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(54) **PLASTIC PALLET HAVING METAL DECK**

Publication Classification

(76) Inventors: **Ronald P. Brochu**, Richmond, KY (US); **Roy E. Moore JR.**, Killingworth, CT (US)

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Correspondence Address:
CHARLES G. NESSLER
P.O. BOX H
CHESTER, CT 06412 (US)

(57) **ABSTRACT**

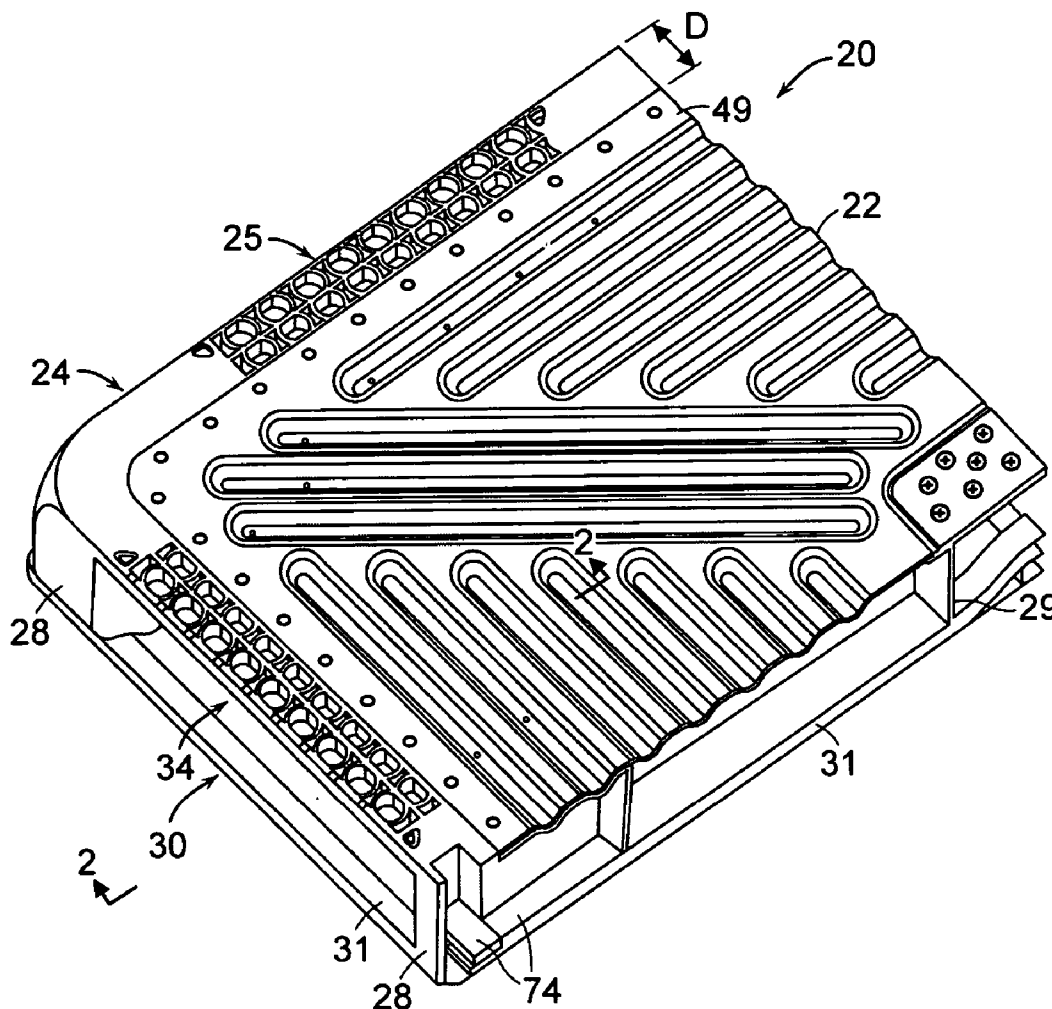
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(60) Provisional application No. 60/654,760, filed on Feb. 18, 2005. Provisional application No. 60/654,761, filed on Feb. 18, 2005. Provisional application No. 60/654,765, filed on Feb. 18, 2005. Provisional application No. 60/654,768, filed on Feb. 18, 2005.

A molded plastic pallet has a base comprised of steel beam-reinforced thermoplastic rails reinforced with steel beams, vertical columns, a frame on top of the columns, and a textured metal deck. The metal deck preferably comprises a flange which is attached to the frame or to a subframe which is within the opening of the frame. The edge of the deck is inset from the outer edge of the frame, and the periphery of the top of the frame is exposed. The frame preferably has one or more impact absorbing zones at the bridge portions of the frame, which span the fork openings between adjacent columns.



