may be made to our copending application Ser. No. 285,900 for a further description of the manner in which the sheets may be formed using the vacuum forming process.

When the sheets 14 and 12 are cooled following the forming steps, a considerable degree of shrinkage occurs. The sheath 32 permits the necessary compliance to reduce residual stresses in the plastic sheets that otherwise would be present.

The amount of the shrinkage that occurs in the plastic relative to the inserts is determined by the particular plastic that is used and the dimensions of the pallet or panel itself.

In FIG. 3, we have shown in cross sectional form the intersection of the intercostal beam member 18 and the peripheral side member 24. The side member 24 is formed with an opening for receiving the right end of the box-like structural beam 34. The opening in the box-like beam 36 for the side beam member 24 is sufficiently large to permit free entry of the beam portion 34 without interference. The beam portion 34 is surrounded by the compliant sheath 38, which was previously described. Similarly, the box member 36 of the side beam is surrounded by a sheet 40, also formed of compliant corrugated cardboard or paper material. Both beam inserts 34 and 36 are surrounded by a plastic skin.

After the pallet or panel is cooled, the beam inserts 34 and 36 assume the relative position shown in FIG. 3A. For purposes of identification, the elements of FIG. 3A have been identified by similar reference characters, although prime notations have been added. Note that the ends of the beam insert 34' enter the cavity occupied by the beam insert 36' and that the sheath 38' becomes compressed at the intersection of the two beam inserts 34' and 36'. The compliance thus offered by the sheath 38' reduces the resultant stresses in the plastic skin.

In FIG. 4 we have illustrated the intersection of the ends of side beam 24 and end beam 20. The end beam 20 includes a box shape beam insert 42 which slides through an end opening in the box sheet beam insert 36 as indicated. When the plastic material encapsulating the beam is at an elevated temperature during the thermoplastic forming operation, only a small portion of the ends of the box shaped beam inserts 36 and 42 are overlapping. The degree of overlapping increases, however, as the pallet is cooled. The positions of the inserts due to shrinkage then assume the dispositions shown in FIG. 4A. The sheath that surrounds the box-like beam insert 42 is shown at 44. As indicated in FIG. 4A, the

sheath **44** is compressed at the intersecting corners of the box-like beam inserts **36** and **42.**

The structural panel of our invention with its encapsulated reinforcing beam members reduces to an acceptable level the residual stresses in the plastic at any point. While using this construction, the thickness of the plastic material may be reduced both in weight and in cost, thereby compensating for the weight and cost of the structural insert itself.

FIG. **5** shows an example of localized compliance which does not involve the concept of interstitial compliance as shown in FIGS. **1** through **4A** where an intermediate sheet of material is crushed at the regions where deformation must occur to avoid excessive localized stresses. In FIG. **5** we have shown in cross sectional form a channel or beam section **50** and a surrounding thermoplastic sheet **52.** FIG. **5** shows the relative positions of the sheet during the forming operation at elevated temperatures. The sheet assumes the general configuration of the beam cross section. Upon cooling of the thermoplastic material, it shrinks and the sheets break away as indicated at **52'** in FIG. **5A.** If the separation were resisted, residual stresses would occur in the localized region of the inside corner.

In FIG. **6** we have shown localized compliance that might occur on an outside corner.

The reinforcing member shown in FIG. **6** at **56** and its corner is grooved as shown at **58.** Located in the groove is a deformable member **60** which may be of any suitable material. The thermoplastic sheet **62** is formed about the corner and encloses the material **60.** During the high temperature thermoplastic forming operation, when the thermoplastic material cools, it conforms more closely to the shape of the reinforcing member, as shown at **62'** in FIG. **6A.** The deformable member, which is shown at **60'** in FIG. **6A** reduces to an acceptable level any localized stresses in the thermoplastic material.

In FIGS. **7, 7A, 8** and **8A,** we have illustrated two types of integrated compliance. In FIG. **7,** the reinforcing member **64** is formed with longitudinal recesses or undulations extending generally in the direction of the axis of the member **64.** Surrounding the undulated or recessed surface of the member **64** is a sheet of thermoplastic material **66.** When the material is heated, as it is during the thermoplastic forming operation, it conforms to the general shape of the surface. When the temperature is lowered following the forming operation, the thermoplastic material contracts, as shown at **66',** and separation occurs intermediate the crests, thereby avoiding the development of internal stresses in the material. Another example of the so-called integrated compliance may be obtained by producing undulations that extend in a peripheral direction as indicated in FIG. **8.** The reinforcing member of FIG. **8** is shown at **68.** It includes undulations extending in a peripheral direction as indicated at **70.** The thermoplastic material **72** conforms to the peripheral undulations when it is heated during the forming operation. Separation occurs, as indicated at **72',** upon cooling. As before, masking material may be applied to the members at the localized regions where separation is desired.