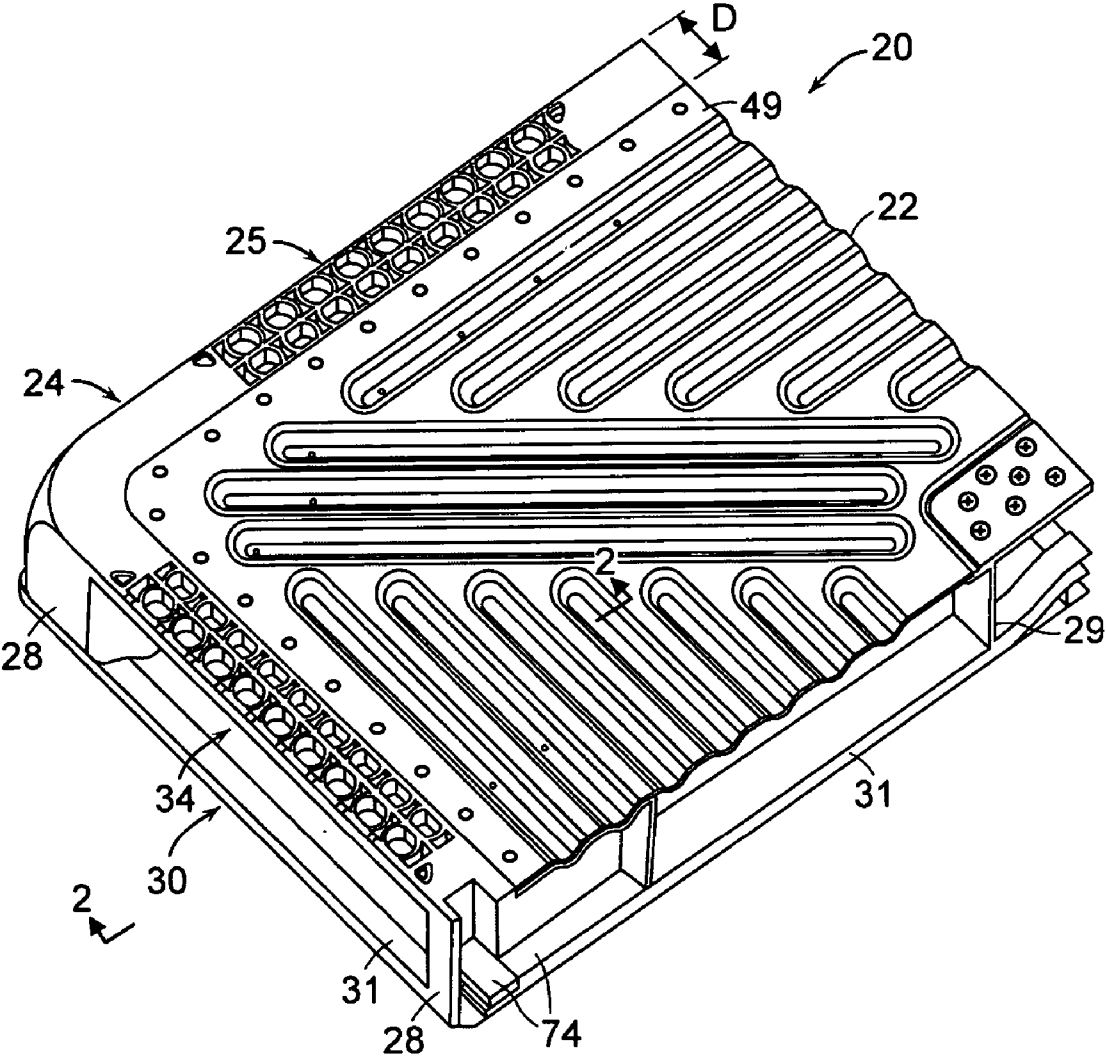


FIG. 1

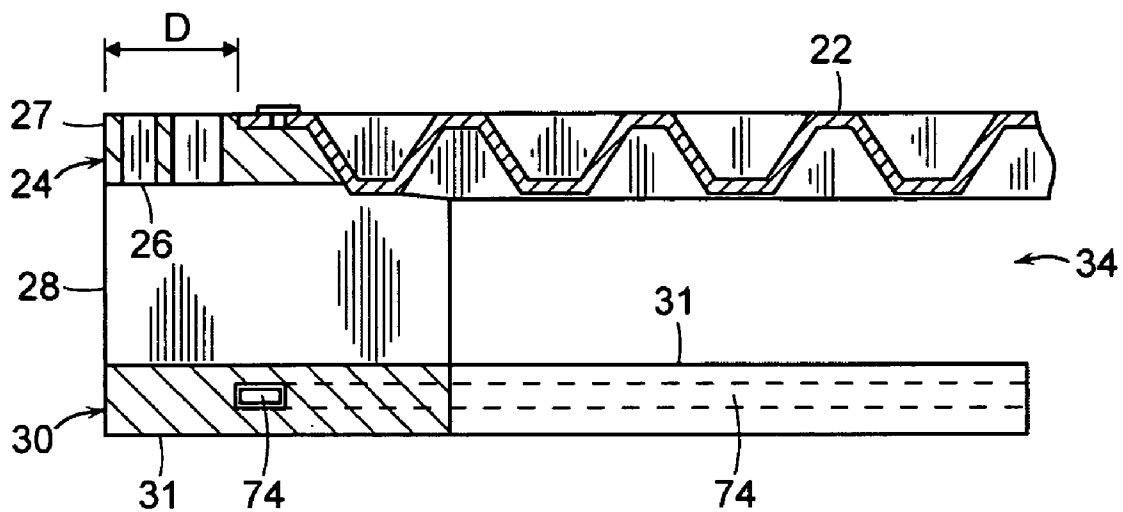


FIG. 2

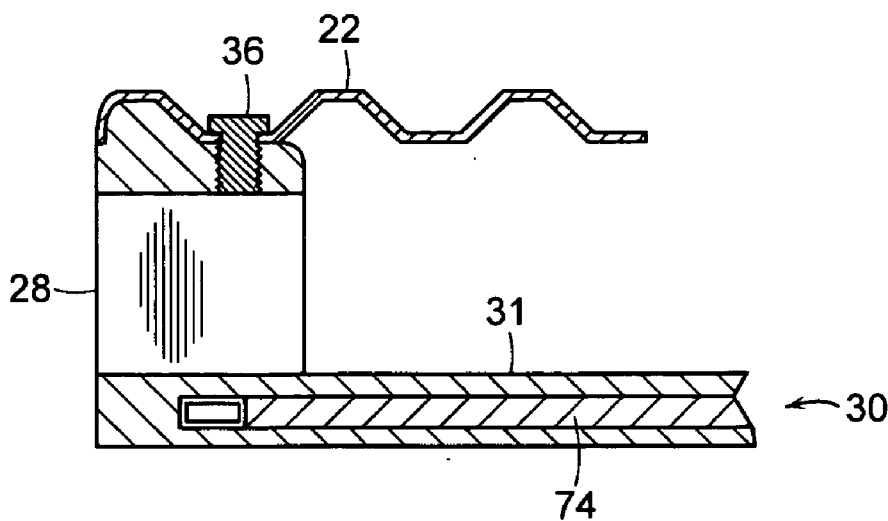


FIG. 3

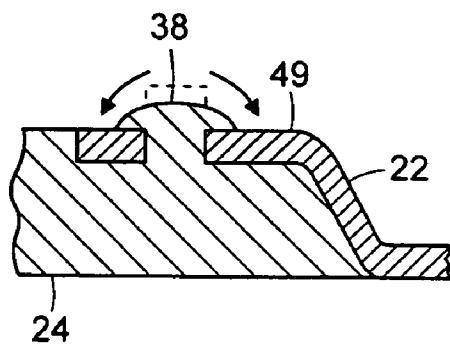


FIG. 4

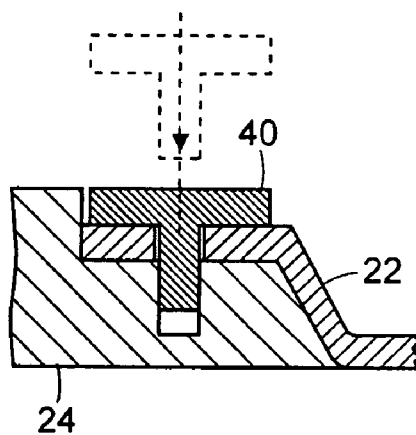


FIG. 5

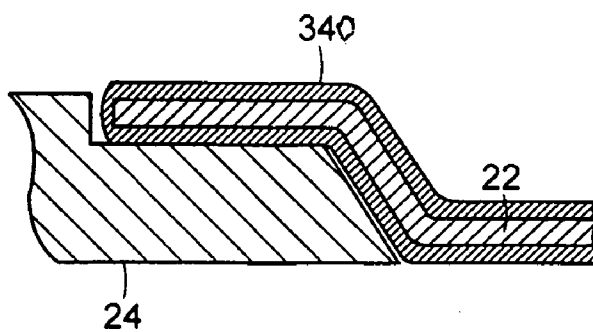


FIG. 6

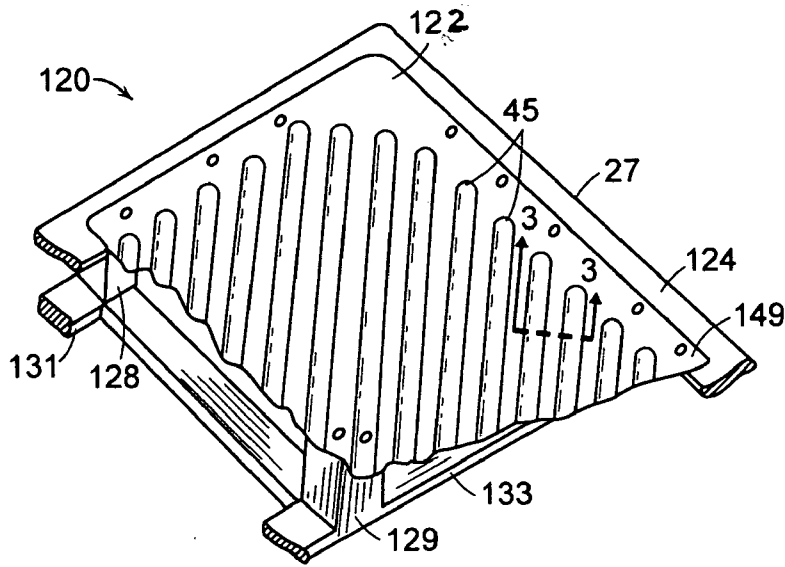


FIG. 7

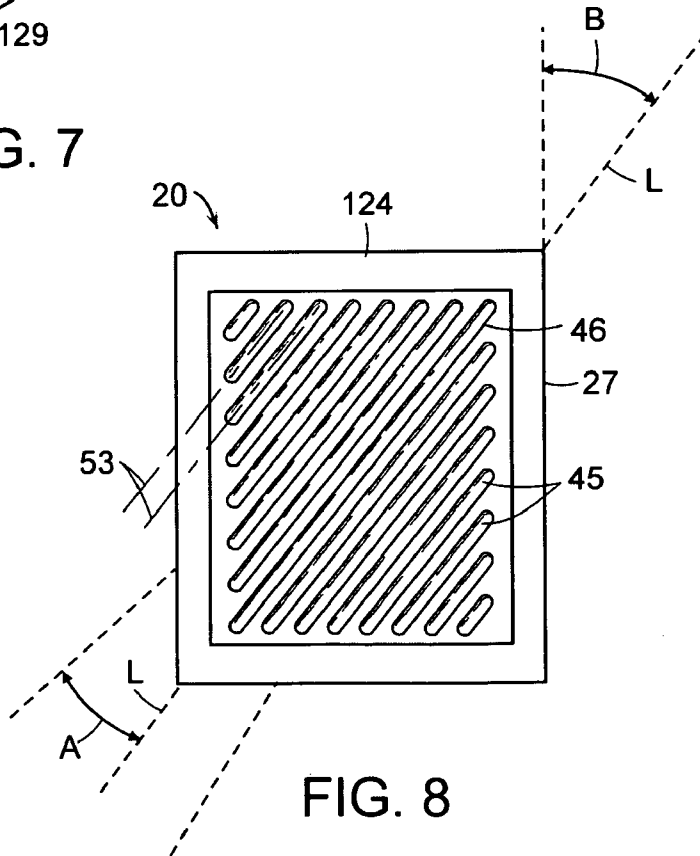


FIG. 8

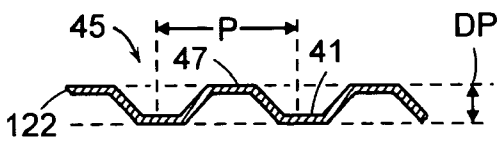


FIG. 9

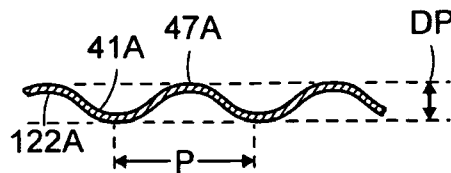


FIG. 10

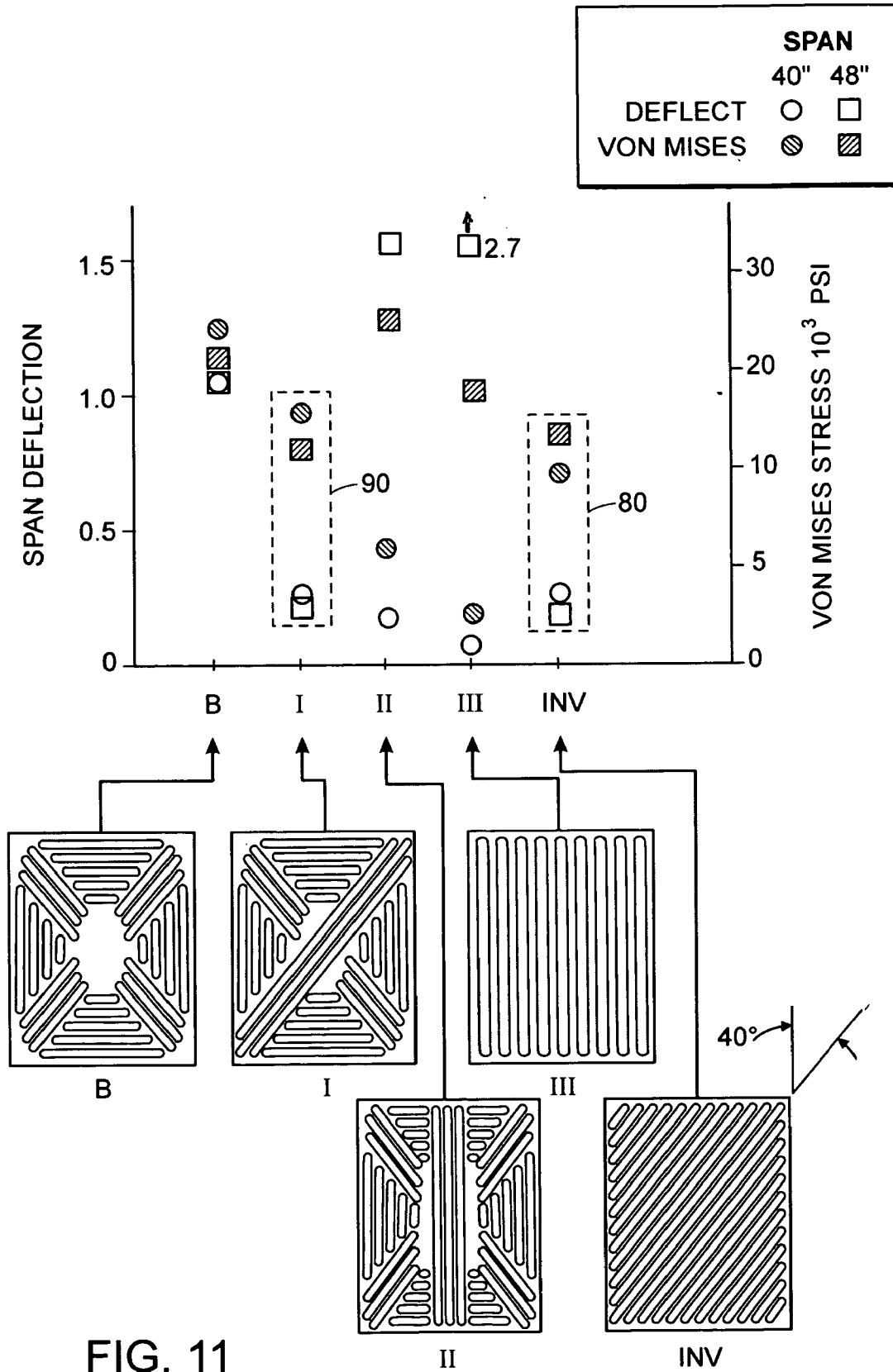


FIG. 11

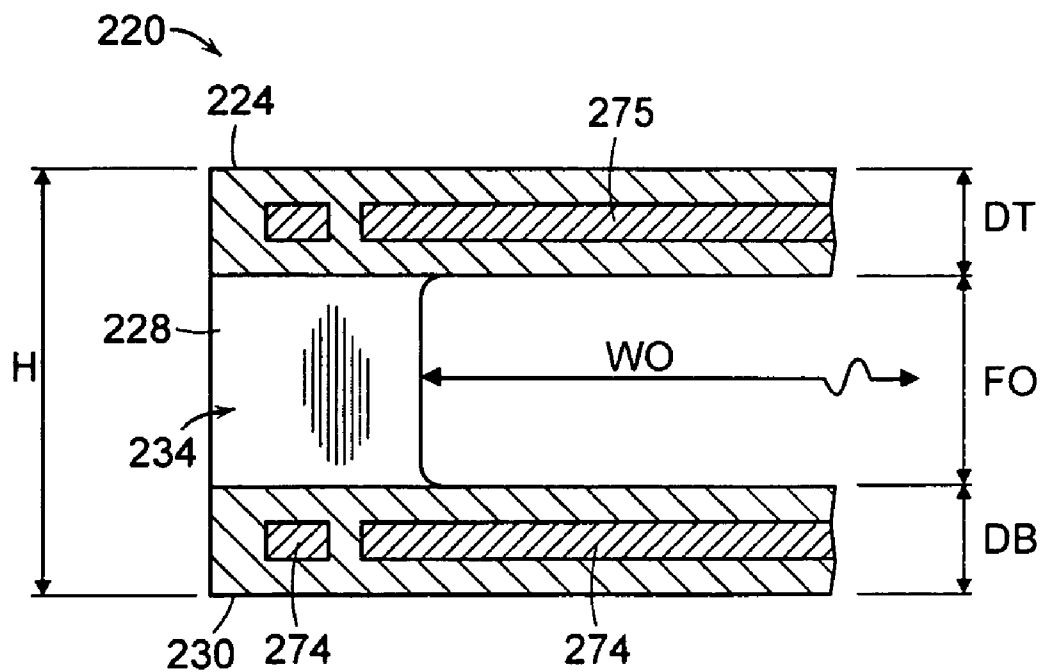


FIG. 12 PRIOR ART

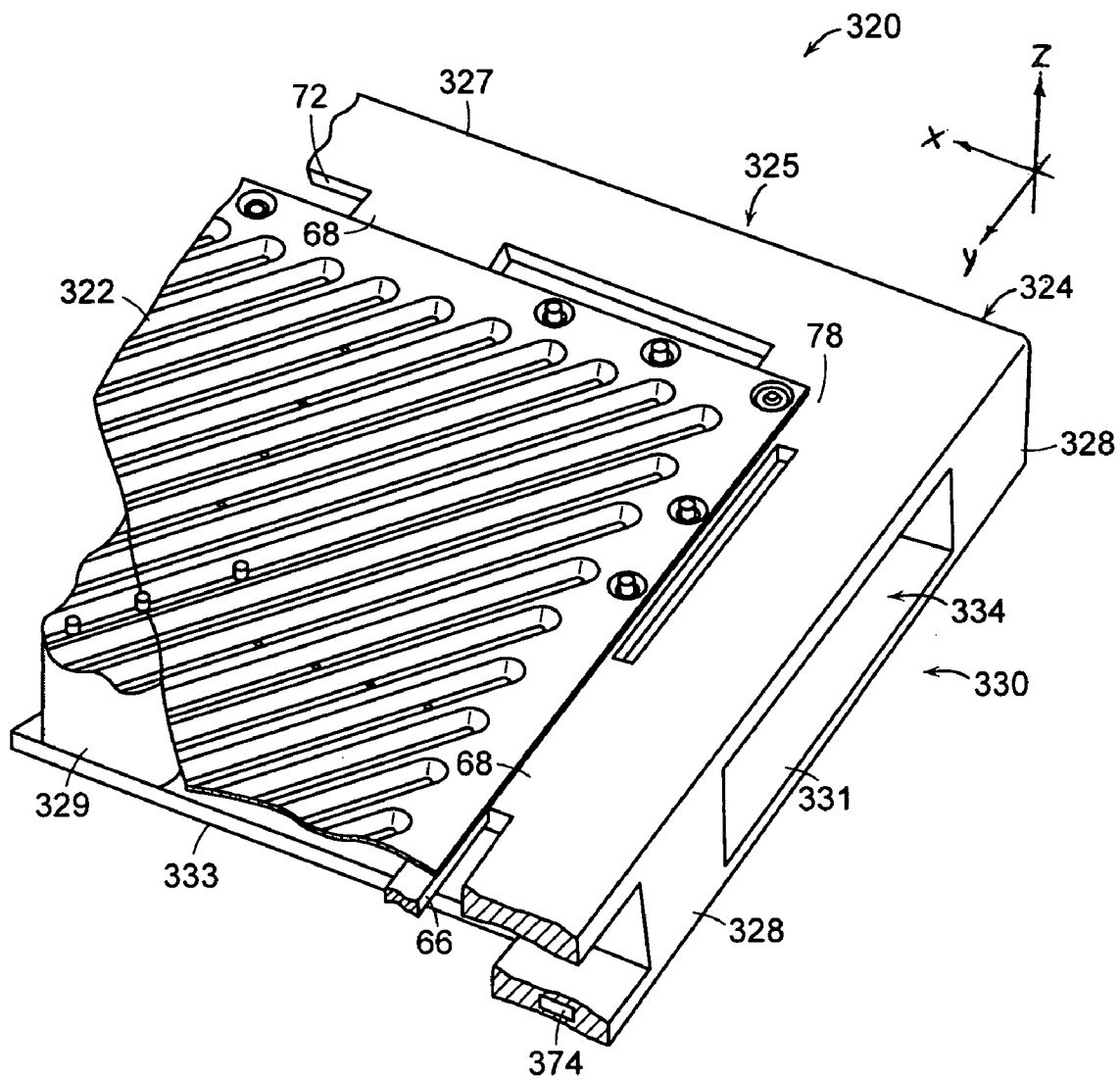


FIG. 13

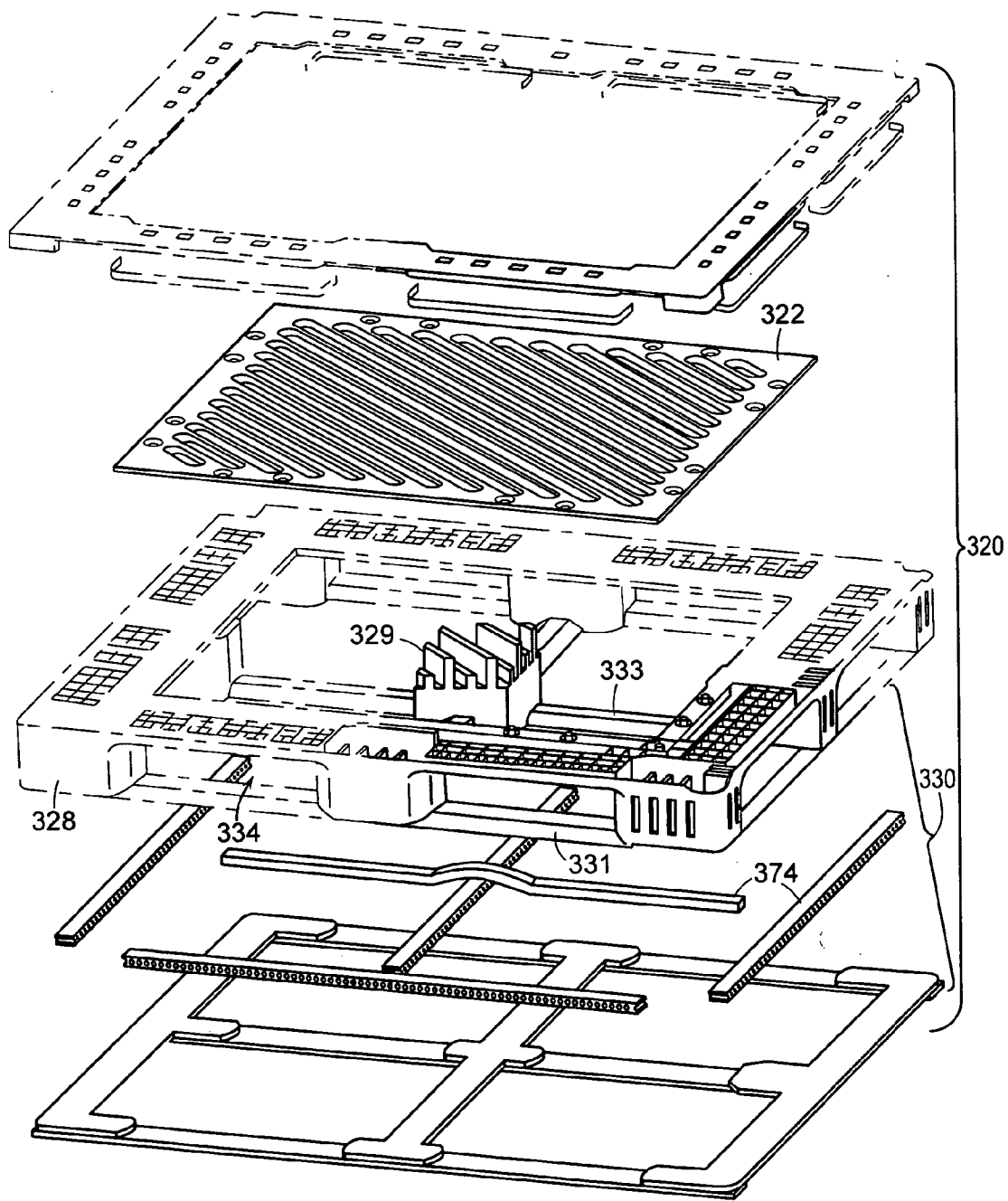


FIG. 14

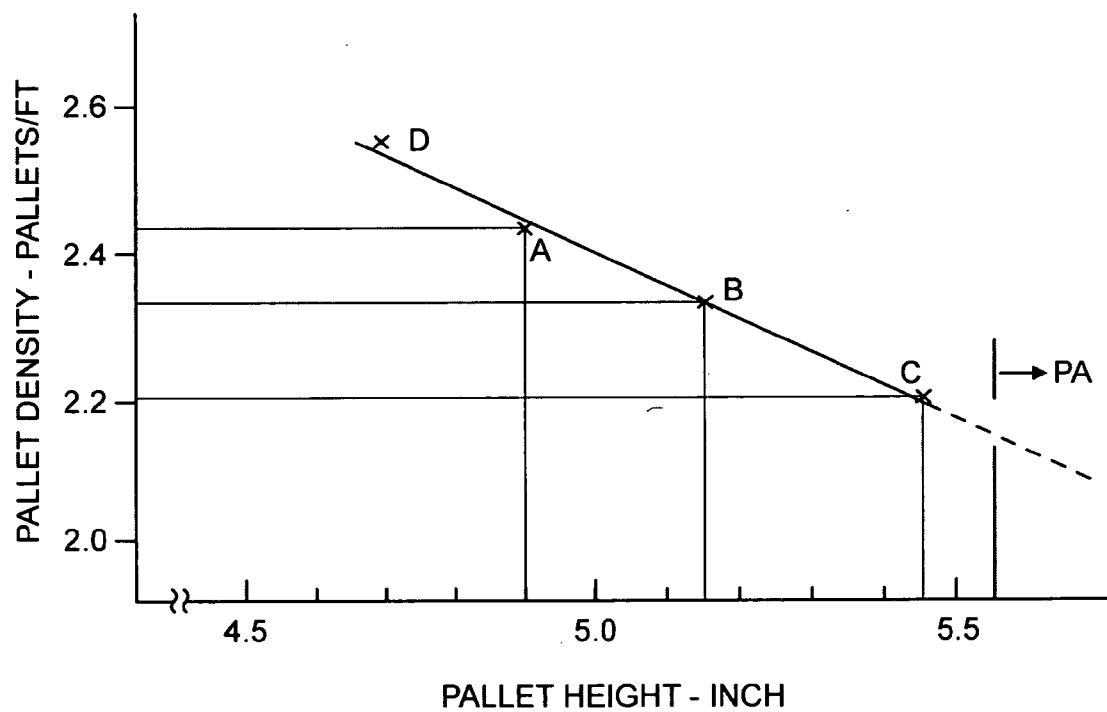


FIG. 15

PLASTIC PALLET HAVING METAL DECK

[0001] This application claims benefit of provisional patent applications Ser. Nos. 60/654,760, 60/654,761, 60/654,765, and 60/654,768, all filed Feb. 18, 2005.

TECHNICAL FIELD

[0002] The present invention relates to plastic pallets, particularly those used for transporting miscellaneous industrial and commercial goods by means of forklift devices and the like.

BACKGROUND

[0003] Rectangular wood pallets have been long used with forklift devices for transporting and storing common goods. They have been attractive because of simplicity and low cost. However, wood pallets are prone to damage during use, and constantly must be replaced or discarded. They also are difficult to keep clean. In recent years plastic pallets have been commercially available. They would seem to offer a number of potential advantages over wood pallets, including better durability, moisture resistance, and other known