Any given pallet or panel design may involve one or more of the various types of beam or corner constructions, and one or more types of the three generally described types of compliance. The embodiment shown in FIG. **6** involves both interstitial compliance and localized compliance. If the beam or reinforcing member of FIG. **6** is formed so that it may serve as a principal reinforcing member, such as that shown in FIG. **8,** the reinforcing member **56** of FIG. **6** could be characterized also by integrated compliance where relative shifting movement of the plastic material relative to the reinforcing member occurs throughout the entire principal dimension of the reinforcing member, rather than at a localized region only.

Having thus described preferred forms of our invention, what we claim and desire to secure by U.S. Letters Patent is:

1. A reinforced plastic member comprising a pair of formed thermoplastic sheets situated in juxtaposed registering relationship, the margins of said sheets being joined together to form an interior cavity, structural inserts having terminations in said cavity encapsulated by said sheets, said inserts being reinforcing beam constructions of rigid material, and compressible means for separating the sheets from the rigid material to establish relative movement of the sheets with respect to the rigid material at said insert terminations thereby avoiding internal stresses in said sheets due to differential changes in dimensions of the plastic material of the sheets and the rigid material of the inserts upon changes in temperature.

2. A reinforced plastic panel comprising a pair of formed thermoplastic sheets situated in juxtaposed registering relationship, the margins of said sheets being joined together to form an interior cavity, structural inserts in said cavity encapsulated by said sheets, said inserts being reinforcing beam constructions of rigid material, a compressible sheath surrounding said beam constructions, said sheath being sandwiched between the encapsulating material and the rigid material of the beams thereby avoiding internal stresses in said sheets due to differential changes in dimension of the plastic material of the sheets and the rigid material of the inserts upon changes in temperature.

3. The combination as set forth in claim **2,** wherein: said reinforcing beams are arranged about the periphery of said sheets, said beams having their registering ends intersecting each other, the rigid material of one beam on one margin portion of said sheets being received within the adjacent rigid beam on an adjacent margin of said sheets, whereby said rigid beams may shift one with respect to the other due to shrinkage of said plastic material upon changes in temperature.

4. The combination as set forth in claim **3,** wherein: said beams include also an intermediate beam bridging intermediate portions of two opposed peripheral beams, thereby increasing the rigidity of the panel at the intermediate load supporting surface.

5. A reinforced plastic panel comprising, a pair of formed thermoplastic sheets situated in juxtaposed registering relationship, the margins of said sheets being joined together to form an interior cavity, structural inserts in said cavity encapsulated by said sheets, said inserts being reinforcing beam constructions of rigid material, a compressible sheath surrounding said beam constructions, said sheath being sandwiched between the encapsulating material and the rigid material of the beams thereby avoiding internal stresses in said sheets due to differential changes in dimension of the plastic material of the sheets and the rigid material of the inserts upon changes in temperature, said reinforcing beams being arranged about the periphery of said

sheets, said beams having their registering ends intersecting each other, the rigid material of one beam on one margin portion of said sheets being received within the adjacent rigid beam on an adjacent margin of said sheets, whereby said rigid beams may shift one with respect to the other due to shrinkage of said plastic material of the sheets upon changes in temperature, said beams including also an intermediate beam bridging intermediate portions of two opposed peripheral beams, thereby increasing the rigidity of the panel at the intermediate load supporting surface, the ends of said intermediate beam intersecting the intermediate portions of said opposed beams, said opposed beams being formed with apertures that receive the ends of said intermediate beam, the ends of the latter overlapping intermediate portions of the opposed beams whereby relative shifting movement therebetween is accommodated upon changes in dimension of said plastic material due to changes in temperature.

6. The combination as set forth in claim **1**, wherein: said inserts form an internal corner and one of said sheets is separated from said reinforcing member in the region of said corner.

7. The combination set forth in claim **1** wherein said reinforcing member includes one or more recesses defining cavities extending in a predetermined characteristic direction, one of said sheets is separated from said reinforcing member in the region of said recesses, thereby avoiding internal stresses in said thermoplastic material.

8. A reinforced plastic panel comprising a pair of formed thermoplastic sheets situated in juxtaposed registering relationship, portions of said sheets being joined together to form an internal cavity, structural inserts in said cavity encapsulated by said sheets, said inserts being formed of rigid material, a compressible member located between at least one of said sheets and said rigid material, said compressible member being sandwiched between the encapsulating material and the rigid material, thereby avoiding internal stresses in said sheets due to differential changes in dimensions of the plastic material of the sheets and the rigid material of the inserts upon changes in temperature.

* * * * *