advantages of a polymer material, compared to wood. Plastic pallets have most often been made of familiar polyolefin thermoplastics; some other polymers have been used, particularly for fire-resistance. However, plastic pallets have not gained wide acceptance, for a number of reasons, which can be stated briefly as relating to a failure to satisfactorily meet all of a variety of criteria, including mechanical performance, weight, cost, and fire resistance.

[0004] A plastic pallet, which can be made in the present invention, is often referred in the U.S. to as a GMA pallet. It has a rectangular base, eight columns running up from the periphery of the base, and a rectangular deck. The pallet is in the shape of a 40 inch×48 inch rectangle. A comparable European pallet is a 1000 mm by 1200 mm pallet, sometimes called a CP-1 pallet. For such pallets to become accepted for widespread use in commerce, they must meet various technical and performance standards. The Grocery Manufacturers of America (GMA), Washington, D.C., U.S., in conjunction with other organizations, has published a document entitled "Recommendations on the Grocery Industry Pallet System" (1992). From that and other references, the characteristics for a GMA pallet which are required for acceptance by large commercial users in the U.S. include the following: The height must be less about 5.56 inches or less. The pallet must allow four-way entry by forks, and each side must have two openings which are at least 3.1 to 3.8 inches high and 12 to 12.5 inches wide. The pallet should weigh less than 55 pounds. The pallet has to be "rackable." By that is meant, among other things, that the pallet must be capable of being held on open beam warehouse racks without failing or exceeding a specified amount of creep deformation when loaded.

[0005] "Recommended Test Protocol for Plastic Pallet, Version 3" (1998) published by Virginia Tech, Blacksburg, Va., U.S., sets forth mechanical performance and test requirements for pallets including a warehouse racking test. ISO 8611:1991 and proposed Underwriters Laboratories (UL) Standard 2417 specify similar mechanical performance and testing standards. Pallets must also meet other standards. UL Standard 2335 specifies fire tests and performance for warehouse pallets made of plastic. To meet such

fire test standard, pallets must not exceed a certain rate of heat release rate during a simulated warehouse fire. ANSI/NSF 2-1996, published by NSF and approved by American National Standards Institute, at Section 7, sets standards for pallets used in food service. Commercial purchasers have their own standards which are often somewhat more demanding.

[0006] In the past, plastic pallets of the size and type described have not been able to simultaneously meet all of the performance criteria for an acceptable cost and weight. Thus, they have not substantially replaced widely used wood pallets. It is an aim of the invention to do better.

[0007] In the plastic pallets which have been commercially offered or described in patent literature, decks appear to have been mostly made from sheet or injection molded plastic. Typically, decks are permanently attached to the other parts of the pallet, although sometimes they have been mechanically and detachably assembled. Often the decks have many openings and ribs for lightness and drainage, which present large surface areas and adversely affect fire test performance.

[0008] In order to have sufficient GMA strengths, the tops of pallets have had to be thick or have had to make use of metal beams, as described in various patents, including U.S. Pat. Nos. 5,868,080, 6,705,237, and 6,955,128. Beams, especially when they are encapsulated in plastic for protection, tend to increase the thickness, height and weight. Having a low pallet height, or low profile, is of interest for the following reason. Economics and current environmental concerns dictate that empty plastic pallets be exchanged, or returned to a source of goods for reuse Shippers want to pack as many empty pallets as possible on a truck or other transport vehicle, to reduce the shipping cost per pallet. Thus, it follows that the bigger the profile, the higher the cost of transporting a pallet.

[0009] Despite the best efforts of engineers and designers, plastic pallets which seek to meet the GMA standards—with or without using beams, have tended to be at or beyond the user-specified maximum 5.56 inch height. Small height changes can have a powerful effect on pallet strength, since section modulus and therefore stiffness of any structure is a cubic function of section height.

[0010] It has also been difficult for plastic pallet designers to meet the fire resisting requirements. The high energy content of thermoplastics, combined with the high surface area of plastic decks and other parts, have meant that the rate of heat evolution during a fire is much greater than allowed by the UL 2335 standard. While fire retardants have been included within the plastics to address the issue, it has been difficult for plastic pallet makers to meet the standard while meeting the other requirements. The fire retarding additives can compromise mechanical properties, increase cost and weight, and introduce environmental problems.

[0011] Thus, there is a need for further improvements in the design and construction of plastic pallets, to meet the difficult goals mentioned above.

SUMMARY

[0012] An object of the invention is to provide a plastic pallet with a desirable combination of properties that meet industry requirements for four way entry commercial pallets

which include creep strength, weight and fire resistance. Another object of the invention is to provide a pallet with a simple and strong deck, and means for attaching the deck to the pallet. A further object is to provide a pallet which does not need reinforcing beams in the top frame, and has reduced height and increased stacking density. A still further object of the invention is to provide a pallet which has better performance in fire tests than pallets which have plastic decks.

[0013] In accord with the invention, a rectangular plastic pallet, for storing and transporting goods and for use with forklift devices, has a plastic frame attached to the tops of plastic columns which run upwardly from a base, and a sheet metal deck is attached the frame and to any center column. Preferably the pallet is made of thermoplastic such as polypropylene, the deck is made of textured aluminum metal, and there is a base comprised of rails having steel reinforcing beams. Preferably, the sheet metal deck comprises a multiplicity of at least three or more corrugations running parallel to a diagonal between opposing corners of the deck.

[0014] A preferred diagonally corrugated metal deck has a flat flange which is inset from, or inwardly spaced apart from, the outer edge of the frame. It is thus less prone to damage when there are horizontal blows on the frame. The bridge parts of the frame, which parts span the spaces between columns, preferably have impact absorbers comprised one or more lengthwise compliant zones. In alternate embodiments, the deck is attached to the frame or to a spaced apart subframe inside the frame. The deck may be attached to the frame or subframe by alternative fastening means, preferably by pinning of the flange. The frame may be wholly plastic. The absence of reinforcing beams in the top enables a reduced top thickness and reduced overall pallet height. The size of the beams in the base is reduced from what was needed previously.

[0015] In accord with the invention, a thermoplastic pallet having a metal deck and metal reinforcing beams in the base is comprised of 30-45 percent metal. Thus, for a given weight pallet, such as a 51-55 pound GMA pallet, there is less readily combustible thermoplastic material available for burning in a fire test. The metal deck, which is at least about 75 percent of the area of the top of the pallet, reduces the surface area of plastic in the pallet, improving fire test performance. A preferred polypropylene pallet having an aluminum deck and steel beams in the base is about 34-37 weight percent metal, balance plastic. When combined with other features, including metal beams which collapse early during burning, metal decks with preferentially placed fire sprinkler water drain holes, and selectively used fire retardants in the plastic parts, 40x48 pallets are able to pass the UL 2335 fire tests, while still meeting all the required dimensional and structural properties.

[0016] In accord with the invention, pallet heights are reduced and the stacking density property is increased. A pallet height of less than 5.4 inches, and as low as 4.9 inches, is achieved, while still meeting the demanding commercial requirements. Stacking density is equal or better than 3.2 pallets per foot.

[0017] The foregoing and other objects, features and advantages of the present invention will become more apparent from the following description of preferred embodiments and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. 1 is an isometric view of a quarter section of a pallet.

[0019] FIG. 2 is a vertical cross section through the outer edge and part of the deck of the pallet of FIG. 1.

[0020] FIG. 3 is like FIG. 2, showing another embodiment pallet deck attachment.

[0021] FIG. 4 shows in vertical section part of the top outer edge of a pallet, where the deck is attached by means of plastic nubs.

[0022] FIG. 5 is a vertical cross section of the top outer edge of a pallet, where the deck is attached by means of a rail having integral pins.

[0023] FIG. 6 shows in vertical section part of the top outer edge of a pallet, where the deck is encapsulated with thermoplastic.

[0024] FIG. 7 is an isometric view of a quarter of a rectangular pallet having diagonal corrugations.

[0025] FIG. 8 is a top view of the pallet, showing continuous corrugations which run parallel to a line L connecting diagonally opposing corners of the pallet.

[0026] FIG. 9 is a vertical cross section through a portion of a corrugated deck showing the shape of the corrugations.

[0027] FIG. 10 is like FIG. 9 and shows different contour corrugations.

[0028] FIG. 11 is a graph comparing the mechanical behavior of decks having different corrugation patterns.

[0029] FIG. 12 is like FIG. 2, showing a vertical cross section portion of a pallet having metal beams, for describing pallet vertical dimensions.

[0030] FIG. 13 is an isometric view of a quadrant of a pallet having a deck mounted on a suspension system which comprises a subframe.

[0031] FIG. 14 is an exploded view of the pallet of FIG. 13.

[0032] FIG. 15 is a graph of pallet stacking density as a function of pallet height.

DESCRIPTION

[0033] The invention is mostly described in terms of a preferred embodiment pallet, having the dimensions of a GMA pallet. The invention will be useful in non-GMA pallets. As detailed further below, the present invention is aimed at meeting particular mechanical requirements, along with the fire test requirements of UL Standard 2335, while minimizing the use of fire retardants.

[0034] In one aspect of the invention, a predominately thermoplastic pallet has a combination of metal beams in the base and a textured, preferably a metal, deck. A metal deck enables avoiding the use of reinforcing beams in the top. That aspect is described first. There is an advantage to having corrugations which having specified orientations and dimensions. That is described next. By using the special combination of features a GMA pallet has the property of uniquely high stacking density. That is described last.

[0035] A pallet of the present invention may be molded-in components and subassemblies, preferably by injection molding using gas assistance. See U.S. Pat. No. 5,401,459. The several parts or subassemblies may be joined as an assembly by known thermoplastic fabrication methods, for example, by mechanical means, by hot plate welding, vibratory welding, or ultrasonic welding. See, for instance, U.S. Pat. Nos. 6,250,234 and 6,283,044. The thermoplastic parts of the pallet may be made of commercial grade polypropylene, high density polyethylene or other polyolefin. Other plastics, including thermosets and engineered plastics, may be used for the parts of the pallet.

[0036] FIG. 1 is an isometric view of a quadrant portion of pallet 20 which has a rectangular base 30. It is useful and illustrates many principles of the invention. The pallet 320, described below, is more complex and more preferred. There are nine columns which run upwardly from the rectangular base. Frame 24 is supported by the eight columns 28 which are at the rectangular periphery of the pallet. There are four corner columns and four columns at the midpoint of each side of the pallet. A frame is by definition a rectangular structure with an interior opening; and the interior opening is spanned by the deck. Formed aluminum sheet metal deck 22 is attached to frame 24. Base 30 is comprised of four outside rails 31 which form a rectangle that corresponds with the shape of frame 24. Two cross rails 33 connect the opposing centers of the outside rails; they cross each other at the center of the pallet. Center column 29 is at the cross rail intersection and deck 22 is fastened to the top of the center column. The openings 34, between adjacent columns 28 have a width and height which enables "four-way" fork entry for lifting and transport and which meet industry dimensional requirements.

[0037] Metal beams 74 are embedded within the rails 31, 33 of base 30. See also the vertical cross section of FIG. 2. The metal beams provide strength and stiffness to the base of the pallet, so that the pallet can be stored in a rack which has spaced apart rack supports, and so the pallet can endure other specified loads. Beams are incorporated within the frame in accord with the teachings of U.S. Pat. No. 6,705,237 of Moore et al., U.S. Pat. No. 6,955,128 of Apps et al., and U.S. Pat. No. 5,868,080 of Wyler et al., the disclosures of which are hereby incorporated by reference. The beams are preferably configured so that during a fire the embedded beams, and the pallet, collapse when the burning thermoplastic softens. See the related application entitled "Fire collapsible beamed pallet," bearing Atty. No. EPC-2443 filed on even date herewith by R. Moore et al., the disclosure of which is hereby incorporated by reference.

[0038] The construction of the deck and its attachment to the thermoplastic parts of the pallet are features of the invention. The deck has texturing which provides the sheet material with strength sufficient to both carry a load of goods and to impart strength to the pallet as a whole. When meeting fire test performance is the main criterion, and diminished strength can be accepted, a variety of ways for imparting stiffness to the deck sheet material may be used. For instance, Rigidized™ metal sheet may be used. For instance, the sheet may have a waffle pattern. Preferably, the deck has a multiplicity of corrugations, and it is also made of metal, as described below.

[0039] With reference to FIG. 1 and FIG. 2, deck 22 of pallet 20 has corrugations running in several different direc-

tions, in accord with the corrugation pattern shown as Type B in FIG. 11. The deck is made of 0.060 inch thick Type 5052 aluminum alloy sheet. The periphery of deck 22 comprises a flange 49, as shown in FIG. 1 and 4, which is plain or un-textured and which facilitates attachment to the frame.

[0040] The deck may be attached to the frame 24 in various ways, to act as a structural element for racking strength and the like. FIG. 3 through 6 show in vertical cross section some alternative deck attachments. FIG. 3 shows how deck 22 is pinned to the frame by screw or driven pin fasteners 36. FIG. 4 shows a multiplicity of vertically extending projections or nubs, which are molded into the plastic frame when it is fabricated. After a deck with mating holes is placed on the frame, the nubs are headed, or flattened over, as indicated by the arrows and phantom in FIG. 4. In another embodiment, shown in FIG. 5, the deck and frame have holes, to receive the stakes of a metal or plastic rail 40, which is pressed down onto the frame to capture the flange of the deck.

[0041] In still another embodiment of deck attachment, illustrated by FIG. 6, deck 22 is first encapsulated in whole or part by a layer 340 of thermoplastic, using commercial processes. Then, the layer is plastic-welded to the frame, for instance by ultrasonic, vibratory or hot plate welding. This embodiment can provide a good seal between the deck and the frame. See a related application entitled "Plastic pallet with sealed deck to frame joint", bearing Atty. No. EPC-2442, filed on even date herewith by R. Moore et al., the disclosure of which is hereby incorporated by reference. In another embodiment, not shown, the outer edge of the deck may be mechanically captured within the frame during the molding of the frame.

[0042] FIG. 3 shows a corrugated deck 22 which has no flange and which is not inset from the outer edge of the frame; the deck covers the entire top of the pallet. Preferably, the edges of a metal deck are inset from, or inwardly spaced apart from, the outside edge of the frame by a distance D, as shown in FIG. 1 and 2. With the inset of the deck edge, a peripheral portion of the top of the frame is exposed. With the inset deck design, the edges of the deck are less prone to being damaged when objects horizontally impact the frame of the pallet. Distance D will be a design choice, according to the character of the exposed part of the frame and anticipated impacts. In a FIG. 1 pallet embodiment, D is preferably the same for all edges, at about 1-3 inches for a GMA size pallet. D may be different at different sides of the pallet. In the pallet 120 embodiment discussed below, D is preferably about 4-5 inches. Thus for a 40x48 GMA pallet the deck area will be at least about 75 percent of total area of the top of the pallet. When the deck is metal, fire test performance is much improved due to the lessening of the quantity and surface area of combustible plastic in the pallet.

[0043] In the generality of the invention, the frame may be constructed in a manner which is familiar to those making ordinary injection molded structural beams. For example it may be shaped like a C-channel; it may have lightening pockets and ribs, etc. Preferably, the bridge parts 25 of the frame 24 are less conventionally constructed, and they have one or more lengthwise compliant zones which comprise an impact absorber 26. A bridge is that portion of a frame which spans the space between adjacent columns 28. One type of

impact absorber **26** is shown in **FIG. 1** and **FIG. 2**; another is shown in **FIG. 7**. In **FIG. 1**, the impact absorber comprises two parallel rows of open cells bounded by lengthwise and transverse ribs near the outer edge **27** of bridge **25**. The bridge comprises a third lengthwise zone, namely, the innermost portion of the bridge, where deck **22** is attached. See **FIG. 6**. That portion is not designed for impact absorption and is of conventional structural plastic design. Thus, when horizontally impacted, the outer portion of the bridge **25** is more compliant, or less stiff and therefore more deformable, than is the innermost part of the bridge. The outer portions absorb the force of a horizontal impact and the inner portion does not appreciably move. Impact absorber construction is described more particularly in the related application entitled "Plastic pallet with sealed deck to frame joint," bearing Atty. No. EPC-2442, filed on even date herewith by R. Moore et al., the disclosure of which is hereby incorporated by reference. Rectangular cross section beams **74** in the rails **31**, **33** of the base **30** are made of sheet metal. For example, 0.059 inch thick AISI 1040 steel, having yield strength of at least 80,000 pounds per square inch, may be used. For example, 0.090 inch thick cold rolled AISI 1018 steel having a Rockwell B hardness of 60-65 may be used. Preferably, the vertical height (or depth) of the beams is about 0.7 inch, when a metal deck is used.

[0044] If pallet weight is not critical, then the deck could be flat plate. However, it is preferred to use lighter gage sheet material and to texture the sheet, so it has good stiffness and section modulus. Some types of deck texturing are much preferred. **FIG. 11** illustrates some of the texturing patterns which are now discussed. **FIG. 7** shows in isometric view, similar to the view of **FIG. 1**, a portion of pallet **120** having a preferred corrugated deck. Pallet **120** has an essential construction and dimensions like those of pallet **20**. Numbers having two digits preceded by the digit 1, 2, 3, etc., here and below, denote elements which correspond with two-digit numbered elements above. The texturing of deck **122** of pallet **120** comprises parallel corrugations **45** which run at an angle to the edges of the deck and pallet. While a GMA pallet **120** preferably has an aluminum alloy sheet metal deck, as described above, the corrugation pattern invention may be employed other pallets having non-metal decks. Flange **149** of deck **122** is attached to the frame **124** of the pallet by means of screw or stake fasteners, or in other ways mentioned above. The center of the deck is fastened to the top of center column **129**.

[0045] Deck **122** has a multiplicity of corrugations **45** which, when viewed in a vertical cross section, comprise valleys **41** and peaks **47**. Some exemplary corrugation cross section patterns are shown in the vertical cross section decks of **FIG. 9** and **FIG. 10**. In the pattern shown in **FIG. 9** the tops of peaks **47** and the bottoms of valleys **41** of deck **122** are substantially flat and parallel to the top of the frame; and, the peaks and valleys are connected by webs running at a nominal 45 degree angle to the horizontal. The pitch, P, or center to center spacing, of the corrugations is about 2 inches. Depth DP is the effective depth of the deck; and is nominally the depth of the valleys. All valleys are preferably of uniform depth and provide the deck with an effective depth of about 0.5 inches.

[0046] **FIG. 10** shows the corrugation cross section of alternate embodiment deck **122A** which has peaks **45A** and valleys **47A** running along a nominally sinusoidal path.

Other dimension corrugations may be used, including those in which the corrugations vary in width or pitch. Depth DP may vary from valley to valley and along the length of any valley. The bottoms of the valleys preferably have spaced-apart drain holes, visible in **FIG. 1** and **FIG. 13**, to make fire sprinkler water drop onto the underlying cross rails, for helping performance in fire tests. See related application entitled "Fire sprinkler-friendly pallet," bearing Atty. No. EPC-2440, filed on even date herewith by R. Moore et al., the disclosure of which is hereby incorporated by reference. When made of metal, decks are formed from flat sheet using conventional metalworking techniques, including cold forming, press forming, drawing, etc. Especially when there is a flat flange, the deck may be conceived as a flat sheet into which valleys **41** have been pressed. Thus, in the following discussion a reference to a corrugation may be considered interchangeably to refer to a valley.

[0047] It has been discovered that particular corrugation dispositions or arrangements are surprisingly advantageous. **FIG. 8** is a top view of pallet **120** and illustrates the lay of the lengthwise axes **53** of the corrugations. In **FIG. 8**, all the corrugations of deck **120** run parallel to L, the line running between the intersects of the edges at two diagonally opposed corners. When the deck is congruent with the frame exterior, as is ordinarily the case, L will also be the diagonal of the frame and pallet as a whole. Line L of the deck will not be coincident with the corresponding diagonal of the frame or pallet when the rectangle of the deck is not congruent with the rectangle of the pallet. For the exemplary 40x48 pallet, the line L lies at an angle B of about 40 degrees to the longer edge of the frame **124**. The axes **53** of all the corrugations of deck **120**, and of certain corrugations in other embodiments, lie within plus or minus angle A of parallelism with line L. Angle A is about 10 degrees, preferably 3 degrees. If a deck is deviant from a perfect rectangle shape, L will be the diagonal of a best fit rectangle. The invention will be useful with patents which are square. When it is said corrugations are parallel, that means they are substantially parallel, and there may be small deviations from exact parallelism between adjacent corrugations.

[0048] **FIG. 11** graphically illustrates the surprising advantage in performance for certain deck corrugation patterns, as revealed by finite element analysis (FEA) of decks which were subject to the same uniform loads. In the analysis, decks were assumed to be made of 0.050 inch Type 5052 aluminum alloy sheet. All corrugations had the same width, depth and the cross section shape which is shown in **FIG. 9**. Thus, only the orientations of the corrugations were changed, from one type deck to another, in the analysis. The icons in **FIG. 11** are simplified top view sketches of pallet decks, to show the different deck corrugation patterns of the analysis.

[0049] The decks in the FEA were analyzed when supported in two different ways. First, the pallet was supported at the opposing 48 inch length sides, or in the so-called "long direction" (the data for which is represented by circle symbols). Second, the pallet was supported at the opposing 40 inch length sides, or in the so-called "short direction" (the data for which is represented by circle symbols). In **FIG. 11**, those two different support modes are indicated by stating the span between the supports, e.g., a span of 40 inches means the deck was supported along the 49 inch sides. The comparative FEA deformations of different configurations

of decks were determined. Those data are represented in the graph by the open symbols. Maximum elastic stress in the deck was calculated according to Von Mises theory and criteria. The Von Mises analysis data are represented by solid symbols. A deck having better strength will have lower deflection and lower Von Mises values, when performance in both directions of support is considered. The comparative deflection performance of some of the patterns was confirmed in testing of prototype decks and pallets.

[0050] Decks of type INV and type I have surprising advantage over the other patterns, and they are preferred embodiments of the present invention. In type INV all the corrugations run parallel to L, the diagonal. The associated data set is marked by the box 80. Deck of type I, with which is associated data set 90, is only somewhat inferior to the most preferred embodiment type INV. A deck of type B provides inferior performance, compared to what artisan intuition about its symmetry might suggest. In fact, such pattern was used on early prototypes. The long direction corrugations which characterize type III deck give the deck excellent results in one span-support direction and quite inferior results in the other span-support direction. The type II deck has similar but somewhat lesser inadequacy. The superior type I and type INV decks are characterized by at least three corrugations running continuously and parallel to the diagonal line of the deck. Type I deck has a second set of three corrugations, namely those running along the other diagonal of the pallet. The corrugations of the second set are discontinuous where their path crosses the first set of corrugations. Type I has in addition 4 to 6 valleys which run parallel to the each of the rectangular edges of the deck. In another embodiment, type IA, not shown, the configuration is like type I: A first set of at least 3 corrugations is parallel to a first diagonal line of the deck; and, all the other corrugations on the deck are parallel to the second diagonal.

[0051] When decks are made of sheet metal, fabricating a deck of type I is much more difficult than fabricating a type INV deck. There is more of tendency for thinning of the deck material during forming, and the thinning can be difficult to predict or eliminate. Thus, a type I deck is less preferred than a type INV deck, but both are substantially superior to other types of texturing. Thus, in a preferred embodiment of the invention there are at least three parallel continuous corrugations running from one corner to the diagonally opposite corner. The permissible range of alignment of corrugations is as described above in connection with FIG. 8.

[0052] Variation is possible within the scope of the corrugation orientation invention. In preferred embodiment deck, one corrugation valley is centered on line L, and there are two or more parallel valleys on either side of the primary valley. The two adjacent primary valleys have only a little shorter than the primary valley length. There need not be a primary valley along L; that is, two equal length valleys of any set of three or more may straddle L. The term "corner" as applied to this aspect of the invention is to be interpreted as embracing a region of the deck, rather than a point. When corrugations are said to run from one corner of the deck to the other corner, that means the corrugations run substantially to the portion of the deck which is in proximity to the right angle intersection of two edges of the deck. Thus, when the deck has a preferred flange, the three corrugations

nearest line L run to the corners, even though the outer portion of the corner near the edge intersect is an un-textured flange.

[0053] While the analysis simulated a metal deck, the invention will be useful with decks which are made of non-metals. Logic suggests that two, or even one, continuous diagonal corrugations would suffice, although providing less strength but that has not yet been proved. There is a benefit of having a deck with a flange in combination with corrugations. Stated simplistically, the oblong or cupped end of each corrugation provides strength to the edge of the deck, and helps inhibits bending of the deck about the length axis of the corrugation at the deck edge.

[0054] The combination of features of the invention provides another unexpected advantage, namely, a heretofore unattainable low profile, or total height, for a pallet which meets the many requirements which have been mentioned above for a GMA pallet. When invention pallets are stacked on top of each other, more pallets can be contained within a stack of a given height, than heretofore; i.e., the stacking density is significantly higher than heretofore.

[0055] A significant economic benefit results from higher stacking density, since more GMA pallets can be carried on a standard transport truck.

[0056] FIG. 12 is used to illustrate dimensions associated with pallets. FIG. 12 is analogous to FIG. 2 and shows a vertical cross section of a simplified prior art pallet 220 having metal beams 275, 274, respectively in the top and base. To meet the aforementioned standards, the fork opening 234 (also sometimes called the window) must have a height FO of at least 3.1 inches and a width WO of at least 12.5 inches wide. As an example of a difficulty associated with a prior art plastic deck pallet, in the pallet of the Moore U.S. Pat. No. 6,705,237 patent, the hollow square AISI 1018 steel beams 275, 274 have a vertical height of about 0.875 inches. That produces a base rail height DB of about 1.1 inches. The top frame has a similar beams and similar height DT. The resultant total height of the pallet is near the maximum 5.56 inch height allowed.

[0057] The present invention which comprises a corrugated metal deck, in particular an aluminum deck, having the corrugations of Type INV or Type I, enables both omitting metal beams in the top and reducing the height of the beams in the base, while meeting the dimensional, load bearing and weight requirements attending a GMA pallet. Leaving the beam out of the top means the top can be made thinner than heretofore has been possible. In the invention, a top frame height DT of about 0.7 inches is achieved. As mentioned, the effective height of the deck is 0.5 inches, and that fits easily within the frame profile. The corrugated deck is sufficiently stiff and supported at the center column. Thus, when it deflects under a load of goods, it does not deflect below the elevation of the bottom of the frame.

[0058] The strong metal deck and thermoplastic elements of the top cooperate with the base to provide good racking strength. The pallet construction enables a reduction in the size of the beams used in the base. For example, the vertical height (also called "depth") of the steel beams in the base of a preferred embodiment pallet is about 0.5 inches, which is about 60% of the previously required beam height of 0.875 inches. Thus, in the present invention, the thicknesses of

both the top and both parts of the pallet are thinner than was heretofore possible. The use of the corrugated metal deck enables a surprising and significant reduction in height and associated stacking density, compared to what could be done in the past.

[0059] Exemplary pallets of the invention have heights of less than 5.4 inches. In a preferred embodiment a pallet is 4.7 to 4.9 inches high. As a fraction of the height of the pallet, the required minimum 3.1 inch fork opening height is more than about 60 percent; the 0.7 inch top height is less than about 15 percent; and the 0.9 inch base height is less than about 20 percent. Those percentages are a measure of the efficiency and uniqueness of the design.

[0060] A quadrant of an exemplary pallet 320 which has features of the present invention is shown in FIG. 13. The exploded view of FIG. 14 shows how it is constructed. With reference to FIG. 13, pallet 320 has most elements like those previously described. The corrugated deck is of the type INV and all the corrugations are parallel to the deck diagonal. Pallet 320 is different from other embodiments described up to this point in the following way: The deck 322 is attached to a subframe 66 which is supported within the frame by attachment to cantilever brackets 68, 78. The deck is also fastened to center column 329 which preferably has vertical fins on top rather than a mirror-fit corrugation contour pattern. The subframe 66 and attached deck are spaced apart from the inner edge 72 of the frame. Preferably, the subframe, brackets and frame are integrally molded. Each bridge 325 has impact absorber construction across its whole width. Since the edge of the deck is spaced apart from the inner edge of the bridge, the bridge can deform compliantly and inwardly under horizontal impact loads without damaging the deck. The construction of the pallet of FIG. 13 is further described in a patent application entitled "Plastic pallet having impact resisting top", bearing Atty. No. EPC-2437, and an application entitled "Plastic pallet having deck suspension system", bearing Atty. No. EPC-2439, both filed on even date herewith by R. Moore et al., the disclosures of which is hereby incorporated by reference.

[0061] A pallet of the present invention like that shown in FIG. 13, when made of polypropylene or comparable density plastic, and when having corrugated aluminum alloy deck and steel beams only in the base, is by weight about 30-45 percent metal, balance thermoplastic. In a preferred embodiment pallet, the metal is about 32-40 weight percent. On a volume percent basis the preferred embodiment pallet is approximately 90 percent plastic. Therefore, on both bases, the invention pallet is characterized as predominately plastic. In an exemplary a pallet, the total weight is about less than 55 pounds, preferably about 51 pounds, according to the particular height. The aluminum deck weighs about 6 lb and the steel reinforcing beams weigh about 12.5 lb, which are respectively about 11-12% and 23-25% of the total pallet weight. Such pallet is 34-37% percent metal by weight. Some or all of the metal parts may be replaced by non-metal parts, such as with engineered plastics or ceramics which provide comparable section moduli and strengths to the metal parts.

[0062] In the present invention, the new technology makes possible the construction of GMA-load rated pallets which are predominately plastic, but at the same time they have a total height which is 10-15% less than GMA-rated pallets in

the prior art. For example, a pallet which has a 4.7 inch height has about 15% less height than a 5.56 inch high prior art pallet. That means that about 20% more pallets can be carried within the volume of a typical large truck or other vehicle, which is explained now.

[0063] A typical stack of pallets for carrying within a familiar U.S. over-the-road enclosed semi-trailer cannot exceed about 109 inch. Obviously, if the remaining space above an uppermost pallet is less than the height of a full pallet, that space must remain empty. In the invention, a stack of 23 most preferred embodiment 4.7 inch high pallets will be about 108 inches high. A stack of 19 prior art 5.56 inch pallets will be about 106 inches high. Normalizing those numbers, a stack of 5.56 inch pallets has a vertical density of 2.15 pallets per foot. In the invention, the most preferred embodiment 4.7 inch high pallet has a stack density of 2.55 pallets per foot. Table 1 shows data for different models, or embodiments of the invention. The pallet height and density data of Table 1 are plotted in FIG. 15. When certain cost considerations are weighed, the design Model A, having a 4.9 inch height, is most preferred at the present time; and a substantial advantage is obtained. Of course, increased stacking density is only of interest when the pallet also meets the diverse other requirements which have been stated. Creep test performance is a demanding and critical parameter and it is used here as a measure of successful design. The creep test behavior of 40x48 pallets having the construction described in connection with FIG. 13 was found to have the required creep properties, as well as meeting other requirements. A uniformly distributed load of 2800 pounds was applied to the deck for a period of 720 hours at a temperature of 115° F. The pallet was simply supported by its opposing base edges on open beam warehouse rack fixture. The span between the rail supports of the fixture was 4 inches less than the length of the pallet side which spanned the space between the support. In passing the test, a 4.9 inch high pallet did not deform downwardly more than 0.8 inches. Reference should be made to the Background here and the Virginia Tech Test Protocol for Plastic Pallet and proposed UL 2417 standard, the disclosures of which are hereby incorporated by reference. See especially "Bending Tests," Section 1.2 of the Virginia Tech document, and the comparable Section 5.5 of the proposed UL 2417 standard. A pallet which passes the aforementioned 30 day creep test is said here to be GMA creep-rated. The exemplary pallet was capable of passing the other structural tests which are required for commercial usage and is thus said here to be GMA structurally rated.

TABLE 1

| Pallet | Pallet height inches | Dimensional and stacking properties of pallets | | Stacking Density units/foot |
|------------|-------------------------|--|----------------|--------------------------------|
| | | Maximum Stack | | |
| Embodiment | | quantity | height(inches) | |
| D | 4.7 | 23 | 108 | 2.55 |
| A | 4.9 | 22 | 108 | 2.44 |
| B | 5.15 | 21 | 108 | 2.33 |
| C | 5.45 | 20 | 109 | 2.2 |
| Prior Art | 5.56 | 19 | 106 | 2.15 |

[0064] Prototype GMA pallets which had the features of most preferred embodiments of the invention passed the test of UL 2335. The pallets were made of polypropylene

containing fire retardants and had a corrugated aluminum deck with drain holes over the base rails, collapsible steel beams in the base rails, and thermoset foam within the hollows of the columns.

[0065] While the above described combinations of aluminum and steel and polypropylene materials are presently preferred, other materials can be used. For example, while the aforementioned 5000 series aluminum alloy is the preferred metal deck material, other wrought metals can be equivalently used within the scope of invention. The 5052 aluminum alloy has an elastic modulus in tension of 10.3×10^5 psi (7.1×10^4 MPa) and a specific stiffness of about 10×10^6 inch (26×10^5 m). In an alternate embodiment, AISI 300 series stainless steel may be used. Such steel alloy has about three times the density of the aluminum alloy, but it also has an elastic modulus which is about three times that of the aluminum alloy. The two classes of metals have about the same specific stiffness. Thus, in a GMA creep rated pallet, the steel deck could be about one-third of the thickness of an aluminum deck. Thus a deck may alternately be made of any of a number of steels which have mechanical properties comparable to the 300 series stainless steels. Alternately, a deck may be made of alloys of magnesium or titanium, although they have poor fire test characteristics. Sheet of fiber reinforced thermoset plastic may be used. Pallets may be alternately constructed using beams which are not metal, such as those made of graphite or glass or metal fibers. The rails of bases may be constructed wholly of engineered plastics.

[0066] As will be understood from the foregoing and as is understood in the art, when a pallet is termed "plastic" or "thermoplastic," unless qualified, the term does not exclude the presence of other materials such as metal reinforcing members, fillers, fibers, fire retardants, and the like; and it means that the pallet is mostly or predominately plastic or thermoplastic, as applies. A thermoplastic pallet or member may also be comprised of lesser fraction thermoset and or elastomer materials. Such terminology compares to a reference to a wholly or purely plastic or thermoplastic pallet or article. In the invention, commercially available fire retardants are ordinarily included with thermoplastics, to help meet the UL 2335 requirements, as is known in the art. See a related application entitled "Thermoplastic pallet having portions with different fire resistances", bearing Atty. No. EPC-2514, filed on even date herewith by R. Moore et al., and U.S. Pat. No. 6,807,910, the disclosures of which are hereby incorporated by reference.

[0067] While the invention is described and in some respects claimed in terms of a 40 inch \times 48 inch U.S. GMA pallet, those dimensions may vary within a several percent; and thus, the dimensions will comprehend a 1000 mm \times 1200 mm European pallet. The features of the invention can be applied to pallets which have other dimensions, different numbers of columns, and which meet other performance specifications. For example, the base of a pallet may have cross rails which run in a different pattern from that described. For instance, the cross rails may run between diagonally opposed corners. For instance, there may only be one cross rail. The cross rails may be wholly metal. Likewise, the columns might be wholly or part metal. For another example, a corrugated deck of the invention can be used with pallets which have no reinforcing beams in the base, or with pallets which have no base rails, but which are sup-

ported by resting the lower ends of the columns on a flat surface, in which case the columns might more accurately be called feet.

[0068] The inventions will be useful as improvements for pallets which are not GMA dimensioned or structurally rated. The deck corrugation patterns can be used in other pallets having sheet material decks, including where the deck material is any kind of plastic, including engineered plastics, such as those reinforced with graphite fibers and fiberglass. The invention may be applied to wholly plastic pallets and pallets having wood bases.

[0069] Although this invention has been shown and described with respect to a preferred embodiment, it will be understood by those skilled in this art that various changes in form and detail thereof may be made without departing from the spirit and scope of the claimed invention.

We claim:

1. A predominately plastic pallet comprising:

a rectangular base;

a multiplicity of spaced apart outer columns extending upwardly from the periphery of the base;

a top, comprising a rectangular plastic frame having inner edges and outer edges, mounted on the columns, the frame comprising bridges which span the spaces between the columns; deck support means, for attaching the deck to the top;

a textured sheet metal deck, for receiving goods placed on the pallet.

2. The pallet of claim 1, wherein the deck support means comprises attachment of the deck to the frame.

3. The pallet of claim 1, wherein the top further comprises a subframe mounted within the frame with the outer edges of the subframe spaced apart from the inner edges of the frame; wherein the deck support means comprises attachment of the deck to the subframe.

4. The pallet of claim 1 wherein the base comprises rails having metal reinforcing beams:

5. The pallet of claim 1 wherein the deck is made from a metal selected from the group which comprises: iron base alloys, aluminum base alloys, titanium base alloys, and magnesium base alloys.

6. The pallet of claim 4 wherein the deck is made of aluminum alloy and the reinforcing beams are made of iron alloy.

7. The pallet of claim 1 wherein the edges of the deck are inset from the outer edges of the frame.

8. The pallet of claim 1 wherein the edges of the deck are inset from the outer edges of the frame; and wherein the deck area is at least 75 percent of the area of the top of the pallet.

9. The pallet of claim 8 wherein the total weight of the deck and reinforcing beams is between 30 and 45 percent of the total pallet weight.

10. The pallet of claim 8 wherein the deck has a circumscribing flange.

11. The pallet of claim 7 wherein a multiplicity of the bridges each comprising at least one impact absorber zones running lengthwise along the portion of the bridge which is nearer to the edge than is the adjacent edge of the deck.

12. The pallet of claim 1 wherein the deck is attached to the top by a means selected from the group which comprises pins, stakes, screws, headed plastic nubs, and hold-down rails.

13. The pallet of claim 1 wherein the deck texturing comprises a multiplicity of parallel continuous corrugations running between opposing diagonal corners of the deck.

14. The pallet of claim 1 wherein the base is comprised of four outer rails which form the sides of the rectangle and cross rails which connect the centers of the opposing side outer rails, further comprising: a center column at the intersection of the cross rails; wherein the deck is attached to the center column.

15. A predominately thermoplastic rectangular pallet comprising:

a base comprised of four outer rails interconnected to form a rectangle; at least one cross rail connecting the center points of opposing side outer rails;

reinforcing beams within said rails, the beams having a higher modulus of elasticity than the modulus of elasticity of the thermoplastic material of the pallet;

eight spaced apart outer columns extending upwardly from the outer rails and one center column extending upwardly from the center of the base;

a thermoplastic frame, attached to the tops of the outer columns, the frame having inner edges and outer edges

and comprised of a multiplicity of bridges which span the spaces between the columns, each bridge comprising at least one impact absorber zone running lengthwise in proximity to the outer edge of the frame;

a subframe, spaced apart from the inside edge of the frame; means for supporting the subframe;

a textured metal deck attached to the subframe and to the center column, wherein the edges of the deck are inset from the inner edges of the frame; wherein, the combination of frame and deck forming the top of the pallet, for receiving goods placed on the pallet.

16. The pallet of claim 15 which is of the GMA type; wherein the frame is 48 inches long and 40 inches wide; wherein the deck is inset about at least 3 inches; where the reinforcing beams are made of steel; and, wherein the pallet is between 30 and 45 weight percent metal.

17. The pallet of claim 16 deck is textured with a multiplicity of parallel continuous corrugations running between opposing diagonal corners of the deck.

18. The pallet of claim 16 wherein the thermoplastic is selected from the group which comprises polyethylene, polypropylene and combinations thereof.

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